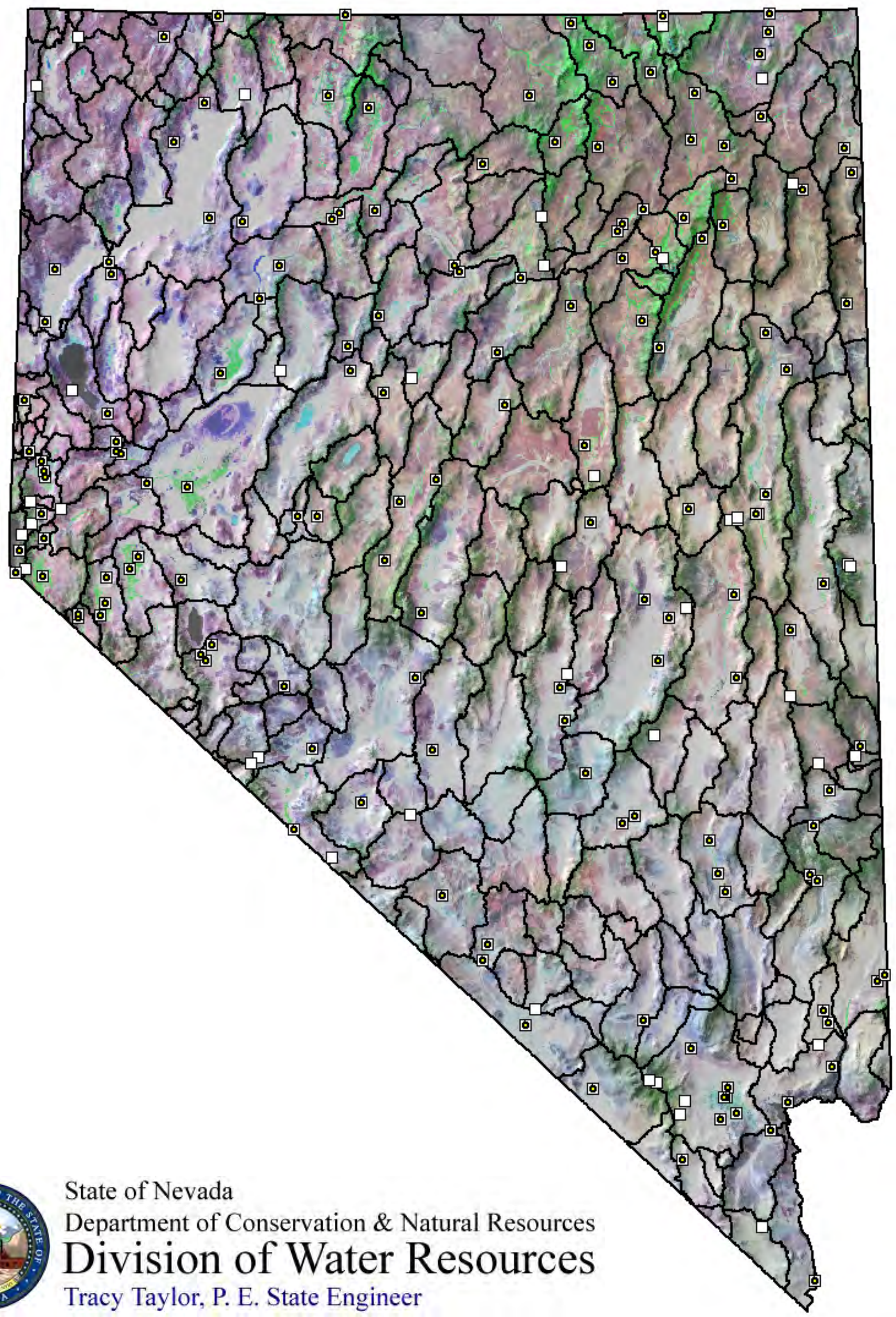
EXHIBIT 134

Evapotranspiration
and
Net Irrigation Water Requirements for Nevada



State of Nevada
Department of Conservation & Natural Resources
Division of Water Resources
Tracy Taylor, P. E. State Engineer

All compiled evapotranspiration data files are available via internet download from the following NDWR website:

http://water.nv.gov/NVET

Evapotranspiration and Net Irrigation Water Requirements for Nevada

By

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EXECUTIVE SUMMARY

Accurate estimates of evapotranspiration (ET) are becoming more important as increasing demands are placed on finite water supplies in Nevada and across the western U.S. Local, state, and federal water resource agencies require accurate crop ET (ET_{act}) and net irrigation water requirement (NIWR) estimates for evaluating irrigation development, transfers of irrigation water for municipal use, and litigation of water right applications and protests. The ET_{act} was calculated via a crop coefficient approach, where ET_{act} is equal to the reference ET multiplied by a crop coefficient. The NIWR is equal to the annual ET_{act} less the effective precipitation entering the root zone that is available for evaporation or transpiration. The major objective of this study was to update estimates of the ET_{act} and NIWR for Nevada. The methods for estimating the reference ET follow the new ASCE-EWRI Standardized Penman-Monteith (ASCE-PM) approach, while the ET_{act} and NIWR were estimated using a dual crop coefficient and daily soil water balance. Estimates of the ET_{act} and NIWR for major crops grown in Nevada were made for daily, monthly, and annual time steps at 190 locations using National Weather Service weather stations located throughout the state for available periods of record.

Assessing the error in estimated ASCE-PM reference ET using estimates of the 'secondary' weather parameters solar radiation, dewpoint, and wind speed, versus using measured data is of significant concern because estimation of these weather variables provides the ability to use NWS stations, which allows for sufficient spatial coverage and statewide application. To address this issue, a comparison was made between estimated reference ET at NWS stations, and calculated reference ET at nearby stations located in irrigated areas that measure the full suite of weather variables. Results of the comparison indicate that the ratios of annual reference ET based on estimated secondary weather parameters, to reference ET based on measured secondary weather parameters, range from 1.01 to 1.06 with an average of 1.03. These results are acceptable considering the overall error or uncertainty inherent to reference ET and crop coefficient calculations, which have been suggested to be about 10%.

To explore the accuracy of estimated alfalfa ET_{act}, a comparison was made to measured ET_{act} of alfalfa using results from previous studies for respective Hydrographic Areas (HAs) and time periods. The average ratio of estimated ET_{act} to the average of the reported ET_{act} is 1.04. Results generally agree well, however there are significant differences in some instances where published measurements of ET_{act} were likely being impacted by water limiting conditions or instrumentation biases.

For purposes of estimating the mean annual ET_{act} and NIWR for each HA, the analysis was limited to weather stations on valley floor areas representative of potential agricultural areas. Mean annual values of the ET_{act} and NIWR were assigned to the HA if a single station was available, or if multiple stations were available, a period of record

weighted average of the ET_{act} and NIWR was assigned to HAs. Of the 256 HAs in the state, 160 are absent of weather stations from which to estimate the ET_{act} and NIWR; therefore, spatial interpolation of weather station estimates of the mean annual ET_{act} and NIWR was performed for alfalfa, grass hay, pasture grass, turf grass, and small shallow open water bodies. Results of the NIWR per HA (Appendix 15 and Plate 1) indicate that in central and northern parts of Nevada, the NIWR for alfalfa is less than the typical permitted irrigation water right of 4 ac-ft/ac. However, in southern Nevada the NIWR may exceed the typical irrigation water right of 5 ac-ft/ac. These results represent the NIWR for pristine crop conditions under full water supply and should be considered the maximum.

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ACRONYMS

α	= albedo
AGRIMET	= U.S. Bureau of Reclamation Agricultural Weather Network
ASC	= Antecedent Soil Condition
ASCE-EWRI	= American Society of Civil Engineers – Environmental Water Resources Institute
ASCE-PM	= American Society of Civil Engineers Standardized Penman Monteith equation
AWC	= Available Water Holding Capacity
AZMET	= Arizona Meteorological Network
β	= angle of the sun above the horizon
B	= empirical solar radiation fitting coefficient
C_d	= ASCE-PM equation constant dependent on reference type
CEMP	= Community Environmental Monitoring Program
CGDD	= Cumulative Growing Degree Day
CIMIS	= California Irrigation Management Information System
CN	= Runoff Curve Number
C_n	= ASCE-PM equation constant dependent on reference type
CN_I	= Runoff Curve Number associated with dry antecedent soil conditions
CN_{III}	= Runoff Curve Number associated with wet antecedent soil conditions
Δ	= slope of the saturation vapor pressure-temperature curve
δ	= solar declination
d	= zero plane displacement height for the weather site vegetation
D_e	= Depletion of evaporative layer
d_r	= squared inverse relative distance factor for the earth-sun
DRI	= Desert Research Institute
e_a	= mean actual vapor pressure
$e^o(T)$	= saturation vapor pressure at a specified temperature T
$e^o(T_{dew})$	= actual vapor pressure at daily dewpoint temperature
e_s	= saturation vapor pressure
ET	= Evapotranspiration

ET_{act}	= Actual Evapotranspiration
ET_o	= Reference Evapotranspiration
ET_{os}	= Standardized Grass Reference Evapotranspiration
ET_{sz}	= Standardized Reference Evapotranspiration
f_{cd}	= cloudiness function
$F_{timeroot}$	= fraction of time from the start of root growth until the time of maximum root depth
γ	= psychrometric constant
G	= soil heat flux
GDD	= Growing Degree Day
h	= vegetation height
HA	= Hydrographic Area
φ	= latitude
J	= Julian day (1-365 or 366 for leap years)
K_b	= index of atmospheric clearness
K_c	= crop coefficient
K_{cb}	= basal crop coefficient
K_{cmean}	= mean crop coefficient curve (i.e. lumps evaporation, transpiration, and cutting effects)
K_d	= diffuse radiation index
K_e	= soil evaporation coefficient
K_o	= dew point depression (i.e. $T_{min} – T_{dew}$)
K_s	= stress coefficient
K_T	= atmospheric transmissivity
K_{tb}	= atmospheric turbidity coefficient
λ	= latent heat of vaporization
LCRAS	= Lower Colorado River Accounting System
MAD	= Maximum allowable Depletion
NCGDD	= Normalized Cumulative Growing Degree Day
NIWR	= Net Irrigation Water Requirement
NRCS	= Natural Resource Conservation Service
NWS	= National Weather Service
P	= mean atmospheric pressure
P_{inf}	= depth of infiltrated precipitation
PPT	= precipitation
R_a	= exoatmospheric radiation
RAW	= Readily Available water in the root zone
RAWS	= Remote Automated Weather Station
REW	= Readily Evaporable Water
RH	= Relative Humidity
RMSE	= Root Mean Squared Error
R_n	= net radiation
R_{nl}	= net long wave radiation
R_{ns}	= net short wave radiation
RO	= surface runoff
R_s	= incoming short wave solar radiation

R_s/R_{so}	= relative solar radiation
R_{so}	= calculated clear sky radiation
S	= maximum depth of water that can be retained as infiltration and canopy interception during a single precipitation event
σ	= Stefan-Boltzmann constant
STATSGO	= State Soil Geographic database
T	= mean daily air temperature
TAW	= Total Available Water in the root zone
T_{base}	= base temperature used in the growing degree method
T_{dew}	= dewpoint temperature
TEW	= Total Evaporable Water
T_{Kmax}	= maximum daily Kelvin temperature
T_{Kmin}	= minimum daily Kelvin temperature
T_{max}	= maximum daily air temperature
T_{min}	= minimum daily air temperature
U_2	= mean daily wind speed at 2m height
USBR	= U.S. Bureau of Reclamation
USDA	= U.S. Department of Agriculture
USGS	= U.S. Geological Survey
u_z	= measured wind speed at z_w m above ground surface
VPD	= Vapor Pressure Deficit (i.e. es – ea)
W	= precipitable water in the atmosphere
ω_s	= sunset hour angle
z	= weather station site elevation above mean sea level
Z_{max}	= maximum effective root depth
Z_{min}	= initial root depth at planting or greenup
z_{om}	= aerodynamic roughness length for the weather site vegetation
Z_r	= effective root depth
z_w	= height of measurement above ground surface

INTRODUCTION

Irrigation water requirements are primarily controlled by the evapotranspiration (ET) of agricultural crops. Quantifying the amount of ET for a particular type of vegetation and region is necessary for proper design of irrigation systems, basin water balance estimates, irrigation water management, and review and litigation of water right applications and disputes; all of which continue to receive high priority attention. In the past, the State of Nevada has based ET and net irrigation water requirement estimates on a combination of reports, mainly from the USDA Nevada Irrigation Guide (USDA-SCS, 1992), State of Nevada Report No. 3 (Pennington, 1980), and studies used in hearings associated with the Alpine Decree (Mahannah, 1979; Hill, 1979; Guitjens and Mahannah, 1977). These publications primarily utilized temperature based Blaney-Criddle, modified Blaney-Criddle, Jensen-Haise, and Penman equations for computing reference ET, as well as empirical relationships between estimated crop ET and crop yields, and soil moisture balance (depletion) estimates of ET, resulting in a wide range of estimates. Other publications specific to Nevada have outlined methods for computing potential ET (Behnke and Maxey, 1969), and have estimated statewide (Shevenell, 1996) and eastern Nevada (McCurdy and Albright, 2004) potential ET, and crop water use for eastern Nevada (Welch et al., 2007) and the Death Valley flow system (Moreo and Justet, 2008). Net irrigation water requirements (crop ET – (precipitation – runoff – deep percolation)) were not estimated in many previous publications, and if so, were estimated as the annual crop ET minus an assumed effective precipitation amount. While these reports have been extremely useful, their somewhat dated methods, or simplified approach for estimating evaporation from surface wetting and effective precipitation, and limited spatial coverage have created a need to update statewide ET and net irrigation water requirement estimates using a standardized and more detailed approach.

The major objective of this report was to update crop ET and net irrigation water requirement estimates for Nevada using newly available standardized methods and detailed soil water balance accounting. Estimates of crop ET and net irrigation water requirements were made for 34 different crop and land cover types using 190 National Weather Service stations located throughout the state (Figure 1).

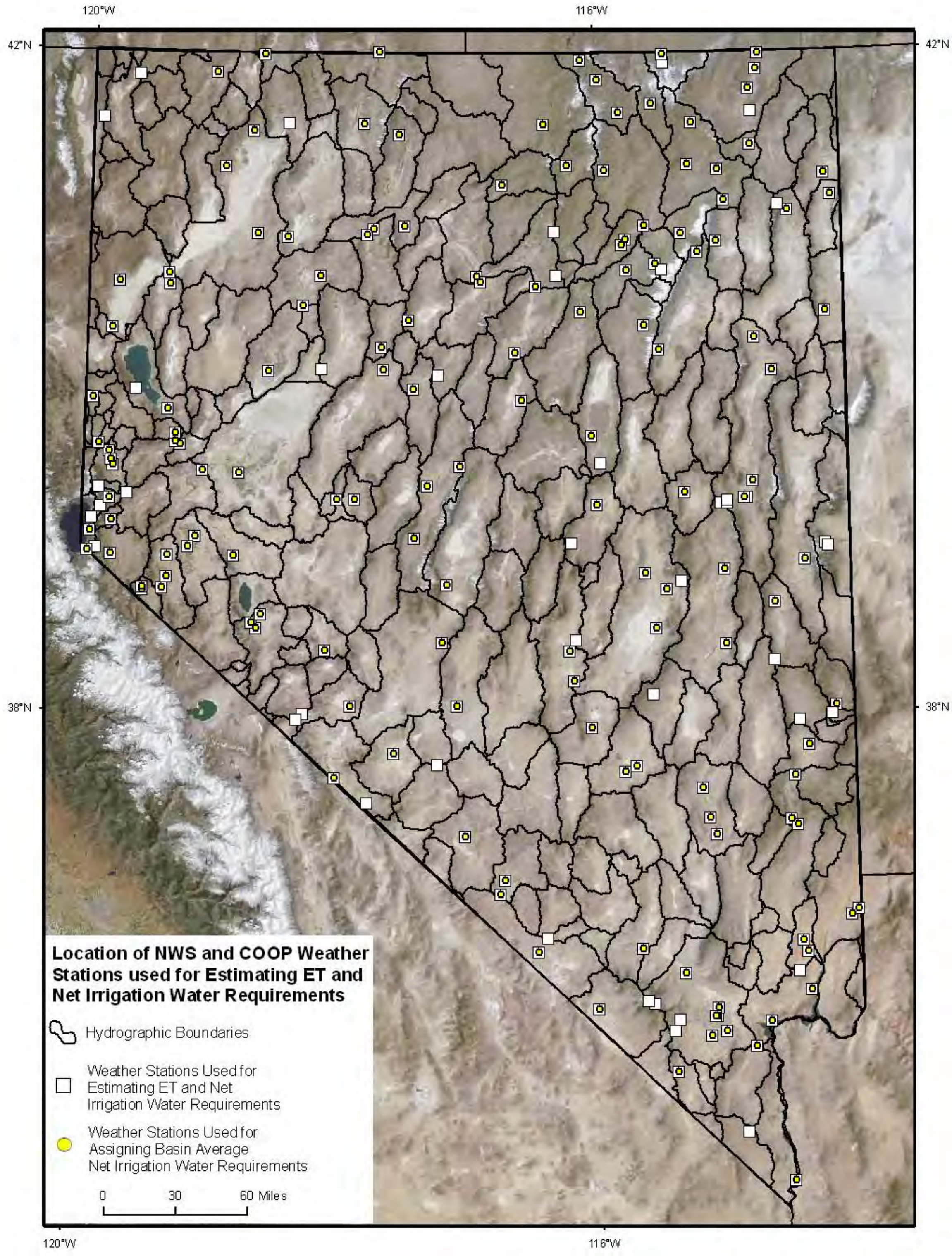


Figure 1. Weather stations used for calculating crop ET and net irrigation water requirements.

EVAPOTRANSPIRATION CALCULATION APPROACH

The approach used in this study for computing crop ET is the common crop coefficient – reference ET approach, where the reference ET is multiplied by a crop coefficient for estimating the actual ET (ET_{act}) of a vegetative surface. There are many methods available for estimating the reference ET (ET_o), while many are simple temperature-based techniques, others are data intensive as required for more physically based models. Estimates of ET_o vary widely among the methods, and there is considerable debate as to which is the more correct method. Generally, the lack of weather variables such as incoming solar radiation, dewpoint temperature, and wind speed needed for more physically based models of ET_o has led to the use of simple temperature based methods, even though investigators are often aware that more physically based methods result in more accurate and representative estimates of ET_o. Given that the number of weather stations that collect incoming solar radiation, relative humidity, and wind speed is limited, there is a great need to utilize basic National Weather Service (NWS) weather data of maximum and minimum temperature and precipitation, and apply these data to an ET_o equation that is robust and currently accepted in the literature and scientific community to estimate the ET_{act} and net irrigation water requirement (NIWR) throughout the state.

The Penman-Monteith method is a physically based method for calculating ET_o and is currently accepted as a standard method (ASCE-EWRI, 2005) for calculating a standardized and consistent value for ET_o, referred to here as ET_{sz}. The Penman-Monteith method requires weather variables that are not routinely measured at NWS stations. Recent advancements in estimating weather variables such as incoming solar radiation (Allen, 1997; Thornton and Running, 1999; ASCE-EWRI, 2005), generalization of dewpoint temperatures representative of irrigated areas (ASCE-EWRI, 2005; Allen et al., 1998; Allen and Robison, 2007) and regionalizing of wind speed (Allen and Robison, 2007) have proven useful for estimating ET_{sz} using the Penman-Monteith equation, while maintaining sufficient accuracy and spatial coverage for state-wide application. The grass reference Penman-Monteith equation is widely applied by Arizona and California State agencies for computing ET_{act} (i.e. AZMET and CIMIS), as well as the U.S. Bureau of Reclamation for their Lower Colorado River Accounting System (LCRAS) model. Consequently, the State of Nevada has adopted the daily time step grass reference Penman-Monteith equation (ET_{os}) as the basis for computing the ET_{act} and NIWR. As a result, this equation was applied in this study.

ET_{sz} refers to ET from a reference crop that is actively growing, not limited by soil moisture, and is at full cover and peak height. The ratio of ET_{act} to the ET_{sz}, otherwise known as a crop coefficient (K_c) representing specific crop types, must be applied to adjust the ET_{sz} to simulate the ET_{act} of a particular crop or surface. The majority of crop coefficients in the literature are derived from research weighing lysimeter measurements of actual ET from stress-free crops and calculated ET_{sz} at the lysimeter sites, mainly from Davis, CA, and Kimberly, ID (Doorenbos and Pruitt, 1977; Wright, 1981, 1982). This study utilizes a dual crop coefficient and daily soil water approach to compute the ET_{act}, where the K_c value is separated into a 'basal' crop coefficient, K_{cb}, and a soil evaporation coefficient, K_e (Allen et al., 1998; Allen et al., 2005). The heritage of many of the K_{cb} values used in this study can be traced to Wright (1982), but have been converted from Wright's alfalfa reference basis to the grass reference basis used here. The advantage of using a dual crop coefficient over a 'mean' or single crop coefficient approach is that it allows for separate accounting of transpiration and evaporation to better quantify evaporation from precipitation and irrigation events, and allows for accounting of winter time soil moisture storage.

METHODS

Weather Station Data Assembly

Weather station data from the NWS used in the computation of ET_{os} and NIWRs include daily maximum and minimum air temperature and precipitation, and observations of snowfall and snow cover depth for some stations. These data are officially collected and housed by the National Climatic Data Center (NCDC) of the National Oceanic and Atmospheric Administration (NOAA). Data are generally available from the NCDC from about 1930 onwards, however lengths of records vary widely from station to station in Nevada, ranging from less than 1 month to 120 years. Limiting weather station datasets to those stations having at least 4 years of complete annual records result in over 190 usable weather stations in Nevada. Missing data, which were usually at monthly periods due to the reporting of monthly data sheets to the NWS, were flagged using values of -999 for temperature and -99 for other variables. Missing temperature data for up to two consecutive days were estimated using the previous day's temperature, otherwise long term averages were used for purposes of computing growing degree days and 30 day mean temperatures to simulate the onset or end of growing seasons during the ET_{act} calculations. However, these periods of missing data were set back to -999 values for temperature and computed ET_{act} in later processing, and those years that contain any missing days were not used in statistical summaries.

Computing the NIWR for each hydrographic area (HA) was accomplished by using weather stations located on valley floor or near irrigated areas, and either assigning or computing the average of multiple station estimates of the NIWR. Limiting stations to valley floor and irrigated areas for computing the NIWR for each HA where weather stations exist reduces the number of weather stations to 148 (Figure 1), however the ET_{act} and NIWR was computed for all 190 stations for other potential uses such as assessing the ET_{act} for high elevation pasture grass, etc. Weather data and results are available through July of 2007, unless weather station data collection ended before this date. Appendix 1a and 1b list the full 190 weather station dataset, along with the respective NCDC station number, station location and altitude, period of record, number of complete years in the period of record, and HA name. Appendix 1a is sorted by weather station name, while Appendix 1b is sorted by HA name. Two weather stations operated and maintained by Washoe County Department of Water Resources were included in this analysis and are located in Washoe Valley and Redrock Valley. Details on data compilation for these stations and modifications made to temperature data for 2 NWS stations due to poor station siting are outlined in Appendix 2. In this report, statistics of ET results were computed over the most recent 30 years of valid data or over shorter periods if less than 30 years of valid data were available (minimum of 4 years). For further discussion on treatment of missing data in computed monthly, annual, and statistical summaries refer to Appendix 9.

Standardized Penman-Monteith Equation

As a part of a standardization effort, the ASCE Penman-Monteith (ASCE-PM) equation and associated equations for calculating aerodynamic and bulk surface resistance are combined and condensed into a single equation that is applicable to both grass and alfalfa surfaces by changing standardized constants (ASCE-EWRI, 2005). The ASCE-PM equation is intended to simplify and clarify the presentation and application of the method. As used in this analysis, the term ET_{os} refers to the standardized grass reference ET. Calculation of parameters required in the ASCE-PM equation was accomplished using guidelines from ASCE-EWRI (2005).

The standardized reference evapotranspiration equation is

$$ET_{sz} = \frac{0.408\Delta(R_n - G) + \gamma \frac{C_n}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + C_d u_2)} \qquad \text{Eq. 1}$$

where

ET_{sz} = standardized reference crop evapotranspiration for short (ET_{os}) or tall (ET_{rs}) surfaces [mm d^{-1}],

R_n = calculated net radiation for the standardized surface [MJ m^{-2} d^{-1}],

G = soil heat flux density at the soil surface [MJ m^{-2} d^{-1}], and is assumed to be 0 over a day,

T = mean daily air temperature at the 1.5 to 2.5m height [°C],

u_2 = mean daily wind speed at 2m height [m s^{-1}],
e_s = saturation vapor pressure at 1.5 to 2.5m height [kPa], calculated for daily time steps as the average of saturation vapor pressure at maximum and minimum air temperatures,
e_a = mean actual vapor pressure at 1.5 to 2.5m height [kPa],
Δ = slope of the saturation vapor pressure-temperature curve [kPa °C^{-1}],
γ = psychrometric constant [kPa °C^{-1}],
C_n = numerator constant that changes with reference type and calculation time step, and
C_d = denominator constant that changes with reference type and calculation time step.

Calculation of the Standardized Penman-Monteith Reference ET

Because NWS stations only measure and report daily maximum and minimum air temperature and precipitation, variables of daily incoming solar radiation, humidity, and wind speed required in Eq. 1 were estimated following recommendations similar to those in ASCE-EWRI (2005) and are discussed below.

Psychrometric and Atmospheric Variables

The standardized application of latent heat of vaporization, λ, equal to 2.45 MJ kg^{-1}, results in a psychrometric constant, γ, that is proportional to the weather station mean atmospheric pressure, P,

$$\gamma = 6.65 * 10^{-4} P \qquad \text{Eq. 2}$$

where P has units of kPa, and γ has units of kPa $^{o}C^{-1}$. Mean atmospheric pressure at weather stations was estimated from the site elevation using a simplified formulation of the Universal gas Law (Burman et al., 1987)

$$P = 101.3\left(\frac{293 - 0.0065z}{293}\right)^{5.26} \qquad \text{Eq. 3}$$

where

z = weather site elevation above mean sea level [m].

The slope of the saturation vapor pressure-temperature curve, Δ, was computed following Murray (1967) as

$$\Delta = \frac{2503\exp\left(\frac{17.27T}{T+237.3}\right)}{(T+237.3)^2} \quad \text{Eq. 4}$$

where

Δ = slope of the saturation vapor pressure-temperature curve [kPa^oC^{-1}], and
T = daily mean air temperature [^oC].

Dewpoint temperature (T_{dew}) is defined as the temperature at which a parcel of air must be cooled to become saturated with water vapor. The dewpoint temperature can be used to represent the humidity content of the lower air mass, for example the relative humidity (RH) is at 100% when the air temperature is at the dewpoint. Because NWS stations do not record relative humidity, the T_{min} was used indirectly to estimate the humidity of the lower air mass. In an irrigated setting T_{min} will usually approach T_{dew}, especially in the early morning when winds are calm and soil moisture is high. Weather measurements taken from non-irrigated settings typically result in higher daily temperatures and lower humidity than those collected in irrigated areas due to the lack of available water, causing the net radiation to be partitioned into sensible heat instead of latent heat or ET. The use of humidity data collected from non-irrigated settings can cause overestimation of reference ET by as much as 20% - 26% (Brown, 2001; ASCE-EWRI, 2005), therefore corrections are required to bring the calculated T_{dew} closer to that which would be measured under irrigated conditions (Allen, 1996; Allen et al., 1998; ASCE-EWRI, 2005).

T_{dew} is typically calculated from actual vapor pressure of the air (e_a), which can be derived from measured maximum relative humidity (RH_{max}) and minimum relative humidity (RH_{min}) following recommendations by Allen et al., (1998) and ASCE-EWRI (2005). T_{dew} was calculated from e_a based on the Murray (1967) equation as

$$T_{dew} = \frac{116.91 + 237.3\ln(e_a)}{16.78 - \ln(e_a)} \quad \text{Eq. 5}$$

where T_{dew} = the dewpoint temperature (^oC), and
e_a = actual vapor pressure (kPa).

Equation 5 can be rearranged to estimate actual vapor pressure, e_a, from T_{dew} as

$$e_a = e^o(T_{dew}) = 0.6108 \exp\left[\frac{17.27 T_{dew}}{T_{dew} + 237.3}\right] \qquad \text{Eq. 6}$$

where $e^o(T_{dew})$ = saturated vapor pressure at daily dewpoint temperature (kPa), and the saturation vapor pressure function for a specified temperature, $e^o(T)$, is

$$e^o(T) = 0.6108 \exp\left(\frac{17.27 T}{T + 237.3}\right) \qquad \text{Eq. 7}$$

where vapor pressure is in units of kPa and temperature is in ^oC. In this study daily T_{dew} at each NWS weather station was estimated from T_{min}, because of the lack of RH or T_{dew} measurements, as

$$T_{dew} = T_{min} - K_o \qquad \text{Eq. 8}$$

where T_{min} is the daily minimum air temperature (^oC) and K_o is an offset coefficient (^oC) and is synonymous with the dewpoint depression. Typically, it is common in arid and semi-arid regions to have a T_{dew} of 2 to 5 ^oC below T_{min} under well watered conditions (Allen, 1996). K_o can be substantially higher in non-irrigated environments (i.e. non-reference conditions), sometimes reaching 10 ^oC in arid climates. However, the 2 to 5 ^oC range is generally observed in arid and semi-arid climates when the local and subregional environment is irrigated.

Most NWS weather stations are located in non-irrigated or only partially irrigated environments. Because non-reference conditions can cause an increase in air temperature due to the lack of the cooling effect of ET, it is recognized that the higher T_{min} may cause the T_{dew} to be overstated, even for reference conditions. Because the computation of vapor pressure deficit, VPD, in the ET_{ref} equation includes both T_{min} and T_{dew}, as

$$VPD = 0.5\left[e^o(T_{max}) + e^o(T_{min})\right] - e^o(T_{dew}) \qquad \text{Eq. 9}$$

where $e^o(T_{dew})$ = saturation vapor pressure at the dewpoint temperature (kPa), both the air temperature and dewpoint temperatures may be overstated for non-reference conditions (since the T_{dew} estimate is based on T_{min}). However, the upward biases in the $e^o(T)$ functions by all temperature parameters will tend to cancel, thereby producing a VPD that is generally representative of a reference condition (Allen et al., 1998; ASCE-EWRI 2005).

Rather than assign NWS stations temporally constant K_o values, spatially distributed K_o values that varied by month were derived and assigned to NWS stations. There are very few weather stations in Nevada that measure RH in irrigated areas to compute K_o, therefore mean monthly K_o values were computed from weather stations located in irrigated areas both in Nevada and in nearby areas outside Nevada (Figure 2), including the AZMET (Arizona Meteorological Network), CIMIS (California Irrigation Management Information System), AGRIMET, and Utah Agriculture Weather Network, as well as U.S. Geological Survey (USGS) micrometeorological stations located in irrigated areas in Nevada from studies by Maurer et al., (2006) and Allander et al., (2009). Calculated mean monthly K_o values for weather stations analyzed are listed in Appendix 3 and illustrated in Figures 3a-c, where it is apparent that mean monthly K_o values vary depending on the climate of the location. For instance, southern regions have higher monthly K_o values than northern regions. Mean monthly K_o values were assigned to NWS stations by spatial interpolation using inverse distance weighting. Spatially interpolated mean monthly K_o surfaces were averaged to individual HAs, and these mean monthly K_o values per HA were assigned to respective NWS stations. Measured mean monthly K_o values were assigned to NWS stations in HAs where measurements occurred. For illustration purposes the spatial distribution of the mean annual K_o is shown in Figure 4.

As expected, southern locations have a larger mean annual dewpoint depression (i.e. larger K_o value) than northern areas. This spatial trend is partially due to regional scale advection of dry air, and more specifically the climatology that governs regional scale advection such as precipitation and available water, the resultant surface energy balance from valley floor areas, and typical air mass origins or jet stream patterns. Figure 5 illustrates the spatial distribution of HA average PRISM precipitation (Daly et al., 1994), which exhibits a similar spatial distribution as the mean annual dewpoint depression and supports the fact that regional scale advection is largely controlled by available moisture and the resultant energy balance of the surrounding environment.

The degree of local advection and its effect on the ET rate of an irrigated area is dependent on the scale of the irrigated area. Local advection occurs when wind blows across a surface, which is discontinuous in temperature, humidity or roughness (Brakke, 1978), such as wind blowing from a dry area across an irrigated field. Many studies have concluded that ET on the leading edge of an irrigated field is highest due to local advection, and as the distance from the leading edge increases, the influence of local advection on ET decreases until the cooler and moist boundary layer is formed and horizontal uniformity is established (Rider et al., 1963; Dyer and Crawford, 1965; Goltz and Pruitt, 1970). Brakke et al., (1978) attempted to partition local and regional advection effects on ET from an irrigated field of alfalfa surrounded by non irrigated areas, and found that advection effects were greatly reduced within 100m downwind of

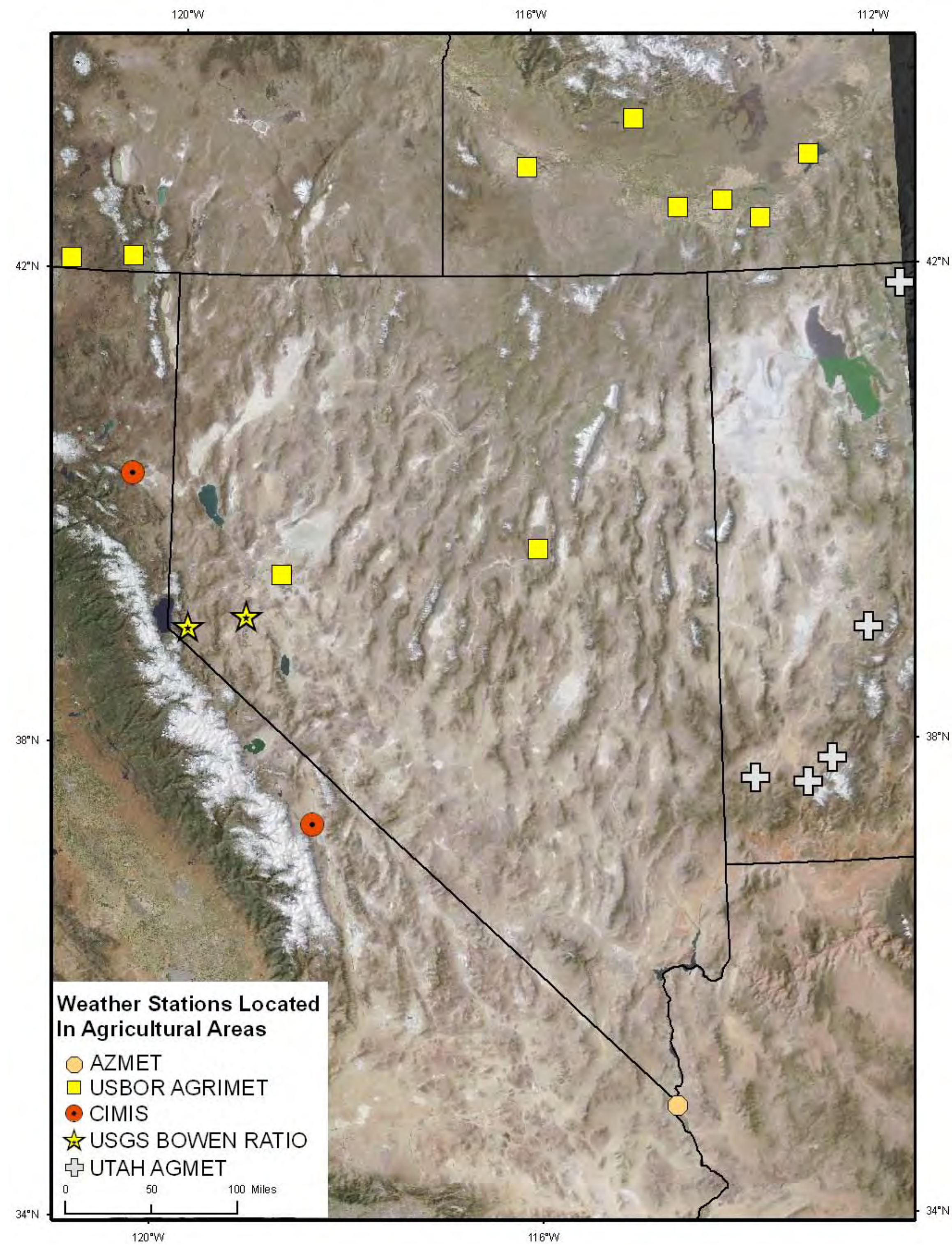


Figure 2. Weather stations located in irrigated areas measuring relative humidity representative of reference conditions. These stations were used for estimating the dewpoint at stations not measuring relative humidity.

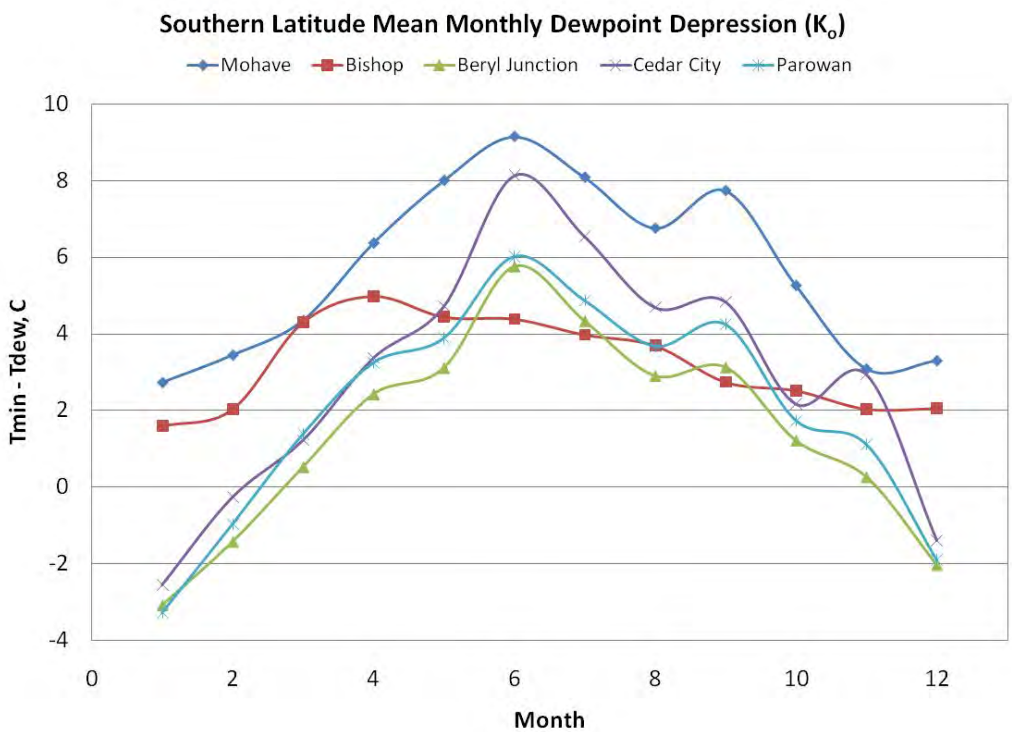


Figure 3a. Measured mean monthly dewpoint depression for southern latitude weather stations in reference (irrigated agriculture) environments.

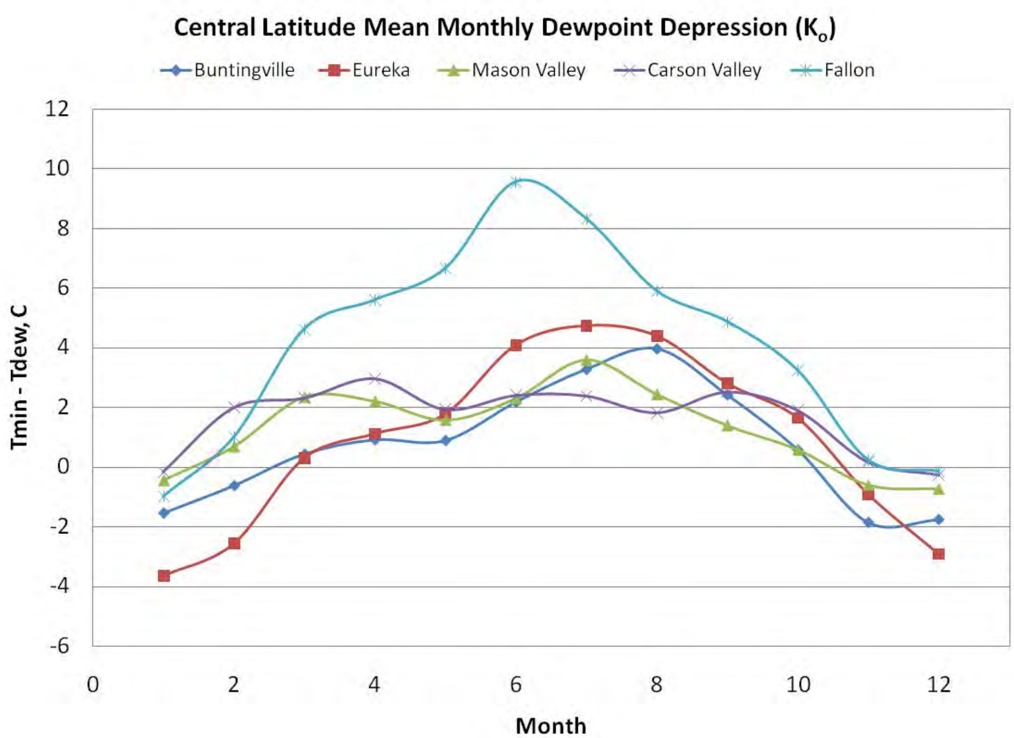


Figure 3b. Measured mean monthly dewpoint depression for central latitude weather stations in reference (irrigated agriculture) environments.

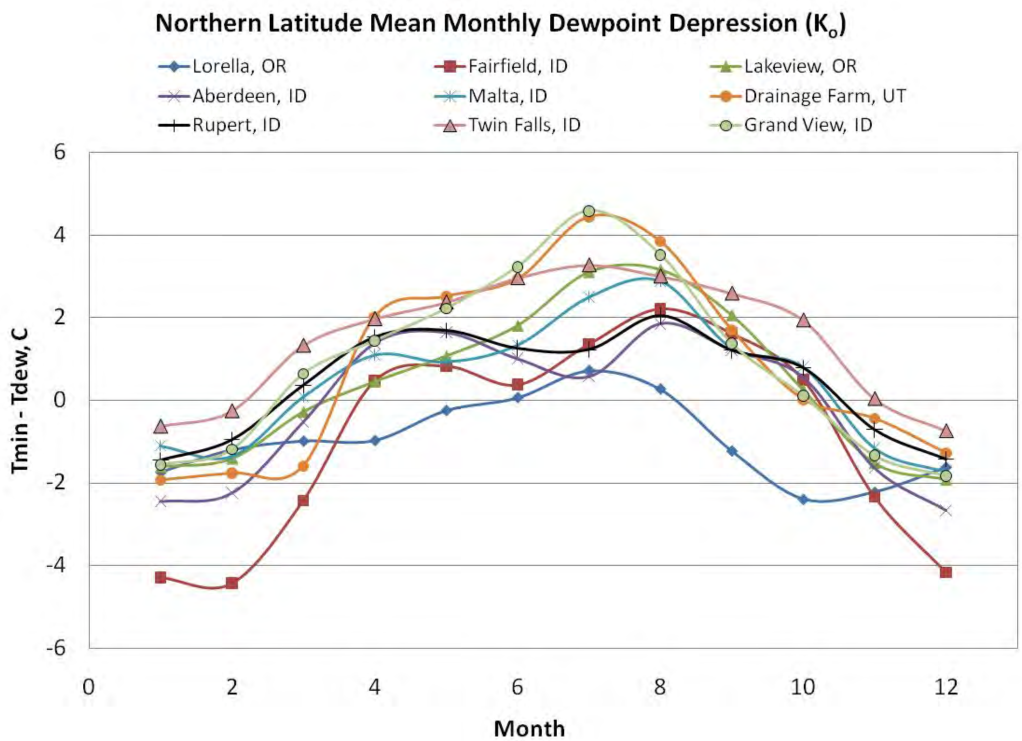


Figure 3c. Measured mean monthly dewpoint depression for northern latitude weather stations in reference (irrigated agriculture) environments.

the field. In this study, the use of weather stations located in predominately irrigated areas for computing regional monthly K_o values tend to minimize local advection effects while preserving regional advection effects that most irrigated areas in Nevada experience due to the arid climate and small scales of irrigation projects. For example, the mean monthly dewpoint depression, $K_{o,}$ for the Fallon AGRIMET site is significantly greater than surrounding stations located in irrigated environments as shown in Figure 3b. To verify this relative 'dryness' of the Fallon AGRIMET station, K_o from a weather station located nearby in a completely dry environment was compared against monthly K_o of the Fallon AGRIMET station. The mean monthly K_o computed at the Fairview Valley DRI weather station, located approximately 30 miles to the east of Fallon and at the same elevation but in a desert environment, indicates that the subregional air mass is much dryer than that found over agricultural areas near Fallon, where the desert K_o peaked at 18^{o}C in the summer compared to 10^{o}C for the Fallon AGRIMET station (Figure 6). This finding suggests that the Fallon AGRIMET site experiences some amount of conditioning of the boundary layer due to the cooling effect of evaporation in the area.

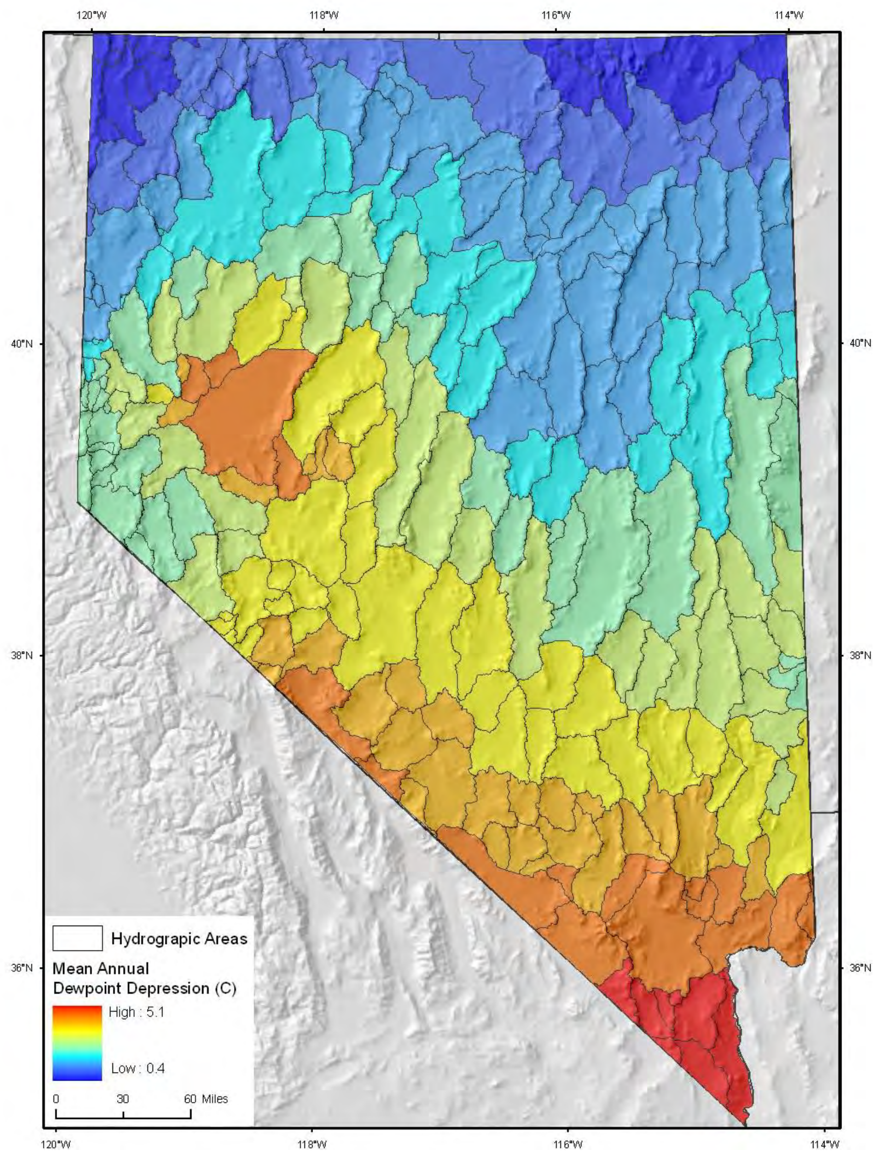


Figure 4. Spatially interpolated mean annual reference condition dewpoint depression.

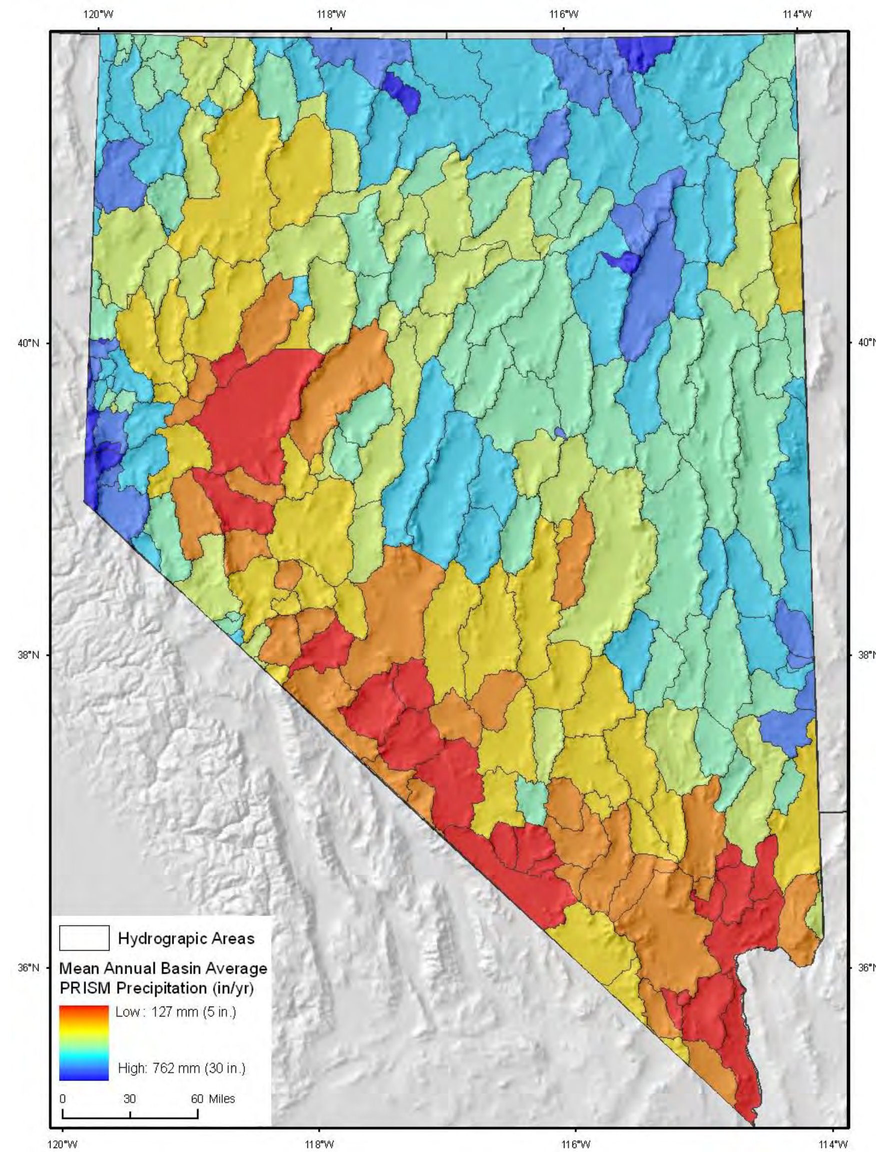


Figure 5. Basin average PRISM precipitation (800m v.2), which illustrates a similar spatial pattern as Figure 4, and supports the fact that regional scale advection is largely controlled by available moisture and the resultant energy balance of the surrounding environment.

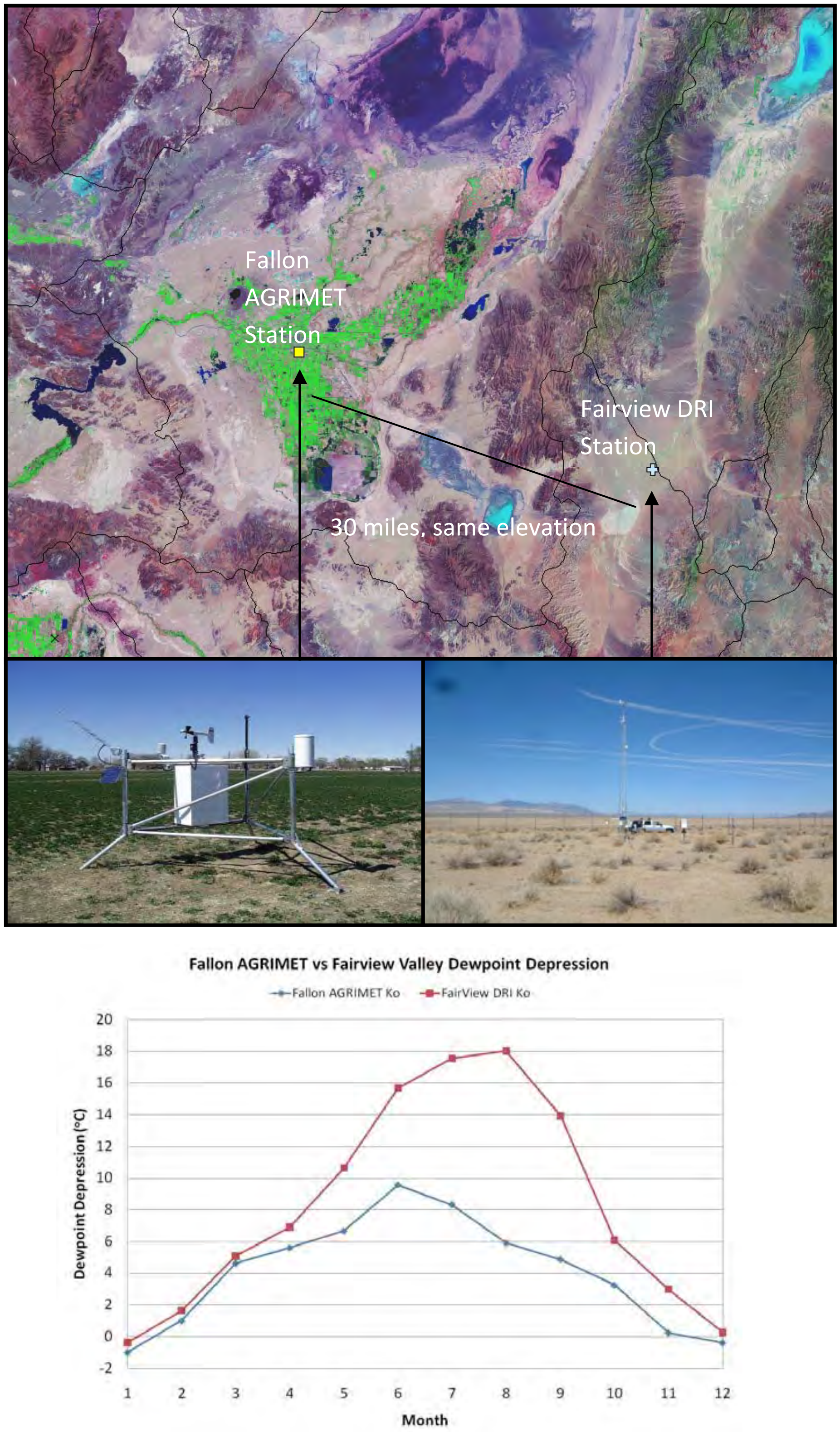


Figure 6. Comparison of dewpoint depression between the Fallon AGRIMET and Fairview Valley DRI stations illustrating how the presence of evaporation of irrigation water impacts the dewpoint depression, K_o.

Net Radiation (R_n)

Net radiation, R_n, is the amount of radiant energy available at a surface that can be used for evaporation of water (latent heat flux), heating of the air (sensible heat flux), or heating of the surface (ground heat flux). R_n includes both long wave and short wave radiation components and defined following Brutsaert (1982) as

$$R_n = R_{ns} - R_{nl} \qquad \text{Eq. 10}$$

where

R_{ns} = net short wave radiation being positive downwards and negative upwards, [MJ m^{-2} d^{-1}], and
R_{nl} = net long wave radiation being positive upwards and negative downwards, [MJ m^{-2} d^{-1}].

Net short wave radiation is the result of the incoming and the reflected solar radiation and was estimated using a fixed albedo or canopy reflection coefficient for the standardized reference evapotranspiration equation as

$$R_{ns} = (1 - \alpha) R_s \qquad \text{Eq. 11}$$

where

α = albedo, and is fixed at 0.23, which represents the albedo of a grass surface [dimensionless],

and

R_s = incoming solar radiation [MJ m^{-2} d^{-1}].

Net Long Wave Radiation (R_{nl})

The methods of Brunt (1932, 1952) are used for the estimation of daily net long wave radiation for the standardized surface, which takes advantage of the actual vapor pressure to predict the net emissivity as

$$R_{nl} = \sigma f_{cd}\left(0.34 - 0.14\sqrt{e_a}\right)\left[\frac{T_{K\max}^4 + T_{K\min}^4}{2}\right] \qquad \text{Eq. 12}$$

where

σ = Stefan-Boltzmann constant [4.901 x 10^{-9} MJ K^{-4} m^{-2} d^{-1}],
f_{cd} = cloudiness function [dimensionless],
e_a = actual vapor pressure [kPa],
T_{Kmax} = daily maximum Kelvin temperature [K], and
T_{Kmin} = daily minimum Kelvin temperature [K].

The superscripts "4" in Eq. 12. indicate the need to raise the air temperature, expressed in Kelvin units, to the power of 4. For daily and monthly timesteps, f_{cd} was calculated following Jensen et al., (1990) and Allen et al., (1998) as

$$f_{cd} = 1.35\frac{R_s}{R_{so}} - 0.35 \qquad \text{Eq. 13}$$

where

R_s/R_{so} = relative solar radiation (limited to 0.3 – 1)
R_s = measured or calculated solar radiation [MJ m^{-2} d^{-1}], and
R_{so} = calculated clear sky radiation [MJ m^{-2} d^{-1}].

The ratio R_s/R_{so} in Eq. 13 represents relative cloudiness and is limited so that f_{cd} has limits of 0.05 – 1.0.

Incoming Solar Radiation (R_s)

Incoming solar radiation (R_s) is the primary variable for net radiation and therefore a primary variable for many ET estimation methods. Because NWS stations do not measure R_s, it was estimated at each NWS station following a method described by Thornton and Running (1999), which is based on the difference between daily maximum and minimum air temperature. The general premise of the method is based from the fact that during cloud cover maximum air temperatures generally decrease and the minimum temperature is increased due to increased downward emission of long wave radiation by clouds at night (Allen, 1997). The Thornton and Running (1999) method estimates R_s as

$$R_s = R_{so}\left[1 - 0.9\exp\left(-B\left(T_{\max} - T_{\min}\right)\right)^{1.5}\right], \qquad \text{Eq. 14}$$

and

$$B = 0.023 + 0.1\exp\left(-0.2\Delta Tmonth\right), \qquad \text{Eq. 15}$$

where R_{so} is the theoretical solar radiation on a clear day (MJ m^{-2} d^{-1}), T_{max} is the daily maximum air temperature (^oC), T_{min} is the daily minimum air temperature (^oC), and B is an empirical fitting coefficient which has a slightly modified form compared to Thornton and Running's original B function, where Allen and Robison (2007) derived coefficients in Eq. 15 using only western stations of Portland and Salt Lake City from the Thornton and Running paper. The generalized equation of Thornton and Running for B was based on weather stations throughout the US. R_{so} is computed using the exoatmospheric radiation, R_a, which is a function of latitude, day of year, and atmospheric transmissivity K_T. R_{so} is computed as

$$R_{so} = K_T R_a. \qquad \text{Eq. 16}$$

For daily time steps R_a was calculated following Duffie and Beckman (1980) as

$$R_a = \frac{24}{\pi} G_{sc} d_r [\omega_s \sin(\varphi)\sin(\delta) + \cos(\varphi)\cos(\delta)\sin(\omega_s)] \qquad \text{Eq. 17}$$

where:

G_{sc} = solar constant [4.92 MJ m^{-2} h^{-1}],
d_r = squared inverse relative distance factor for the earth-sun [unitless]
ω_s = sunset hour angle [radians]
φ = latitude [radians], and
δ = solar declination [radians].

The squared inverse relative distance factor was calculated as

$$d_r = 1 + 0.033\cos\left(\frac{2\pi}{365} J\right) \qquad \text{Eq. 18}$$

where

J is the day in the year from 1 to 365 (366 for leap years), and the sunset hour angle was calculated as

$$\omega_s = \arccos[-\tan(\varphi)\tan(\delta)]. \qquad \text{Eq. 19}$$

ASCE-EWRI (2005) provides an accurate method for estimating atmospheric transmissivity, K_T, needed for Eq. 16 that considers sun angle and the effects of water vapor as it relates to the absorption of short wave radiation as well as scattering of beam and diffuse radiation. ASCE-EWRI (2005) separates K_T into scattering and absorption components such that:

$$K_T = K_B + K_D \qquad \text{Eq. 20}$$

where K_B is a index of atmospheric clearness for direct beam radiation [unitless] and K_D is a index of transmissivity for diffuse radiation [unitless]. The ASCE-EWRI (2005) equation for K_B is:

$$K_B = 0.98\exp\left[\frac{-0.00146P}{K_{tb}\sin\beta} - 0.075\left(\frac{W}{\sin\beta}\right)^{0.4}\right] \qquad \text{Eq. 21}$$

where K_{tb} is a atmospheric clearness coefficient and ranges between 0 and 1, and $K_{tb} = 1$ for clean air and $K_{tb} < 0.5$ for turbid, dusty, or polluted air. P is the atmospheric pressure at the station elevation [kPa], β is the angle of the sun above the horizon [radians], and W is the precipitable water in the atmosphere [mm]. A value of $K_{tb} = 1$ was used in Eq. 21 for this study, which represents clean, low aerosol air and is generally appropriate for Nevada due to the lack of consistent turbid conditions and significant development causing haze. Precipitable water in the atmosphere, W, was estimated as:

$$W = 0.14e_a P + 2.1 \qquad \text{Eq. 22}$$

where e_a is the actual vapor pressure of the air [kPa] and P is the atmospheric pressure at the station elevation [kPa].

The diffuse radiation index needed for Eq. 20 was estimated following Allen (1996) and ASCE-EWRI (2005) as:

$$K_D = 0.35 - 0.36K_B \quad \text{for} \quad K_B \geq 0.15 \qquad \text{Eq. 23}$$

$$K_D = 0.18 + 0.82 K_B \quad \text{for} \quad K_B < 0.15 .$$

For daily time steps the average value of the angle of the sun above the horizon, β, was weighted according to R_a and was approximated by regression following Allen (1996) as:

$$\sin \beta_{24} = \sin\left[0.85 + 0.3\varphi \sin\left(\frac{2\pi}{365} J - 1.39\right) - 0.42\varphi^2\right] \qquad \text{Eq. 24}$$

where β_{24} is the average β during the daylight period, weighted according to R_a [radians].

The Thornton-Running equation has been found to produce more accurate estimates of R_s on a daily and monthly basis than the commonly used Hargreaves-Samani equation (Hargreaves and Samani, 1982) when compared to measurements of R_s, where the Hargreaves-Samani was found to consistently over estimate measured R_s by about 7% (Allen and Robison, 2007). One other advantage of the Thornton-Running equation is that it is self-limiting to the maximum value of R_s, being the clear sky solar radiation, R_{so}. For more information on the computation of R_{so} and its accuracy, see Allen (1996) and ASCE-EWRI (2005).

<u>Estimated vs. Measured Incoming Solar Radiation</u>

To evaluate the accuracy of R_s estimates using the Thornton-Running equation, a comparison was made between measured R_s at 14 weather stations and estimated R_s at nearby NWS weather stations. Weather stations that measure R_s in Nevada are part of several weather station networks including the US Bureau of Reclamation (USBR) AGRIMET, joint agency Community Environmental Monitoring Program (CEMP), Remote Automated Weather Stations (RAWS), and Desert Research Institute (DRI) networks. All weather stations within these networks measure R_s, air temperature, RH, wind speed and direction, and precipitation. Figure 7 illustrates the location of R_s measurement stations and respective NWS stations used for the comparison of measured and estimated R_s discussed below. While there are considerably more stations in Nevada that measure R_s that are part of the CEMP, RAWS, and DRI networks, a QAQC assessment of measured R_s from these stations following recommendations of Allen (1996) and ASCE-EWRI (2005) revealed that the majority of stations were inadequate for comparison to estimated R_s due to pyranometer malfunction or miscalibration.

Because R_{so} is the theoretical limit of measured R_s, it can easily be used as a check to ensure quality R_s measurements. An example comparing R_{so} to measured R_s is illustrated in Figure 8 for the Baker Flat RAWS station where it is obvious that the measured R_s exceeded the theoretical limit for the majority of the time series due to pyranometer drift or miscalibration, but compared very well with the R_{so} curve during some years. Figures 9 illustrates the comparison of R_{so} vs. measured R_s at the Fallon

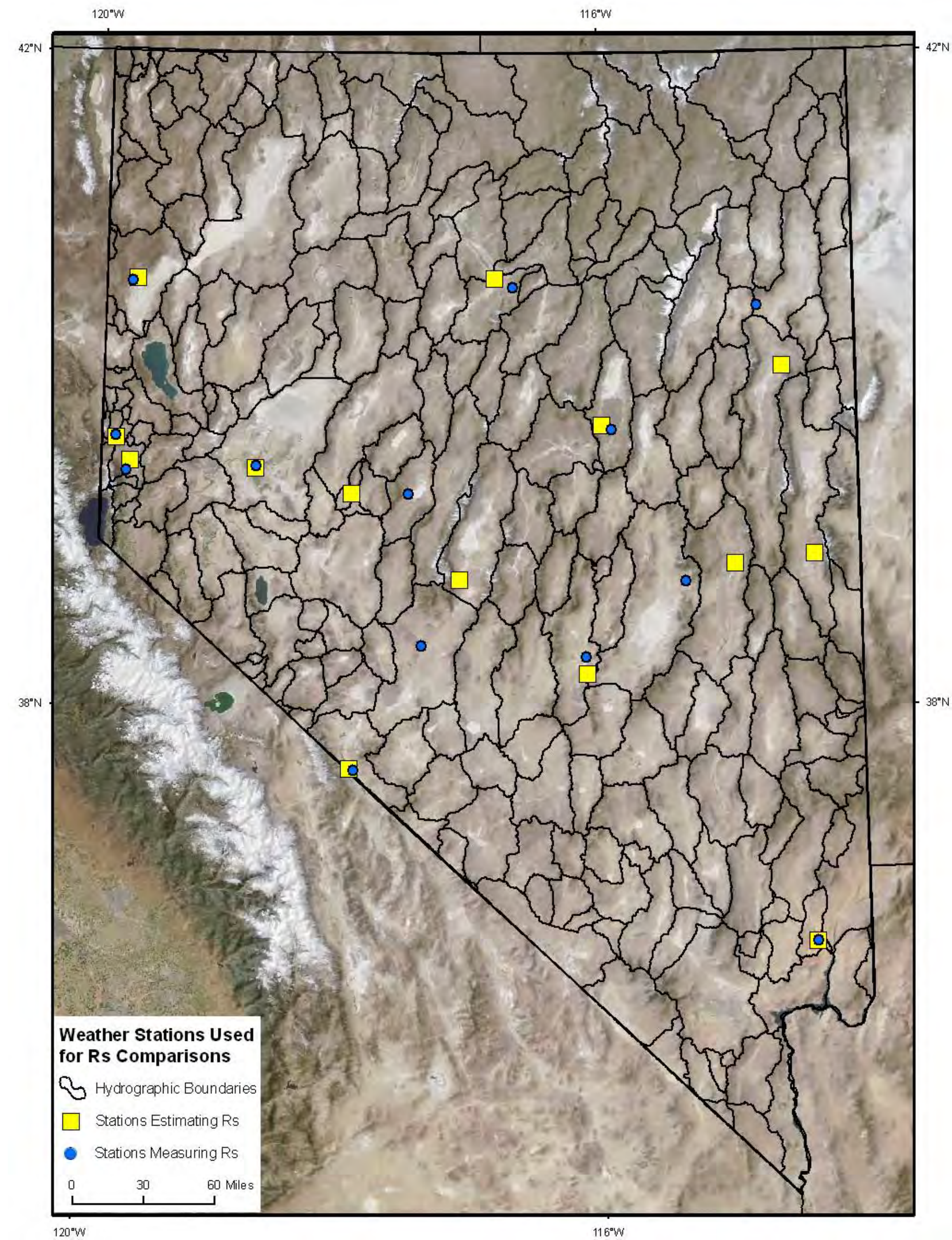


Figure 7. Location of weather stations used for comparing measured to estimated daily solar radiation, R_s.

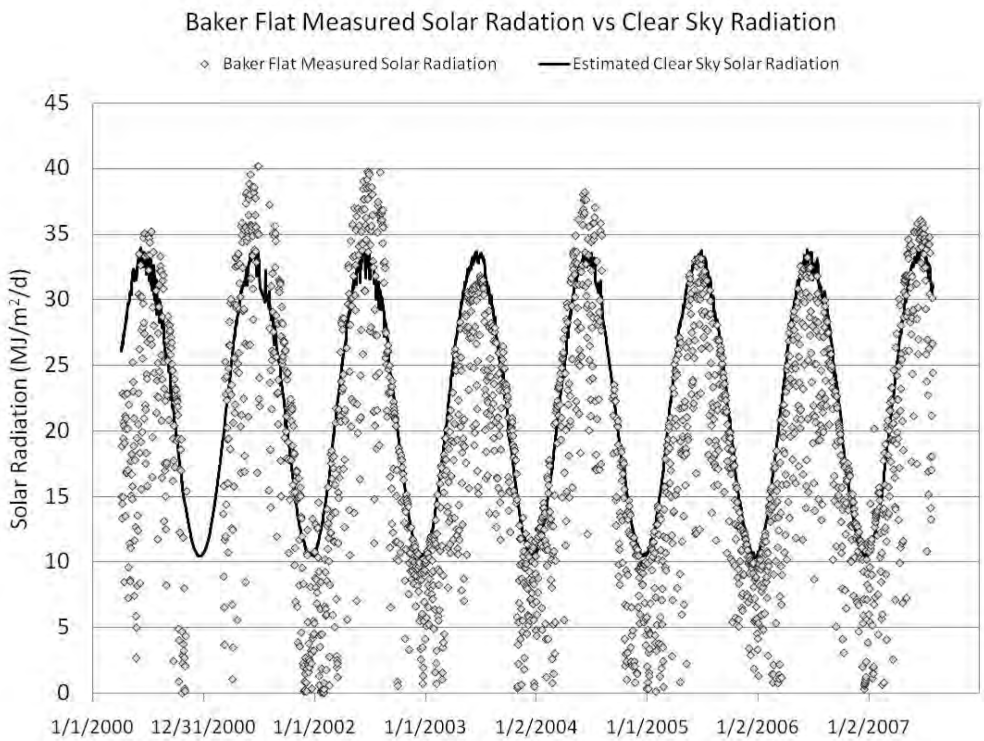


Figure 8. Baker Flat RAWS measured R_s and theoretical clear sky radiation, R_{so}, showing miscalibration of the pyranometer during years 2000, 2001, 2002, 2003, 2004, and 2007.

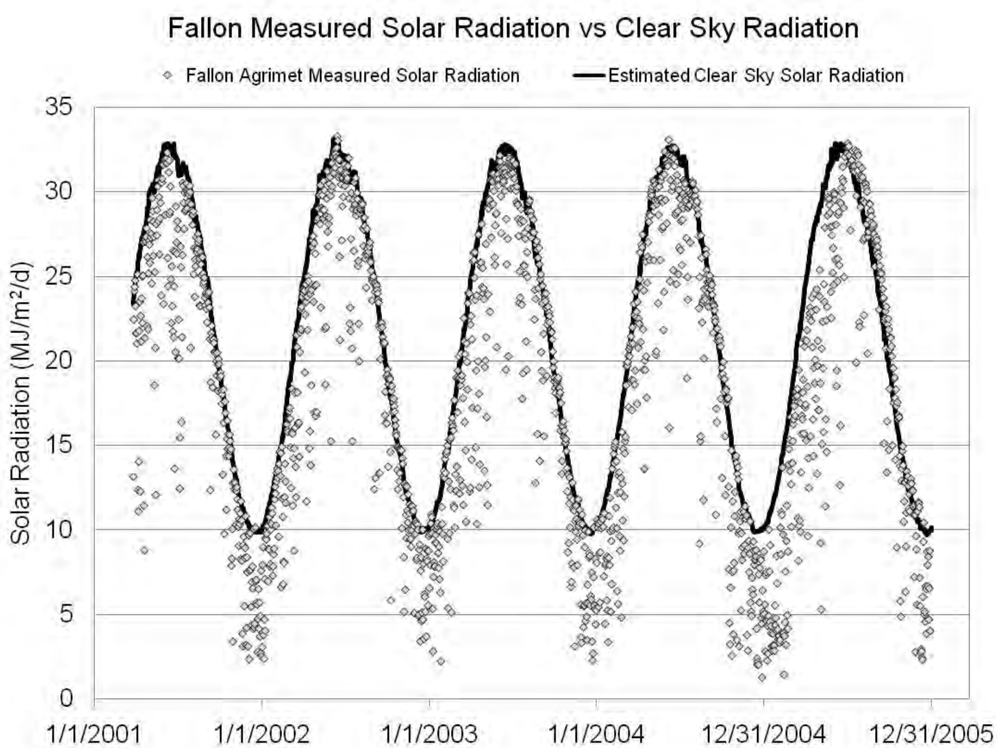


Figure 9. Fallon AGRIMET measured R_s and theoretical clear sky radiation, R_{so}, showing results from a well calibrated pyranometer, with the exception of 2005.

AGRIMET station. AGRIMET sites generally collect high quality R_s data and employ annual sensor calibration, which Figure 7 illustrates; however, it appears that the pyranometer drifted out of calibration or contains a time stamp error in 2005, therefore R_s measurements for 2005 were omitted from the larger comparison. Periods of record for the comparison were determined from the length of quality of R_s measurement and the respective period of record of the NWS station data.

When comparing daily time series of measured vs. estimated R_s, using Fallon as an example, it is evident that there are some discrepancies (Figure 10); however, this is expected since the estimates of R_s are based on only daily T_{max} and T_{min}. On a mean monthly basis, the estimated R_s compares well with the measured mean monthly R_s at most sites. Figure 11 illustrates the mean monthly comparison between measured R_s and estimated R_s for the Fallon AGRIMET station. Table 1 lists the R_s measurement stations and respective NWS stations used for the comparison, as well as the HAs where the stations are located, measurement station network, period of record used for the comparison, ratio of estimated to measured R_s, and root mean squared error (RMSE) of the daily estimated $R_{s.}$ The RMSE is computed as

$$RMSE = \sqrt{\frac{\sum \left(X_{est} - X_{meas}\right)^2}{n}} \qquad \text{Eq. 25}$$

where X_{est} is the estimated R_s and X_{meas} is the measured R_s, and n is the number of observations. The average ratio of estimated to measured R_s for all 14 stations was 1.02 with a standard deviation of 0.05, while the average RMSE for daily estimated R_s was 3.75 MJ/m^2/d. In general the Thornton-Running equation provides good estimates of R_s over the ranges measured and during all months of the year. The Thornton-Running equation was applied in similar applications for Idaho by Allen and Robison (2007).

Wind Speed

Wind speed (U) is not measured at NWS stations except at airport stations; therefore, mean monthly wind speed (Appendix 4) was derived from available data from NWS airport stations and weather stations operated by the Nevada Department of Transportation (NDOT), AGRIMET, CEMP, RAWS, and DRI networks located on valley floor areas with sufficient period of record, totaling 58 stations. These wind speed means were used to assign the mean monthly wind speed at each NWS station as

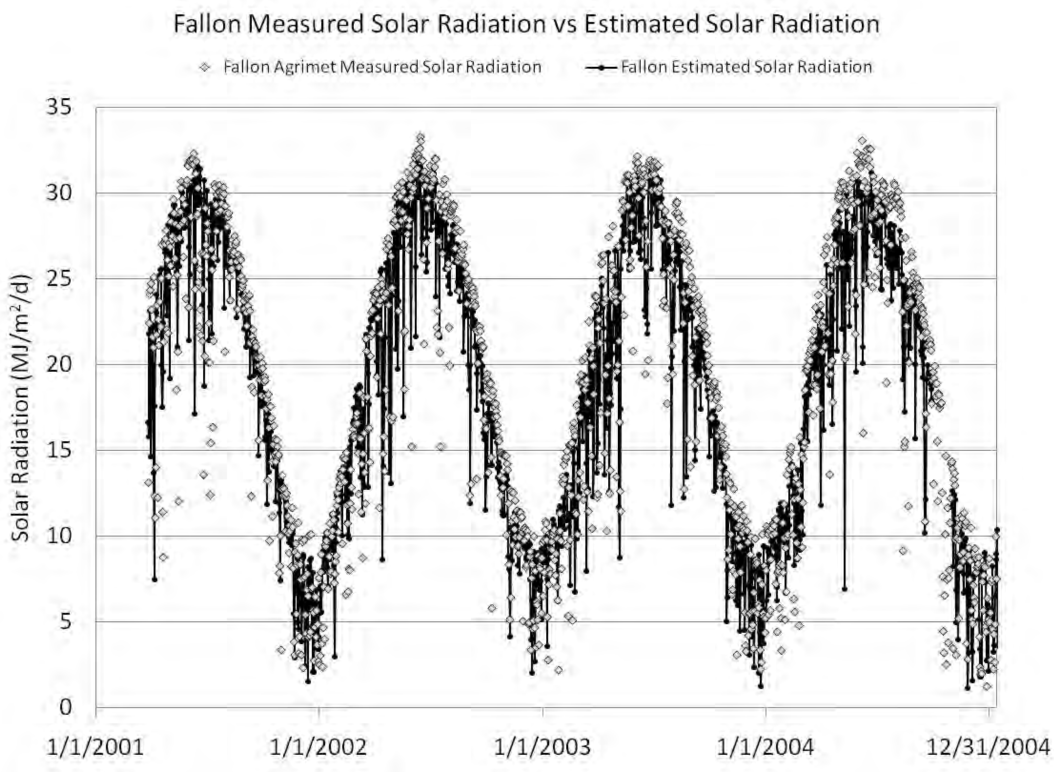


Figure 10. Fallon AGRIMET daily measured and estimated R_s.

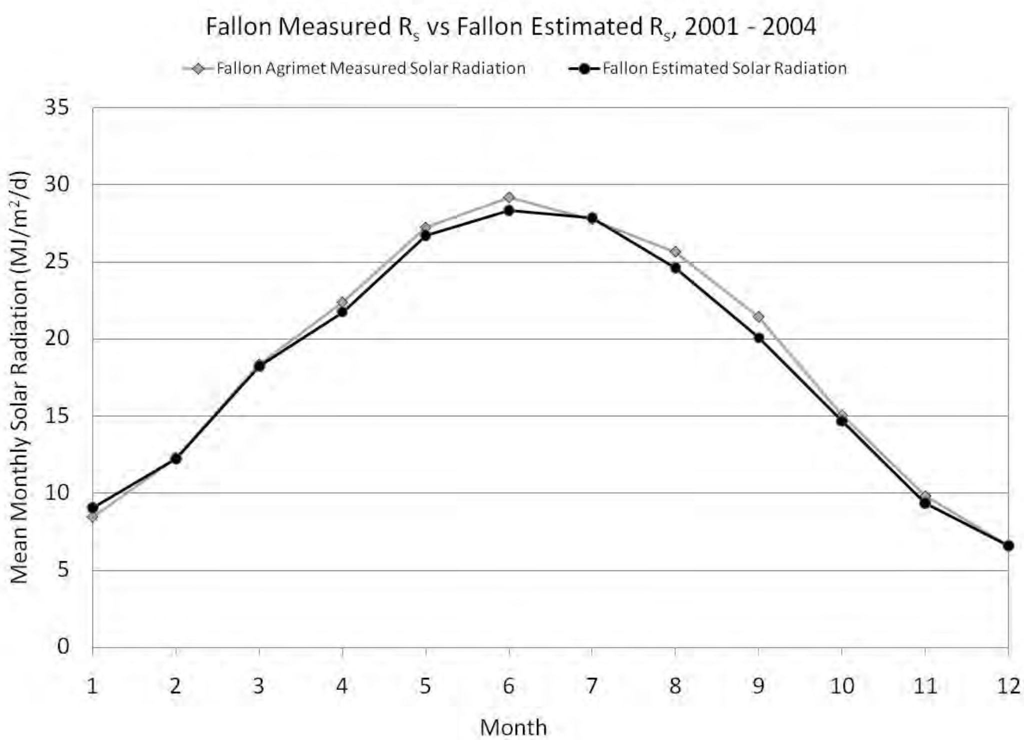


Figure 11. Fallon AGRIMET mean monthly measured and estimated R_s.

Table 1. Estimated solar radiation at NWS stations vs. measured solar radiation at weather stations nearby NWS stations.

Name of NWS Station for Rs Estimation	NWS Station Latitude	NWS Station Longitude	Basin of NWS Station Location	Name of R_s Measurement Station	R_s Station Latitude	R_s Station Longitude	Basin of R_s Station Location	Type of R_s Measurement Station	Period of Record for Comparison	Ratio of Estimated R_s to Measured R_s	RMSE for Daily Estimated R_s, MJ $m^{-2}d^{-1}$
Battle MTN AP	40.62	-116.90	Lower Reese River Valley	Beacon Light	40.56	-116.76	Lower Reese River Valley	RAWS	1/98 - 5/04	1.08	3.62
Smokey Valley	38.78	-117.17	Big Smokey Valley	Lower Big Smokey Valley	38.37	-117.47	Big Smokey Valley	DRI	12/03 - 6/07	1.01	3.77
Diamond Valley USDA	39.72	-116.05	Diamond Valley	Eureka AGRIMET	39.69	-115.98	Diamond Valley	AGRIMET	8/01 - 6/06	1.09	3.51
Dyer	37.62	-118.02	Fish Lake Valley	Dyer Wallace Farms	37.61	-117.99	Fish Lake Valley	DRI	4/03 - 7/06	1.01	3.65
Fallon EXP STN	39.45	-118.78	Carson Desert	Fallon AGRIMET	39.46	-118.78	Carson Desert	AGRIMET	3/01 - 12/04	1.01	3.00
Lages	40.07	-114.62	Steptoe Valley	Spruce Mountain	40.44	-114.81	Goshute Valley	RAWS	8/98 - 5/04	1.05	3.91
Lund	38.87	-115.02	White River Valley	Currant Creek	38.76	-115.41	Railroad Valley - Northern Part	RAWS	1/99 - 12/04	1.00	3.53
Middlegate - Lowery	39.30	-118.02	Cowkick Valley	Desatoya Mountain	39.30	-117.58	Smith Creek Valley	RAWS	1/99 - 5/05	1.09	3.77
Overton	36.55	-114.45	Lower Moapa Valley	Overton	36.55	-114.45	Lower Moapa Valley	CEMP	1/04 - 5/07	1.03	3.21
Reno INT AP	39.48	-119.77	Truckee Meadows	Reno Wolf Run Golf Course	39.42	-119.80	Truckee Meadows	DRI	4/00 - 3/06	0.99	3.67
Shoshone 5N	38.92	-114.40	Spring Valley	Currant Creek	38.76	-115.41	Railroad Valley - Northern Part	RAWS	1/99 - 12/04	1.00	4.04
Smoke Creek Espil	40.60	-119.75	Smoke Creek Valley	Buffalo Creek	40.58	-119.79	Smoke Creek Valley	RAWS	9/98 - 12/04	0.90	3.33
Stead	39.62	-119.88	Lemmon Valley	Stead Golf Course	39.63	-119.89	Lemmon Valley	DRI	7/01 - 9/04	0.99	5.55
Twin Springs Fallini	38.20	-116.18	Hot Creek	Pancake	38.30	-116.19	Hot Creek	RAWS	1/98 - 4/04	1.02	3.88
									Average of Ratios and RMSE	**1.02**	**3.75**
									Std. Dev. of Ratios and RMSE	**0.05**	**0.59**

$$U_2 = U_{2\,meanmonthly_i} \qquad \text{Eq. 26}$$

where U_2 is the estimated daily 2 meter height wind speed for each NWS station, and $U_{2meanmonthlyi}$ is the measured mean monthly 2 meter height equivalent wind speed or HA spatially averaged 2 meter wind speed assigned from a measurement site. Adjustment to the measured wind speed was required to estimate the wind speed at the standardized 2 meter height using a typical logarithmic wind profile relationship

$$U_2 = \frac{\ln\left(\frac{2-d}{z_{om}}\right)}{\ln\left(\frac{z_w - d}{z_{om}}\right)} \qquad \text{Eq. 27}$$

where

U_2 = wind speed at 2m above ground surface [m s^{-1}],
u_z = measured wind speed at z_w m above ground surface [m s^{-1}],
z_w = height of measurement above ground surface [m],
d = zero plane displacement height for the weather site vegetation [m], and
z_{om} = aerodynamic roughness length for the weather site vegetation [m].

The wind speed measurement heights for weather stations used vary from 2-10 meters, and have vegetation surface heights that range from bare ground to small brush found in xerophyte communities. Given the range of vegetation height associated with wind speed measurements it was assumed that the standardized zero plane displacement height of d=0.67m, and standardized aerodynamic roughness length of z_{om} = 0.123h, representing a tall grass of 0.12m be employed. Station locations and measured wind speed time series from all selected stations were visually inspected during QAQC, in which many stations were rejected due to excessive anemometer height, fetch obstructions by buildings and or trees as determined from photos, or bad quality data due to anemometer calibration or lack of maintenance causing systematic error. For example, Figure 12 illustrates a decreasing trend in measured wind speed at the Caliente CEMP station. From observation of the Caliente station photo, the long-term decrease is likely caused by a growing tree next to the station. Analyses of measured wind speed time series generally reveal strong seasonal variations, with increased wind speeds in early spring and summer and decreased wind speeds in early fall and winter. Figure 13 illustrates 2m height equivalent mean monthly wind speed for selected stations located across the state. Of the 58 stations analyzed, the Lower Big Smokey Valley DRI station had the highest 2m equivalent mean annual wind speed of 3.6 m/s.

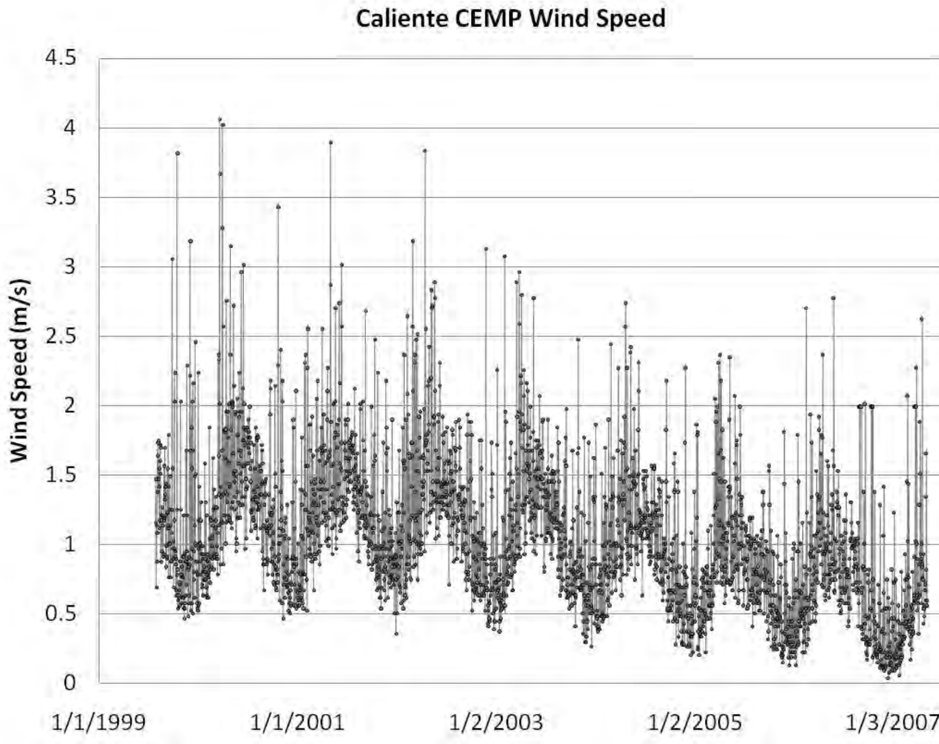


Figure 12. Daily measured wind speed at the Caliente CEMP weather station. The downward trend over time illustrates that the anemometer is likely being influenced by a nearby growing tree and/or failing bearing.

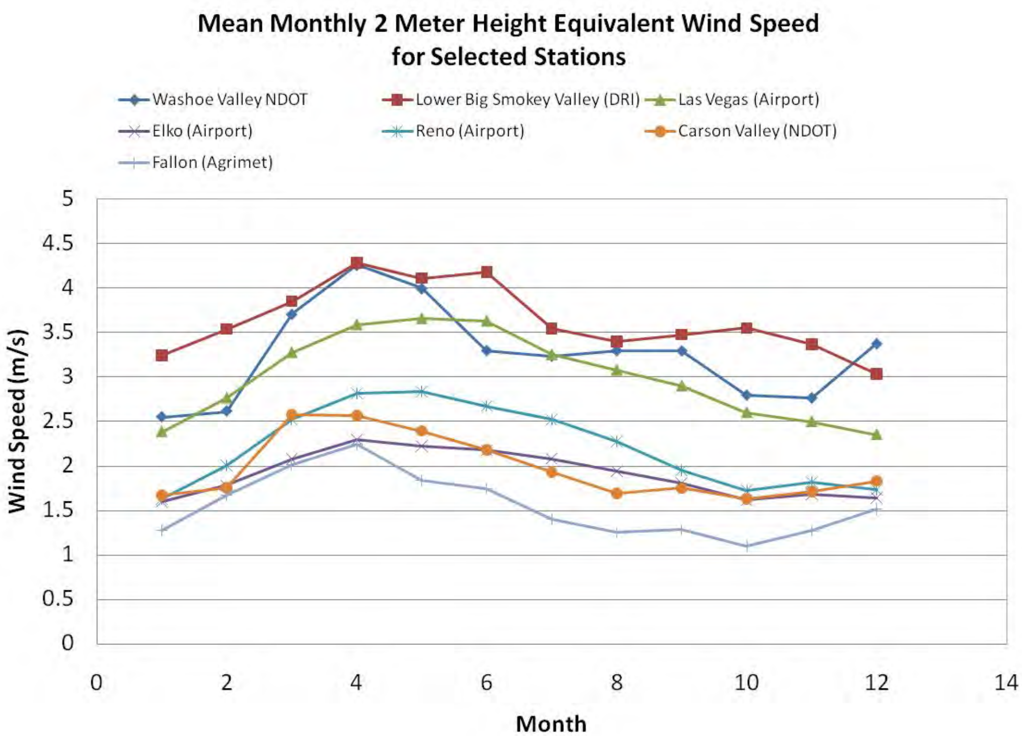


Figure 13. Mean monthly 2 meter height equivalent wind speed for selected stations across the state illustrating seasonal trends and magnitudes of wind speed.

Similar to the assigning of K_o values to NWS stations with no measurements within a HA, spatially interpolated mean monthly wind speed surfaces were generated using inverse distance weighting and were spatially averaged to HAs, where NWS stations were assigned respective spatially averaged mean monthly wind speed values for computation of ET_{os}. Figure 14 illustrates the weather stations used for spatially interpolating mean monthly wind speed as well as the spatial distribution of mean annual wind speed spatially averaged to HAs. In general, the spatial distribution of mean annual wind speed is spatially consistent with wind power maps produced by the Nevada State Office of Energy (NSOE) and U.S. Department of Energy, National Renewable Energy Laboratory (NREL) (data available at http://www.nrel.gov/).

Crop Evapotranspiration

Crop Coefficient Approach

The application of K_c values to ET_{os} simulates cutting periods, initial and late crop stages where the crop is not at full cover or peak height, roughness of the crop surface to account for turbulent effects, and crop geometry. Simply put, the effects of weather variables are incorporated into ET_{os}, whereas the effects that distinguish vegetated, bare, or open water surface from the reference surface are integrated into the crop coefficient. As such, the K_c is defined as the ratio of ET_{act} to the calculated ET_{os}, such that the crop evapotranspiration, ET_{act}, which includes evaporation from the soil surface following wetting by precipitation or irrigation is defined as

$$ET_{act} = K_c ET_{os} \qquad \text{Eq. 28}$$

where

ET_{os} = the standardized reference ET
K_c = crop coefficient respective of the ET_{os}.

Several crop ET studies conducted in Nevada have applied the 'mean' K_c approach (Rashedi, 1983; Guitjens and Goodrich, 1994; Pennington, 1980; Moreo et al., 2003; Welch et al., 2007; Moreo and Justet, 2008), where all time-averaged effects of evaporation from the soil surface from precipitation and irrigations are averaged into the K_c value. The mean K_c therefore represents the average evaporation fluxes expected from the soil and plant surface under some average wetting interval, either by precipitation or irrigation. A more detailed K_c approach is the 'dual' K_c method, where the K_c value is separated into a 'basal' crop coefficient, K_{cb}, and a soil evaporation coefficient, K_e. The basal crop coefficient is defined as the ratio of ET_{act} to ET_{os} when the soil surface is dry and transpiration is solely derived from the root zone soil moisture present to support the full potential transpiration. The soil evaporation component is calculated

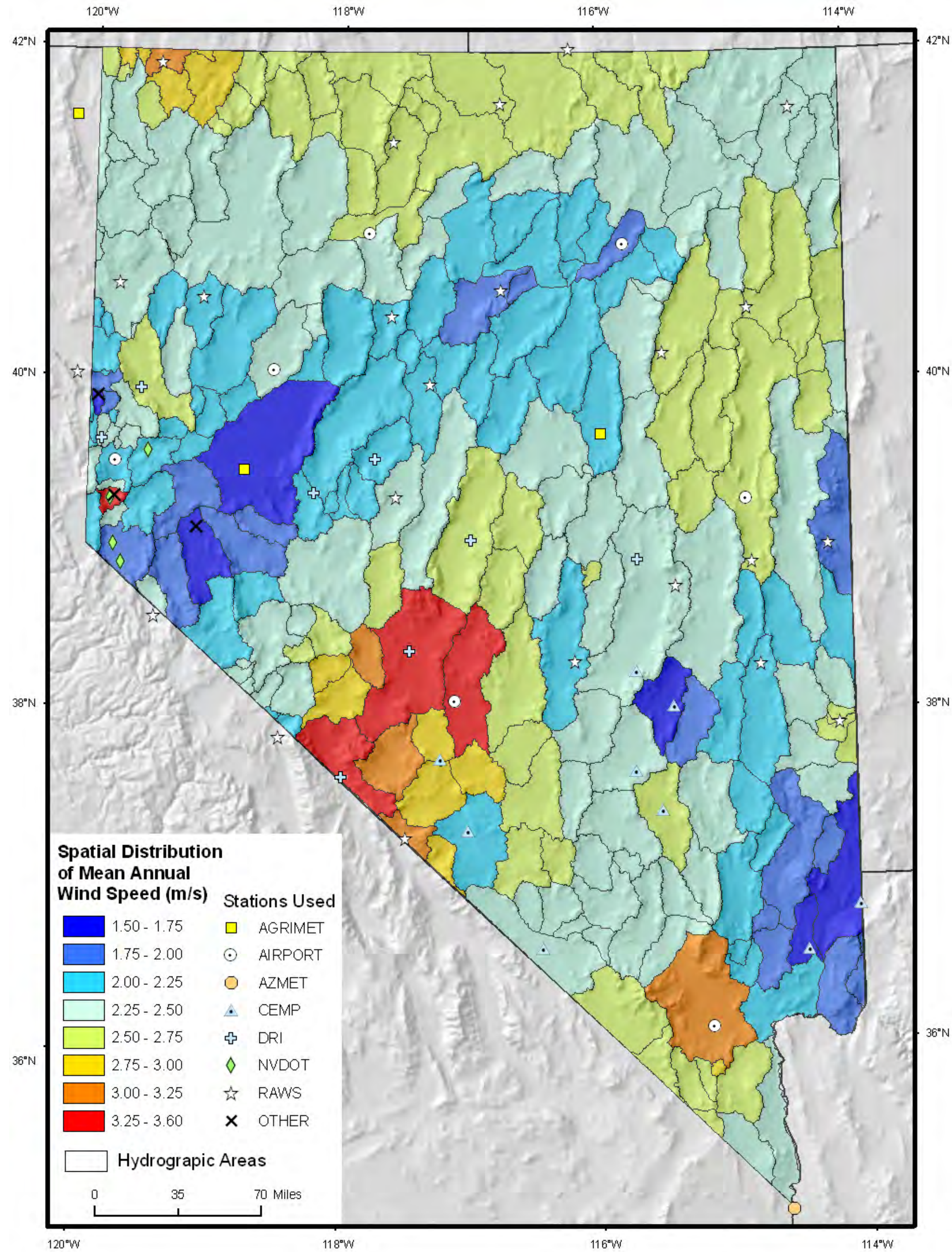


Figure 14. Spatially distributed mean monthly wind speed derived from multiple weather station networks located on valley floor areas. For basins where wind speed measurements exist, basins were assigned 2m height equivalent estimated wind speed, or the average 2m height equivalent estimated wind speed where multiple measurements exist. Basins with no wind speed measurements were estimated using inverse distance weighting.

separately according to precipitation and simulated irrigation events and is then added to the K_{cb} to produce the total K_c. The equation for the potential ET, ET_{pot}, in the dual K_c approach is

$$ET_{pot} = (K_{cb} + K_e)ET_{os} \quad \text{Eq. 29}$$

where K_{cb} is the basal crop coefficient and K_e is the soil water evaporation coefficient. K_{cb} and K_e range from 0 to 1.4 when used with ET_{os} and are dimensionless. ET_{act} may be less than the ET_{pot} when the soil water content is less than that needed to sustain full rates of transpiration. In this situation the ET_{act} is calculated by incorporating a stress coefficient

$$ET_{act} = (K_s K_{cb} + K_e)ET_{os} \quad \text{Eq. 30}$$

where K_s is a dimensionless coefficient ranging from 0 to 1 for when there is stress caused by low soil moisture not adequate to sustain full potential plant transpiration. K_s is equal to 1 when there is no water stress, as is the case for irrigated crops during the irrigation season opposed to rain fed crops or native vegetation.

A daily root zone water balance is required to calculate K_s, which incorporates the available soil moisture for the simulated effective root zone. An additional soil water balance is maintained for the estimation of K_e, and is limited to the upper 0.1m of the soil since this zone is assumed to be the only layer that supplies water for direct evaporation from the soil surface.

The daily water balance procedures and the calculation of K_s and K_e follow methods established in FAO-56 (Allen et al., 1998) and further refined in Allen et al., (2005). Included as an annex to this report (Annex 1) is the Allen et al., (2005) ASCE publication describing in detail the dual crop coefficient approach and daily soil water balance procedures used in this study. Departures from the FAO-56 and Allen et al., 2005) procedures implemented in this study are not in the soil water balance, but in the K_{cb} curves, which are curvilinear, similar to those published by Wright (1982), rather than the linear curves used in FAO-56 and Allen et al., (2005). This same modification was used by Allen and Robison (2007) for applications in Idaho and provides more flexibility in representing the changes in K_{cb} over the course of the growing season using a growing degree approach rather than using specified dates that define linear segments of the K_{cb} curves.

Soil Characteristics and Water Holding Properties

Infiltration characteristics and water holding properties needed for calculations of the soil and root zone water balance were estimated using spatial soils information. Spatial soil information was obtained from STATSGO (State Soil Geographic Database), a digital soils map developed by the USDA Natural Resource Conservation Service (NRCS). The STATSGO database depicts soil units at a regional scale (Figure 15) and contains attributes pertaining to the physical character of soils such as the available water holding capacity (AWC), layer thickness, soil texture, and permeability for use with the USDA-NRCS curve number method for estimating runoff. The primary variable used in the soil and root zone water balance is the AWC, which affects the estimation of irrigation scheduling, evaporation losses from soil, and deep percolation from root zones. Soil attributes of AWC and permeability for each polygon were depth weighted according to the reported layer thickness. Hydrologic soil groupings for use in the curve number method were assigned to soil polygons according to Allen and Robison (2007), where permeability ranges of greater than 4, 1-4, and less than 1 inch per hour were assigned hydrologic groupings of A, B, and C, respectively. Soil attributes were then assigned to weather stations based on weather station location. Rather than taking a spatial average of soil attributes associated with some boundary, such as a valley floor boundary, and assigning spatially averaged soil attributes to respective weather stations that are located within the boundary, a simple identity operation was performed. The identity operation simply assigns soil attributes to weather stations that fall within respective soil polygons. As illustrated in Figure 16, most irrigated areas are generally within contiguous soil units, making the assignment of soil attributes to respective weather stations generally representative of irrigated areas.

The daily soil water balance model includes the simulation of evaporation from the upper 0.10m of the surface layer of the soil, and is parameterized by the readily evaporable water (REW) and total evaporable water (TEW). The REW represents the cumulative depth of soil evaporation during the period when evaporation is energy limited (known as stage 1), and TEW is the maximum cumulative depth of soil evaporation that occurs from an initially wet soil at the AWC (total evaporation during stage 1 and stage 2). For further details on REW and TEW, see FAO-56 (Allen et al., 1996) or Annex 1. REW and TEW were estimated from regression equations of Allen and Robison (2007) as

$$REW = 0.8 + 54.4\frac{AWC}{1000} \qquad \text{Eq. 31}$$

and

$$TEW = -3.7 + 166\frac{AWC}{1000} \qquad \text{Eq. 32}$$

where AWC is in mm/m, the independent variables REW and TEW are in mm, and the dependent variable of depth weighted AWC was estimated from the STATSGO soils database. These regression equations were developed based on values of REW and TEW vs. AWC presented in Table 1 of Allen et al., (2005) shown in Annex 1, and have R^2 values of 0.88 and 0.85 respectively. The estimate for REW is limited to less than or equal to 0.8 TEW during the growing season and 0.7 TEW during winter periods having low ET. The primary parameters associated with the root zone soil water balance include the total available water in the root zone (TAW) and the readily available water in the root zone (RAW).

Figure 15. State Soil Geographic Database (STATSGO) used for estimating soil properties at weather stations for soil water balance simulations.

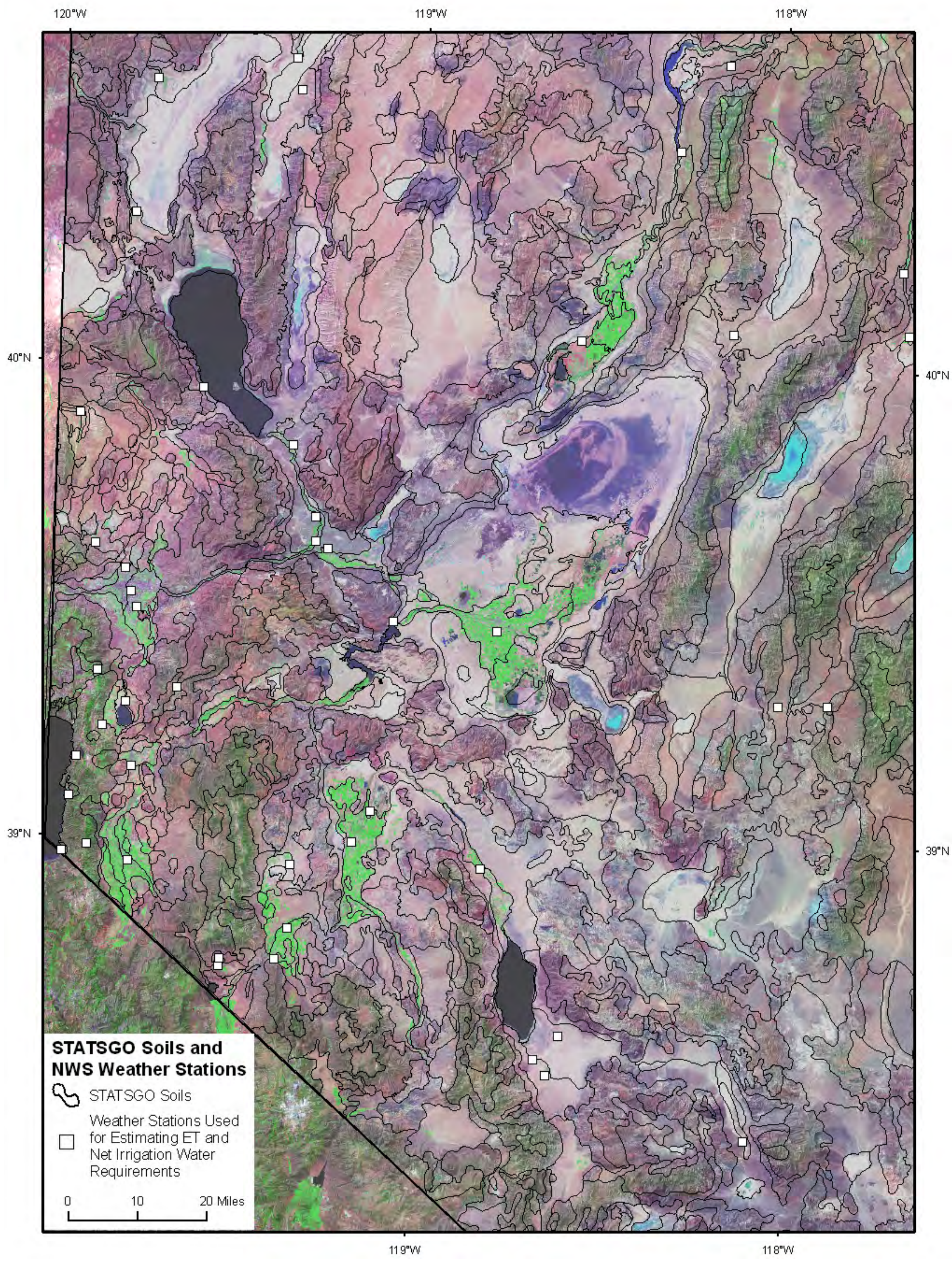


Figure 16. A close up view of the STATSGO soils database illustrating contiguous soil units that surround irrigated areas, which commonly include weather stations.

The TAW (mm) was estimated as

$$TAW = AWC * Z_r \quad \text{Eq. 33}$$

where Z_r is the root depth (m) and AWC is the available water holding capacity (mm/m), and was estimated from the STATSGO soils database. The RAW (mm) represents the fraction of TAW that a crop can extract from the root zone without suffering water stress, and was estimated as

$$RAW = TAW * \frac{MAD}{100} \quad \text{Eq. 34}$$

where MAD is the maximum allowable depletion of soil moisture for each crop (%) before stress occurs (see Appendix 5 for crop dependent MAD values). A conceptual model of the root zone soil water balance is shown in Figure 17. For more detailed information on the soil and root zone water balance and calculation of K_e and K_s coefficients, refer to FAO-56 (Allen et al., 1996) and Annex 1.

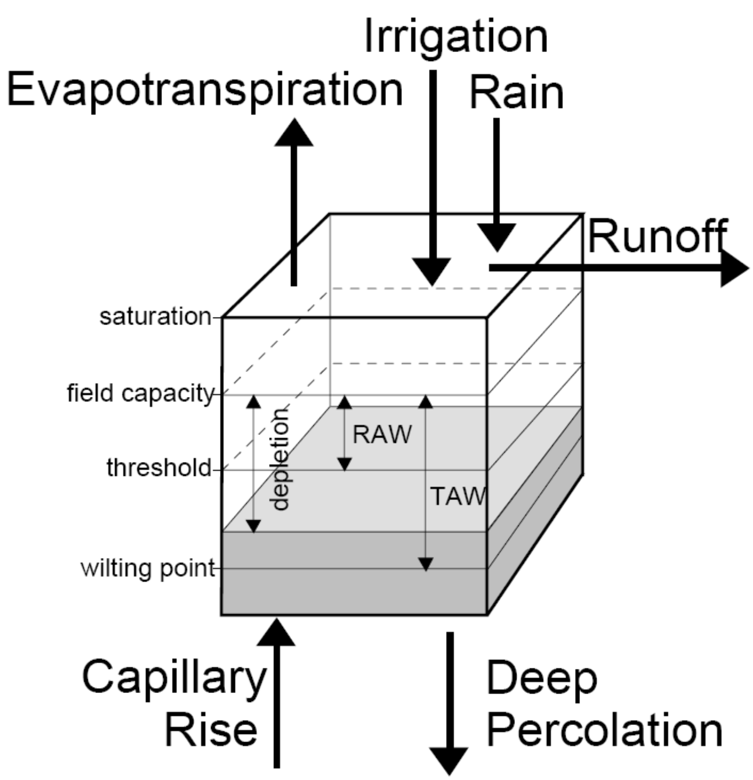


Figure 17. Conceptual model of the FAO-56 root zone water balance used in this study. Capillary rise in this study was assumed to be negligible. Modified from Allen et al., 1998.

Root Growth

Root depth is an important variable when considering the daily root zone soil water balance, specifically the amount of soil water available to plants over time. Root growth was estimated as a function of time between the initial rooting, assumed to occur at the time of planting or greenup, until the time of maximum effective rooting depth. Both initial and maximum effective root depths were specified for each crop (Appendix 5, crop parameter table). Initial and maximum root depths were adopted from FAO-56 and Allen and Robison (2007). The root depth between the initial and maximum root depth values were estimated using the Borg and Grimes (1986) sigmoidal function as

$$z_r = z_{\min} + [0.5 + 0.5\sin(3.03F_{timeroot} - 1.47)][z_{\max} - z_{\min}] \qquad \text{Eq. 35}$$

where z_r is the effective root depth at some time during the growing season, z_{min} is the initial root depth at planting or greenup, z_{max} is the maximum effective root depth, and $F_{timeroot}$ is the fraction of time from the start of root growth until the time of maximum root depth. The root depth variables can have units of meters or feet. The Borg and Grimes root growth function is illustrated in Figure 18.

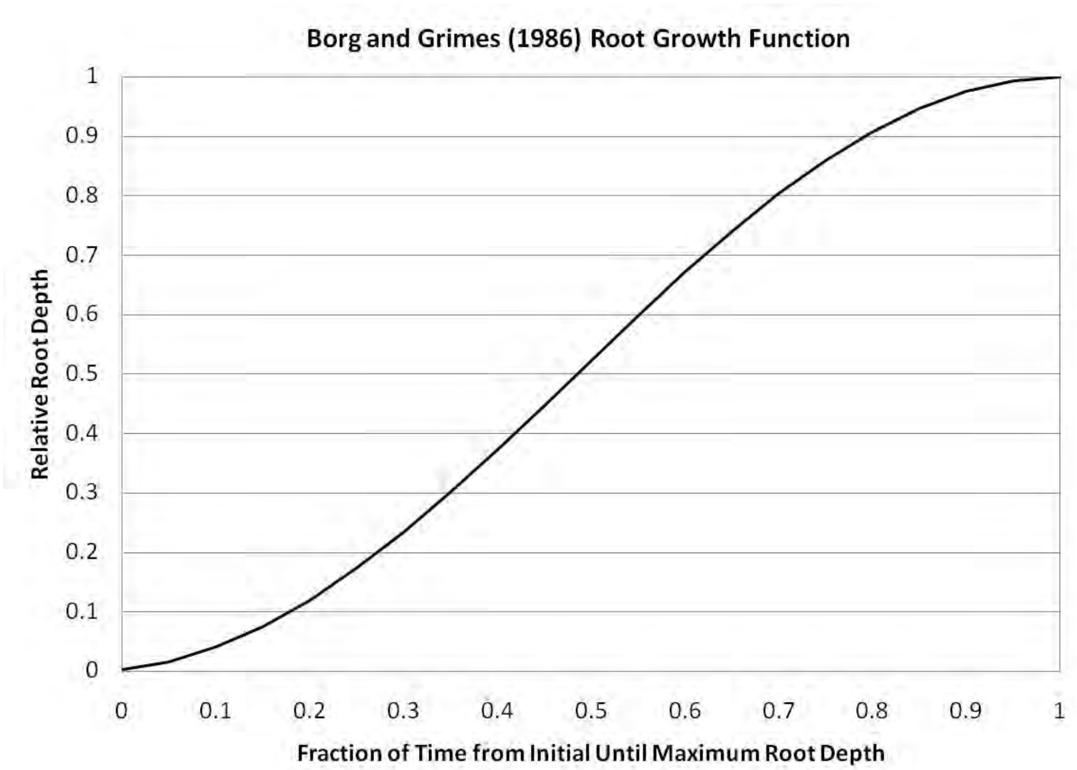


Figure 18. Root growth function following Borg and Grimes (1986) used for simulating root growth and plant available soil water in soil water balance calculations.

Runoff from Precipitation

Runoff during precipitation events is strongly influenced by soil texture, soil structure, sealing and crusting of the soil surface, slope, local land forming such as tillage and furrowing, antecedent moisture, and precipitation intensity and duration. Because of the complexities of estimating runoff, the simple, widely accepted USDA-NRCS curve number approach was applied in this study. Required data are daily precipitation depth and computation of a daily soil water balance to determine antecedent soil water conditions.

The curve number (CN) represents the relative imperviousness of a soil-vegetation surface and ranges from 0 for an infinite pervious surface to 100 for a completely impervious surface. Generally, the CN is selected from standard tables based on general crop and soil types and is adjusted for the antecedent soil conditions prior to the precipitation event. The soil water content prior to the rainfall event affects the CN value, as the soil infiltration rate is a function of the soil water content. Therefore, the CN was adjusted according to the estimated soil water content prior to the rainfall event. This soil water content is termed the antecedent soil condition (ASC). Adjustment of the CN based on the ASC is defined by the USDA-SCS (1972) for dry (ASC I) and wet (ASC III) conditions. USDA-SCS defined the ASC I occurring when "soils are dry enough for satisfactory plowing or cultivation to take place" and ASC III as when the "soil is practically saturated from antecedent rains."(National Engineering Handbook, Section 4 Hydrology, 1972, p. 4.10). The ASC II is defined as the average condition. CN values for the ASC II condition for various crop types and hydrologic groupings used in this study are listed in Table 2, which were adopted from SCS (1972) and Allen (1988).

Hawkins, et al., (1985) expressed tabular relationships in SCS (1972) in the form of equations relating CN values for ASC I and ASC III, to CN values for ASC II as:

$$CN_I = \frac{CN_{II}}{2.281 - 0.01281 CN_{II}} \qquad \text{Eq. 36}$$

and

$$CN_{III} = \frac{CN_{II}}{0.427 + 0.00573 CN_{II}} \qquad \text{Eq. 37}$$

where CN_I is the curve number associated with ASC I (dry), CN_{II} is the curve number associated with ASC II (average condition), and CN_{III} is the curve number associated with ASC III (wet).

The soil surface layer water balance associated with the dual K_c procedure was used to estimate the daily ASC condition. An approximation for the depletion of the soil surface layer at ASC III (wet) is when De=0.5 REW, that is when the evaporation process is halfway through stage 1 drying (Annex 1, Figure 2). This point will normally be when approximately 5 mm or less has evaporated from the top 150 mm of soil since the time it was last completely wetted. Thus, the relationship for De-ASC III is developed as

$$D_{e-ASCIII} = 0.5REW \qquad \text{Eq. 38}$$

where $D_{e\text{-}ASCIII}$ is the depletion of the evaporative layer at ASC III. AWC I (dry) can be estimated to occur when 10 to 20 mm of water have evaporated from the top 100 to 150 mm of soil from the time it was last completely wetted. This is generally equivalent to when the evaporation layer has dried to the point at which D_e exceeds 30% of the total evaporable water in the surface layer beyond REW. This depletion amount was expressed as

Table 2. Typical antecedent soil water conditions (AWC) II curve numbers (CN's) for general crops and hydrologic group classes. Hydrologic groups classes of A, B, and C, represent coarse, medium, and fine textured soils, respectively. Table modified from from SCS (1972) and Allen (1988).

	Soil Texture - Hydrologic Grouping		
Crop	Coarse-A	Medium-B	Fine-C
Spring Wheat	63	75	85
Winter Wheat	65	75	85
Field Corn	67	75	85
Potatoes	70	76	88
Sugar Beets	67	74	86
Peas	63	70	82
Dry Edible Beans	67	75	85
Sorghum	67	73	82
Garden Vegetables	72	80	88
Fruit Trees-Bare	65	72	82
Fruit Trees-Grnd.	60	68	70
Onions/Garlic	72	80	88
Tomatoes	65	72	82
Alfalfa Hay	60	68	77
Pasture	40	70	82
Lentils, canola, safflower, sunflower	58	72	83
Bare Soil	77	86	92
Suggested defaults	65	72	82

$$D_e = REW + 0.3(TEW - REW) \quad \text{Eq. 39}$$

where TEW is the total evaporable water in the surface layer. Therefore

$$D_{e-ASC\,I} = 0.7REW + 0.3TEW \quad \text{Eq. 40}$$

where TEW is the cumulative evaporation from the surface soil layer at the end of stage 2 drying. When D_e is in between these two extremes, that is when 0.5REW < De < 0.7REW+0.3TEW, then the ASC is near the ASC II condition and the CN value is linearly interpolated between CN I and CN III. In equation form, the CN for the intermediate ASC condition becomes

$$CN = CN_{III} \text{ for } De \leq 0.5REW \text{ ,} \quad \text{Eq. 41}$$

$$CN = CN_I \text{ for } De \geq 0.7REW + 0.3TEW \text{ ,} \quad \text{Eq. 42}$$

and

$$CN = \frac{(D_e - 0.5REW)CN_I + (0.7REW + 0.3TEW - D_e)CN_{III}}{0.2REW + 0.3TEW} \quad \text{Eq. 43}$$

for the condition where

$$0.5REW < D_e < REW + 0.3(TEW - REW). \quad \text{Eq. 44}$$

Equation 43 produces CN_{II} when D_e is half way between the endpoints of CN_I and CN_{III} due to the symmetry of CN_I and CN_{III} relative to CN_{II}.

Parameter S [mm] in the CN procedure is the maximum depth of water that can be retained as infiltration and canopy interception during a single precipitation event, and is calculated as

$$S = 250\left(\frac{100}{CN} - 1\right) \quad \text{Eq. 45}$$

and surface runoff is then calculated from the standard curve number method for P > 0.2S as

$$RO = \frac{(PPT - 0.2S)^2}{PPT + 0.8S} \qquad \text{Eq. 46}$$

where RO is the depth of surface runoff during the precipitation event [mm], and PPT is the depth of precipitation during the event [mm]. The 0.2S term represents the abstracted precipitation that is intercepted by canopy and soil surface before any runoff occurs. Once the surface runoff depth was estimated using the CN procedure, the depth of precipitation infiltrated was calculated as

$$P_{\inf} = PPT - RO \qquad \text{Eq. 47}$$

where P_{inf} is the depth of infiltrated precipitation [mm] and RO is the depth of surface runoff [mm]. If P_{inf} exceeds the depth of the soils AWC, the remainder is considered deep percolation.

Simulated Irrigations

The simulation of irrigations was accomplished using the daily root zone soil water balance. Irrigations are simulated when the root zone dries to the maximum allowable depletion threshold point where stress will begin to occur (point where RAW is exceeded). The simulated irrigation amount is the difference between the cumulative depletion at or slightly beyond the RAW (due to that day's depletion), and the TAW (AWC*Z_r). In other words, at the threshold where stress is to occur, irrigations are scheduled to fill the root zone from the cumulative depletion amount to the field capacity (see Figure 17). Irrigations are scheduled on the day that the cumulative depletion first exceeds the RAW. The initiation of the irrigation season begins when K_{cb} exceeds 0.22 during the initial K_{cb} curve development period to prevent a series of frequent, light irrigations early in the season when the root zone is shallow. The irrigation frequency and depth per irrigation represent surface and fixed grid types of sprinkler systems such as wheel line and hand lines. The frequency would be greater for center pivot and solid set types of sprinkler systems where smaller depths are applied.

Deep Percolation

Deep percolation is defined as the flux of water past the root zone. Deep percolation is simulated when the soil water content is at the AWC and additional water is applied via precipitation. Deep percolation is also simulated to occur during irrigation events where 10% of the irrigation depth was assumed to contribute to deep percolation. This 10% of the irrigation depth was included in the soil water balance computations to provide recharge to depths in the soil profile within the maximum rooting depth but below the current rooting depth of the crop. This was necessary to simulate buildup of soil water during irrigation events that is used later in the season as roots deepen. This phenomenon is typical in practice. The deep percolation from irrigation is summed separately from deep percolation from PPT in output data files.

Crop Coefficient Curves

Vegetation phenology is impacted by seasonal changes in solar radiation, temperature, precipitation, and agricultural practices. The crop coefficient curve represents changes in vegetation phenology of a particular crop or vegetation type. The shape of the crop coefficient curve is dependent on the growing season and changes in vegetation cover and maturation. During the beginning of the growing season, which is often shortly after planting of annuals or the emergence of new leaves for perennials, the value of K_{cb} is small, typically ranging from 0.1 to 0.2. When soil evaporation of non-growing season accumulation of soil moisture is accounted for by adding the K_e coefficient to the K_{cb} coefficient, the total K_c value typically ranges from 0.3 to 0.4 during the beginning of the growing season. As the vegetation develops over the course of the growing season and leaf area increases, covering more of the soil surface, the K_{cb} curve increases until the vegetation reaches full cover. Depending on the vegetation or crop type during the middle of the growing season the K_{cb} curve is generally constant, or is reduced based on simulated cuttings and harvest. Later in the growing season the K_{cb} curve is reduced due to aging and drying of the leaves (Figure 19).

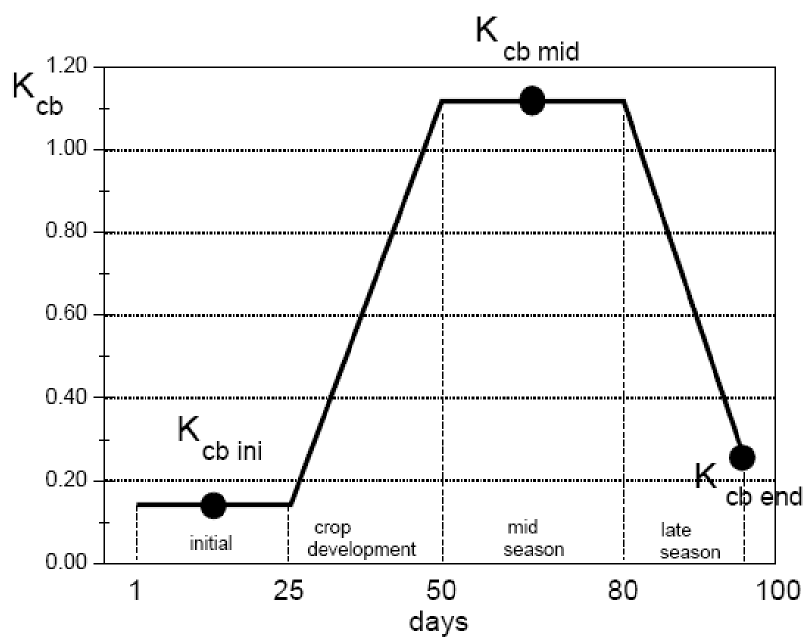


Figure 19. Schematic showing the typical shape of the FAO-56 K_{cb} curve with four different crop stages dependent on development of vegetation. Modified from Allen et al., (1998).

As described above, K_{cb} curves represent changes in vegetation phenology, which can vary from year to year depending on the start, duration, and termination of the growing season, all of which are dependent on air temperature conditions during spring, summer, and fall periods. Three different methods were used to define the shape and duration of the K_{cb} curves to allow the curves to be scaled differently each year according to weather conditions based on relative time scales or thermal units. These methods are:

1) Normalized cumulative growing degree-days from planting to effective full cover, with this ratio extended until termination,
2) Percent time from planting to effective full cover, with this ratio extended until termination, and
3) Percent time from planting to effective full cover and then number of days after full cover to termination.

Basal crop coefficient curves from Allen and Robison (2007) for 34 crop types were adopted for this study and are listed in Table 3, along with the type of normalizing basis used for scaling the curve and primary source of the curve. The K_{cb} curves listed in Table 3 were originally based on percent time from planting or greenup until effective full cover and days after effective full cover following procedures described by Wright (1981, 1982), and were later normalized to a cumulative growing degree base by Wright (2001) and Allen and Robison (2007), and converted for use with the ASCE standardized Penman-Monteith tall reference equation (ET_{rs}) by Allen and Wright (2006). In this study the more widely accepted ASCE standardized Penman-Monteith short reference (ET_{os}) method was used, therefore the family of K_{cb} curves derived from Wright (2001) and Allen and Robison (2007) for use with ET_{rs} were converted to an ET_{os} basis for the Nevada applications by multiplying the K_{cb} curve values by 1.20, which is the standardized ratio for alfalfa to grass reference for the standard climate condition proposed by FAO (Allen et al., 1998), where mean wind speed at 2m is 2m/s and mean daily minimum relative humidity is 45%. Departures from the standard climate condition were accounted for during daily calculations by adjusting the daily K_{cb} value upward based on the estimated daily RH, wind speed, and simulated crop height following procedures outlined in FAO-56 (Allen et al., 1998). Tables of K_{cb} values and for each crop and land cover type simulated in this study are listed in Appendix 6.

Application of cumulative growing degree-days (CGDD) has been widely used as a basis for crop coefficient development representing crop phenology, allowing for the scaling of lengths of development and growth periods and transferability among regions (Sammis et al., 1985; Slack et al., 1996; Howell et al., 1997; Snyder et al., 1999; Wright, 2001; deTar, 2004; Marek et al., 2006; Allen and Robison, 2007). Because air temperature regulates nearly all plant functions, the phenology of vegetation is closely related to the amount of heat the crop and soil is exposed to, as opposed to calendar dates. For this reason, the CGDD has gained wide spread use and was adopted in this study. The equation for the general growing degree-day (GDD) method following Mitchell (1997) and Wright (2001) is

$$GDD = \max\left(\frac{T_{\max} + T_{\min}}{2} - T_{base}, 0\right) \qquad \text{Eq. 48}$$

where T_{max} and T_{min} are the daily maximum and minimum air temperatures, respectively, and T_{base} is the base temperature. If T_{min} is far enough below T_{base} to cause the average daily temperature to be below T_{base}, then GDD is zero. This formulation is suggested by Wright (2001) to be realistic for many crops in semi-arid climates, where cold nighttime temperatures can limit growth. Values for T_{base} for this study range from $0^{o}C$ to $5^{o}C$ depending on the crop type and are listed in Appendix 5 (crop parameter table). For corn crops a variation of the GDD equation is used that assumes no growth at air temperatures above $30^{o}C$ and no negative adjustment to the GDD value if the minimum temperature goes below $10^{o}C$, and is defined as

Table 3. Basal crop coefficient type, normalizing basis, and source.

Crop Curve Name	Type of Basis[1]	Primary Source
Spring Grain (wheat, barley)	1	modified from Wright(1982)
Winter Grain (wheat, barley)	1	modified from Wright(1982)
Peas, seed	1	modified from Wright(1982)
Peas, fresh	1	modified from Peas, seed
Sugar Beets	1	modified from Wright(1982)
Potatoes (baking)	1	modified from Wright(1982)
Potatoes (processing)	1	modified from Potato, baking
Field Corn	1	modified from Wright(1982)
Sileage Corn	1	modified from Wright(1982)
Sweet Corn	1	modified from Wright(1982)
Snap Beans (dry)	1	modified from Wright(1982)
Snap Beans (fresh)	1	modified from snap beans, dry
Alfalfa 1st cycle	1	modified from Wright(1982)
Alfalfa Intermediate cycles	1	modified from Wright(1982)
Alfalfa Last cycle	1	modified from Wright(1982)
Garden Vegetables	1	modified from Onion curve
Grass Hay	1	modified from AGRIMET
Onions	2	modified from AGRIMET
Winegrapes	2	modified from AGRIMET
Melons	2	modified from AGRIMET
Hops	2	modified from AGRIMET
Orchards	2	modified from AGRIMET
Canola	2	modified from AGRIMET
Sunflower/Safflower	2	modified from Canola
Turf/Lawn	2	modified from AGRIMET
Pasture Highly Managed	3	modified from Allen and Robison (2007)
Pasture Low Managed	3	modified from Allen and Robison (2007)
Alfalfa Seed	3	modified from Allen and Brockway (1983)

[1] Curve Basis
1 = Normalized cumulative growing degree days (NCGDD)
2 = Percent of time from planting or greenup to effective full cover, applied all season
3 = Percent of time from planting or greenup to effective full cover, then days after effective full cover

$$GDD_{corn} = \left(\frac{\max(\min(T_{\max}, 30), 10) + \max(\min(T_{\min}, 30), 10)}{2} \right) - 10 .$$ Eq. 49

This formulation of the GDD equation is commonly referred to as the standard corn GDD equation or heat unit equation.

In this study the starting date for accumulation of GDD was specified as January 1 for all crops except for winter wheat, which was specified as October 1. The CGDD was normalized following Wright (2001) by the quantity of CGDD required to advance the K_{cb} curve from planting or greenup to effective full cover. The normalized CGDD, NCGDD, ranges from 0 to 1 for the period from planting or greenup until effective full cover, and typically ranges from 1 to 2 for the period of effective full cover to harvest or the killing frost. The NCGDD is defined as

$$NCGDD = \frac{CGDD_i}{CGDD_{EFForTERM}}$$ Eq. 50

where $CGDD_i$ is the cumulative growing degree-day for the i^{th} day, and $CGDD_{EFF\ or\ TERM}$ is the cumulative growing degree-day from planting or greenup to effective full cover, or the cumulative growing degree-day from planting or greenup to termination depending on the crop type. Formulation of the x axis for percent time based K_{cb} curves is similar to equation 50, but time based. The K_{cb} curves are advanced by interpolating between K_{cb} values according to the NCGDD or percent of time. NCGDD or percent of time and their respective K_{cb} values are listed in Appendix 6. Harvests or termination of crops were calculated by evaluating when the CGDD value, percent of time since planting or greenup, or days after effective full cover, exceed threshold values that are specified for each crop (Appendix 5), or a killing frost occurs.

Defining the length of the growing season, time to effective full cover, and harvest dates are all important aspects of estimating the ET_{act} and NIWR. The greenup and time to effective full cover of perennial vegetation during spring months is strongly impacted by short-term weather conditions, primarily by air temperature, soil temperature, and water availability. Likewise, planting dates for annual crops are affected by temperature conditions, in particular the soil temperature at seed depth. Sakamoto and Gifford (1970) published spring and fall low temperatures and growing season probabilities for 71 locations in Nevada by statistically analyzing NWS weather station minimum air temperature data. The Nevada Irrigation Guide (USDA-SCS, 1992) outlines earliest planting dates and termination dates based on daily minimum air temperatures. The Bureau of Reclamation's Lower Colorado River Accounting System (LCRAS) ET_{act} estimates are based on fixed dates defining the time limit and shape of K_c curves for different crops (Jensen, 1998). Estimating growing season length and crop phenology from fixed minimum air temperatures and/or dates is useful for general applications, however an approach that takes into account year to year variations of air temperature and provides the ability to estimate year to year variations in time to greenup or planting, time to effective full cover, harvest, and termination, is desired for a more detailed analysis of the ET_{act} and NIWR as proposed in this study.

Two methods were used for estimating the greenup or planting dates for various crops in this study, a 30-day moving average of mean daily air temperature, T_{30}, and CGDD depending on the crop type following Allen and Robison (2007). Values of T_{30} and CGDD used in this study are listed for each crop or land cover type in Appendix 5. The T_{30} approach for defining greenup and planting dates has been previously applied in Washington (James et. al., 1982) and Idaho (Allen and Brockway, 1983; Allen and Robison, 2007), and the CGDD approach has been recently applied in Idaho (Wright, 2001; Allen and Robison, 2007), Texas (Marek et al., 2006), Oregon (Mitchell, 1997), and Nebraska (NHPCC, 2006). Both the T_{30} and CGDD approaches provide the ability to account for annual variations in temperature and automate the selection of the greenup or planting dates. While the T_{30} and CGDD approaches take into account temperature variations, actual farm and field practices can significantly alter the greenup, planting, time to effective full cover, harvest, and termination dates, therefore calculated dates defining crop stages from this study should be considered general.

Values of T_{30} and CGDD that define greenup dates were initially adopted from Allen and Robison (2007), which were originally developed from noted planting and greenup dates during lysimeter studies in Kimberly, ID (Wright, 1982) and modified to reflect more recent observations and current cultivars. After analyzing computed greenup and planting dates using initial CGDD and T_{30} values from Allen and Robison (2007), CGDD and T_{30} values were adjusted to reflect known greenup and planting dates for specific crops grown in Nevada. Calibration of greenup and planting T_{30} and CGDD values was based on computing T_{30} and CGDD using temperature data collected at NWS stations located in valleys where early spring photos were available, documented greenup or planting dates were available from previous studies, or verbal and written communication was obtained from phone interviews. If ‘typical’ greenup or planting information was obtained, the simulated mean annual greenup or planting date was calibrated. Likewise if detailed yearly greenup or planting date information was available, respective year-to-year calibration was performed.

Calibration of the CGDD for simulating harvests is similar to calibration of greenup and planting dates. Calibration of CGDD and T_{30} for simulating greenup and planting dates is simpler than calibration of CGDD for predicting harvest and termination dates due to the wide variation in farming practices, impacting harvest. For example, some farming operations have dozens of fields of alfalfa, in which they need to stagger cutting dates to have a continuous flow of cut, dry, and bail cycles. Recognizing the reality of large variations in cutting, harvest, and termination dates, both generalized and specific cutting and harvest dates that were assumed to be ‘typical’ were used for calibrating CGDD, percent time since effective full cover to harvest, and days after effective full cover to harvest values.

Calibration of CGDD, T_{30}, percent time from effective full cover to harvest, and days after effective full cover to harvest, for simulating greenup and harvest dates was ultimately accomplished by minimizing the error in simulated vs. documented/typical greenup, planting, and harvest dates outlined in Table 4, which lists the results and specific information used in the calibration. Figures 20 and 21 illustrate the calibration results for alfalfa where the best fit CGDD value from January 1 until greenup for alfalfa was 300 ^{o}C-days, and the best fit CGDD value for time from greenup until the first cutting for alfalfa was 880 ^{o}C-days, and 740 ^{o}C-days for later cuttings. Calibrated CGDD values give promising results across the state considering the extreme spatial variation of air temperature. General descriptions of greenup, planting, and harvest information obtained from farmers and ranchers, including locations of observations and dates, are summarized in Appendix 7.

Crop Specific K_{cb} Curves

As discussed earlier, three different methods were used, depending on crop type, to define the time to effective full cover, and harvest and/or termination for the construction of K_{cb} curves (see Appendix 5). The first method, the normalized cumulative growing degree-days from planting to effective full cover, with this ratio extended until termination, is used for advancing the K_{cb} curve for many primary crops grown in Nevada, including alfalfa. In the following sections, each crop simulated will be discussed in terms of the K_{cb} curve used, source of the K_{cb} curve, parameters used defining the shape of the K_{cb} curve, and some details about the implementation. Crops chosen for simulation of ET_{act} were primarily based from common knowledge of occurrence and crops chosen in the Nevada Irrigation Guide (USDA-SCS, 1992). Some crops were simulated that are not grown in Nevada to assess potential water use.

Normalized cumulative growing degree-days from planting to effective full cover, with this ratio extended until termination:

Alfalfa

Alfalfa farming practices in Nevada can vary significantly depending on the climate, water availability, and market prices. For example, in central western Nevada harvesting beef hay typically results in three large cuttings, while harvesting dairy hay typically results in four cuttings, often before any bloom occurs. However, some beef hay farmers get four cuttings depending on climate, water availability, and length of growing season. Dairy hay is cut more frequently to increase the protein content of the hay and to reduce steminess, and tends to be a less dormant genotype with quicker re-growth, but with less longevity. For simplicity only one type of alfalfa crop was simulated, which could be considered more representative of beef hay than dairy hay; however, calibration of cutting dates used information from both beef and dairy hay farmers. Calibration of CGDD values to predict known cutting cycles of both beef and dairy hay farmers was accomplished by optimization of CGDD values to known cutting dates for both

Table 4. Documented/typical greenup and harvest dates vs. simulated greenup and harvest dates.

Crop	Hydrographic Area	Weather Station Used for Analysis	Documented/Typical Green Up or Planting Dates	Simulated Mean Green Up or Planting Dates	Documented/Typical Cutting and Harvest Dates	Simulated Mean Cutting/Harvest Dates	Source	Notes
Alfalfa	Carson Desert	Fallon EXP	3/20	3/23	6/15, 7/19, 9/1, 10/21	6/12, 7/22, 9/1, 10/21	Rashedi (1983)	Simulated and Measured Greenup and Cutting Dates are an average from 1974, 75, 77, 78, 81, 82, 83
Alfalfa	Carson Desert	Fallon EXP	3/20-4/1	3/21	6/1-6/10, every 30-40 days after, 3-4 cuttings	6/8, every 40 days after, 3-4 cuttings	Latin Farms (2008), Verbal Communication	Simulated Greenup and Cutting Dates are the 1971-2005 average
Alfalfa	Carson Valley	Minden	3/20-4/5	4/2	6/15, 8/1, 9/15	6/19, 7/29, 9/10, sometimes a 4th cutting at 10/29	Aldax (2008), Verbal Communication	Simulated Greenup and Cutting Dates are average annual estimates from 1971-2006
Alfalfa	Carson Valley	Minden	3/20-4/5	3/27	6/8, 7/28, 9/20, no 4th cutting	6/15, 7/26, 9/4, no 4th cutting	Aldax (2006), Written Communication via USGS	Documented and Simulated Cutting Dates are an average for the 2003-2004 growing season. The reported last cutting date average of 9/20 is abnormally late for a 3rd cutting.
Alfalfa	Carson Valley	Minden	3/20-4/5	3/27	6/8, 7/21, 9/5, no 4th cutting	6/14, 7/24, 9/3, no 4th cutting	Godecke (2006), Written Communication via USGS	Documented and Simulated Cutting Dates are for the 2004 growing season
Alfalfa	Smith Valley	Yerington	NA	4/1	6/2, 7/12, 8/17 no 4th cutting	6/5, 7/13, 8/17, no 4th cutting	Rush (1976)	Simulated Greenup and Cutting Dates are from 1973 to match study period of Rush (1976)
Alfalfa	Mason Valley	Yerington	3/15-4/1	3/20	5/25-6/5, every 35-45 days after, mostly 4 cuttings	6/3, every 39 days after, 9 out of 10 years have 4 cuttings (6/3, 7/12, 8/17, 9/28)	Snyder Livestock (2008), Verbal Communication	Simulated Greenup and Cutting Dates are the 1971-2006 average

Table 4 cont. Documented/typical greenup and harvest dates vs. simulated greenup and harvest dates.

Crop	Hydrographic Area	Weather Station Used for Analysis	Documented/Typical Green Up or Planting Dates	Simulated Mean Green Up or Planting Dates	Documented/Typical Cutting and Harvest Dates	Simulated Mean Cutting/Harvest Dates	Source	Notes
Alfalfa	Moapa Valley	Overton	2/1-2/20	2/9	4/5-4/20, every 30 days after	4/18, every 32 days after	Hardy (2008), Verbal Communication	Simulated Greenup and Cutting Dates are a 1949-2006, 15 year average
Alfalfa	Antelope Valley	Antelope Valley Farr	4/1-4/15	4/6	6/15, 8/5, 10/15, no 4th cutting	6/24, 8/3, 10/17, no 4th cutting	Farr Farms (2008), Verbal Communication	Simulated Greenup and Cutting Dates are a 1985-1997 average
Alfalfa	Lake Valley	Gyser Ranch	4/10-4/20	4/20	6/15-6/30, every 35-45 days after, 3-4 cuttings	7/3, every 48 days after, 3-4 cuttings	Atlanta Farms (2009), Verbal Communication	Simulated Greenup and Cutting Dates are a 1944-1987, 14 year average
Alfalfa	Boulder Flat	Beowawe	4/1-4/15	4/9	5/25-6/15, 7/21-8/4, 9/29-10/13, no 4th cutting	6/19,7/27, 10/10, no 4th cutting	TS Ranch (2008), Written Communication	Documented and Simulated Greenup and Cutting Dates are for the 2004 growing season
Onions (fresh)	Mason Valley	Yerington	4/1-4/15	4/7	8/20-9/20	9/7	Snyder Livestock and Peri and Sons (2008), Verbal Communication	Simulated Greenup and Harvest Dates are the 1970 -2007 average
Garlic	Mason Valley	Yerington	4/1-4/15	4/7	8/15-9/10	8/29	Snyder Livestock and Peri and Sons (2008), Verbal Communication	Simulated Greenup and Harvest Dates are the 1970 -2007 average
Garlic	Black Rock Desert	Gerlach	4/5-4/20	4/16	8/15-9/15	9/3	Empire Farms and Orient Farms (2009), Verbal Communication	Simulated Greenup and Harvest Dates are the 1994-2003 average
Potatoes (fresh)	Lake Valley	Gyser Ranch	4/10-5/10	5/4	9/15-10/10	9/30	Atlanta Farms (2009), Verbal Communication	Simulated Greenup and Harvest Dates are the 1972-1977 average
Potatoes (processing-early)	Paradise Valley	Paradise Valley	4/1-5/15	4/5	9/1-10/15	9/1	Winnemucca Farms (2008), Verbal Communication	Simulated Greenup and Harvest Dates are the 1970-2007 average
Potatoes (fresh-late)	Paradise Valley	Paradise Valley	4/1-5/15	4/5	9/20-10/20	9/19	Winnemucca Farms (2008), Verbal Communication	Simulated Greenup and Harvest Dates are the 1970-2007 average
Spring Wheat	Antelope Valley	Antelope Valley Farr	4/1-4/20	4/5	7/10-7/31	7/31	Farr Farms (2008), Verbal Communication	Simulated Greenup and Harvest Dates are the 1985-1997 average

Table 4 cont. Documented/typical greenup and harvest dates vs. simulated greenup and harvest dates.

Crop	Hydrographic Area	Weather Station Used for Analysis	Documented/Typical Green Up or Planting Dates	Simulated Mean Green Up or Planting Dates	Documented/Typical Cutting and Harvest Dates	Simulated Mean Cutting/Harvest Dates	Source	Notes
Spring Wheat	Paradise Valley	Paradise Valley	3/20-4/20	4/10	7/15 - 9/15	8/5	Winnemucca Farms (2008), Verbal Communication	Simulated Greenup and Harvest Dates are the 1970 -2007 average
Spring Wheat	Carson Desert	Fallon EXP	3/10-4/1	3/13	7/10-7/31	7/15	Latin Farms (2008), Verbal Communication	Simulated Greenup and Harvest Dates are the 1970 -2007 average
Winter Wheat	Paradise Valley	Paradise Valley	9/15-10/30	10/15	7/15-8/15	7/29	Winnemucca Farms (2008), Verbal Communication	Simulated Greenup and Harvest Dates are the 1970 -2007 average
Winter Wheat	Carson Desert	Fallon EXP	9/20-10/20	10/15	6/1-6/30	6/30	Latin Farms (2008), Verbal Communication	Simulated Greenup and Harvest Dates are the 1970 -2007 average
Melons	Carson Desert	Fallon EXP	5/1-5/15	5/9	8/10-8/20	8/19	Latin Farms (2008), Verbal Communication	Simulated Greenup and Harvest Dates are the 1970 -2007 average
Fresh Beans	Carson Desert	Fallon EXP	5/10-5/20	5/14	8/10-8/20	8/10	Latin Farms (2008), Verbal Communication	Simulated Greenup and Harvest Dates are the 1970 -2007 average
Sweet Corn - Early	Carson Desert	Fallon EXP	4/20-5/10	4/27	8/10-9/1	8/23	Latin Farms (2008), Verbal Communication	Simulated Greenup and Harvest Dates are the 1970 -2007 average
Silage Corn	Carson Desert	Fallon EXP	4/20-5/10	4/27	9/20-10/10	9/29	Latin Farms (2008), Verbal Communication	Simulated Greenup and Harvest Dates are the 1970 -2007 average

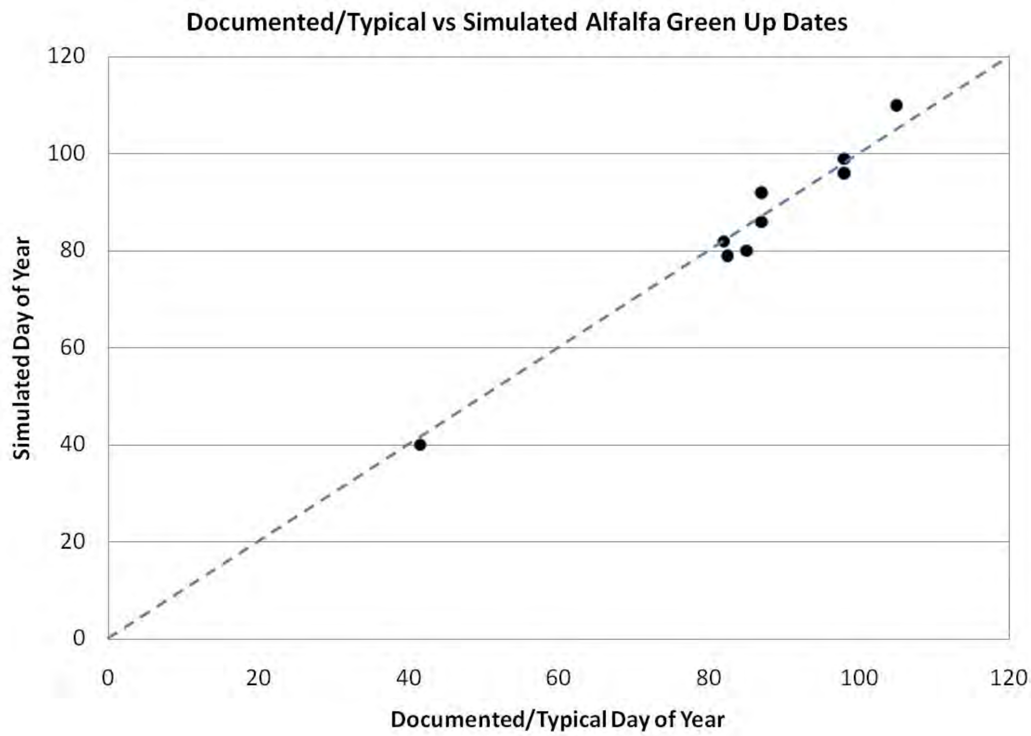


Figure 20. Documented and typical greenup dates compared to simulated greenup dates for alfalfa for 9 locations using a CGDD value of 300 ^{o}C-days from January 1.

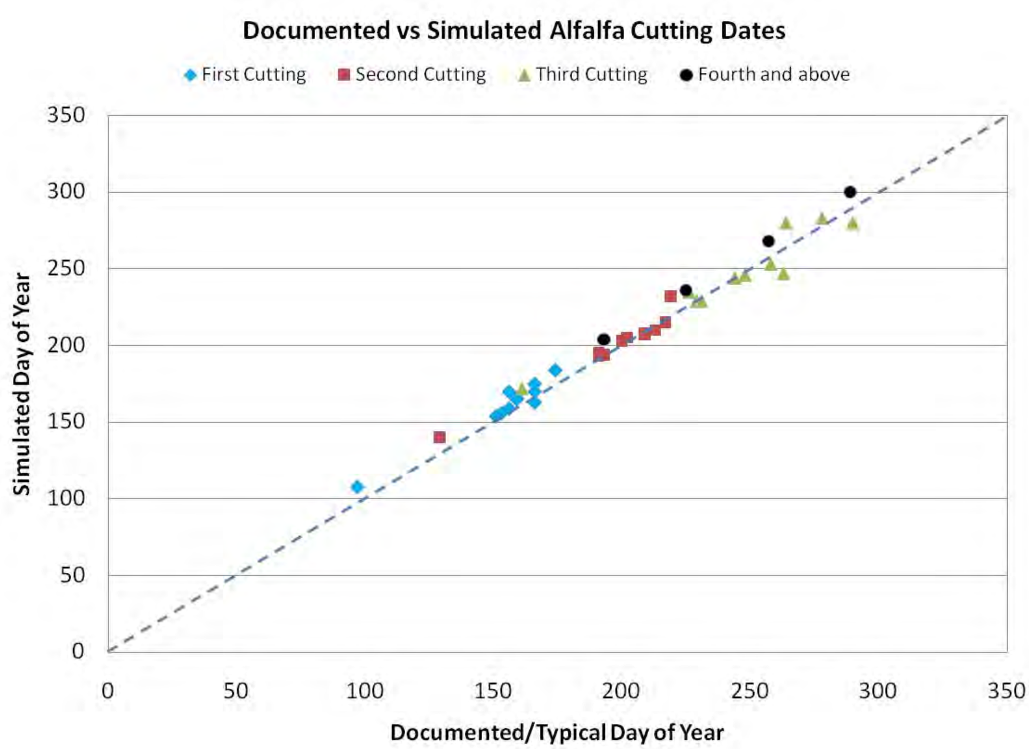


Figure 21. Documented and typical cutting dates compared to simulated cutting dates for alfalfa using a CGDD value of 880 ^{o}C-days from greenup to the first cutting, and 740 ^{o}C-days for later cuttings.

dairy and beef hay as discussed in the previous section. Results from initial simulations of ET_{act} using separate dairy and beef hay parameterizations of CGDD revealed that the ET_{act} for the two different classes are nearly identical, due to the fact that while the dairy hay reaches a max K_{cb} value faster than beef hay, dairy hay is cut more frequently, reducing the simulated ET_{act}, and making ET_{act} of both classes nearly equal.

Three different alfalfa K_{cb} curves were used according to the cycle of growth, that being an initial cycle, an intermediate or mid cycle, and a late cycle curve according to Wright (1981, 1982) and lysimeter records in Kimberly, ID (Figure 22). Implementation of three different K_{cb} curves for alfalfa is consistent with the fact that the first cycle or cutting of alfalfa has the largest yield and hence water consumption, with subsequent cuttings having less yield, and the final cutting generally having the least amount of yield. The second and later cycles require more CGDD since these cycles contain a period of no growth after cutting prior to launch of rapid growth that is not present in the first growth cycle. The CGDD values for the first growth cycle are accumulated beginning at greenup of the crop in spring, and from the time of cutting for all subsequent growth cycles. The killing frost temperature of -7°C defines termination of the growing season for alfalfa. This temperature was also used by Allen and Robison (2007) in Idaho.

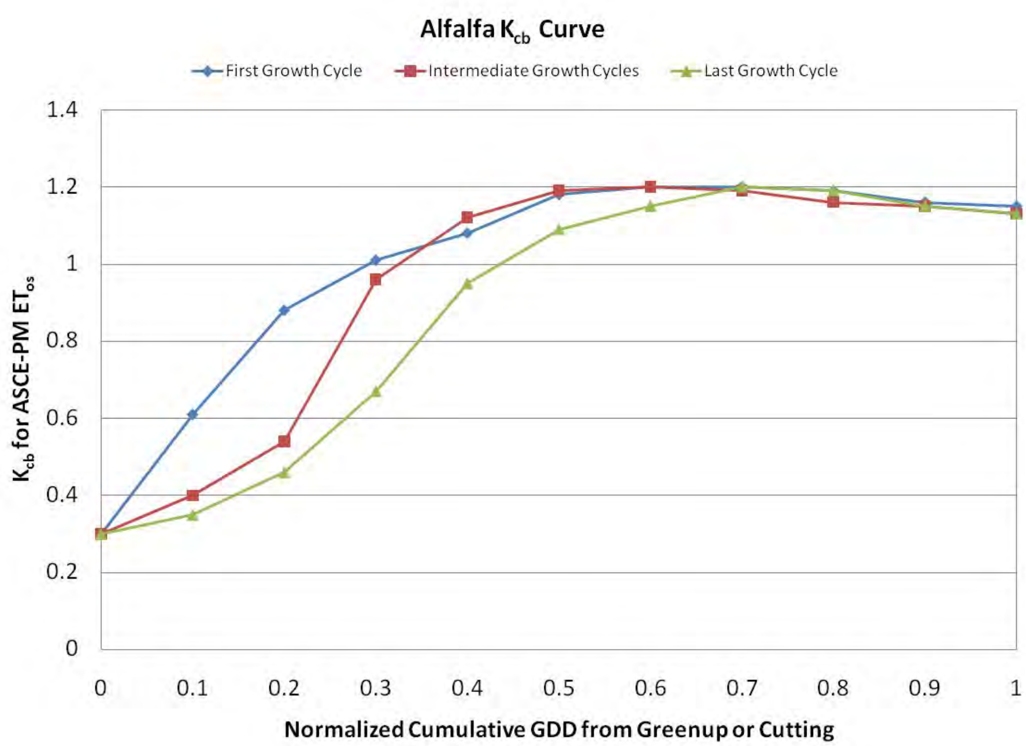


Figure 22. Alfalfa K_{cb} curve for the first, intermediate, and last growth cycles.

The number of cuttings of alfalfa varies significantly from southern to northern Nevada due to the large variation in growing season length, therefore an automated approach was applied to determine when to shift to the late cycle K_{cb} curve. To accomplish this, the average number of cuttings for the period of record for each weather station was recorded during an initial simulation, and then specified in a subsequent simulation using the recorded average number of cuttings. The average number of cuttings was rounded to the nearest whole number, and the late cycle K_{cb} curve for each year was implemented by evaluating if the cutting count exceeded the rounded average number of cuttings minus one.

Adjustments were made to the computed K_{cb} curves during fall periods following Allen and Robison (2007) to account for effects of cold nighttime temperatures and occasional light but non-killing frosts. The adjustments reduced the value for K_{cb} following the first occurrence of a –3°C in the fall by 0.005 each day following the -3°C temperature. For example, this reduction of 0.005/day would equate to a total reduction in K_{cb} of 0.10 by the 20th day following the first occurrence of $T_{min} < -3$°C. Justification for the reduction is based on field observation of stunted and retarded growth, and verbal communication with farmers and ranchers in Nevada.

Grass Hay

The grass hay K_{cb} curve was constructed to follow the shape of the K_{cb} curve for the first cycle of alfalfa, but with a peak K_{cb} of 1.14 rather than 1.2, and about a 25% longer CGDD required until a single large cutting (1200 °C-days at a base of 0°C), usually occurring around mid July in central and northern Nevada (Davidson et al., 1988). Following the single large cutting (at NCGDD = 1.0), the K_{cb} was assumed to stay near 0.90 and then decline towards fall, when subsequent grazing or smaller cuttings may occur (Figure 23). The curve was terminated at the killing frost as listed in Appendix 5. The shape is similar to the AGRIMET grass hay curve.

Winter and Spring Grain

Winter wheat and spring grain K_{cb} curves (Figures 24 and 25) were derived from Wright (1982). The K_{cb} vs. NCGDD curve for winter wheat is begun on October 1 and run through the winter. The planting date of October 1 was selected based on typical planting dates of winter wheat for most areas of Nevada where winter wheat is grown. Adjustments to winter wheat CGDD following Allen and Robison (2007) are implemented to account for extremely cold weather retarding growth. Adjustments to winter wheat CGDD are made using the following criteria. Whenever T_{min} was below –25°C and there is no documented snow cover present, 10% of the canopy was assumed to be frost burnt, with the reduction in green material implemented by reducing any CGDD accumulated since Oct. 1 by 10% on the day following the low temperature. Also, whenever T_{min} was below -10°C, the GDD for the following day, if greater than 0, was reduced by 5 GDD units to reflect retarded growth on the day after the cold freeze

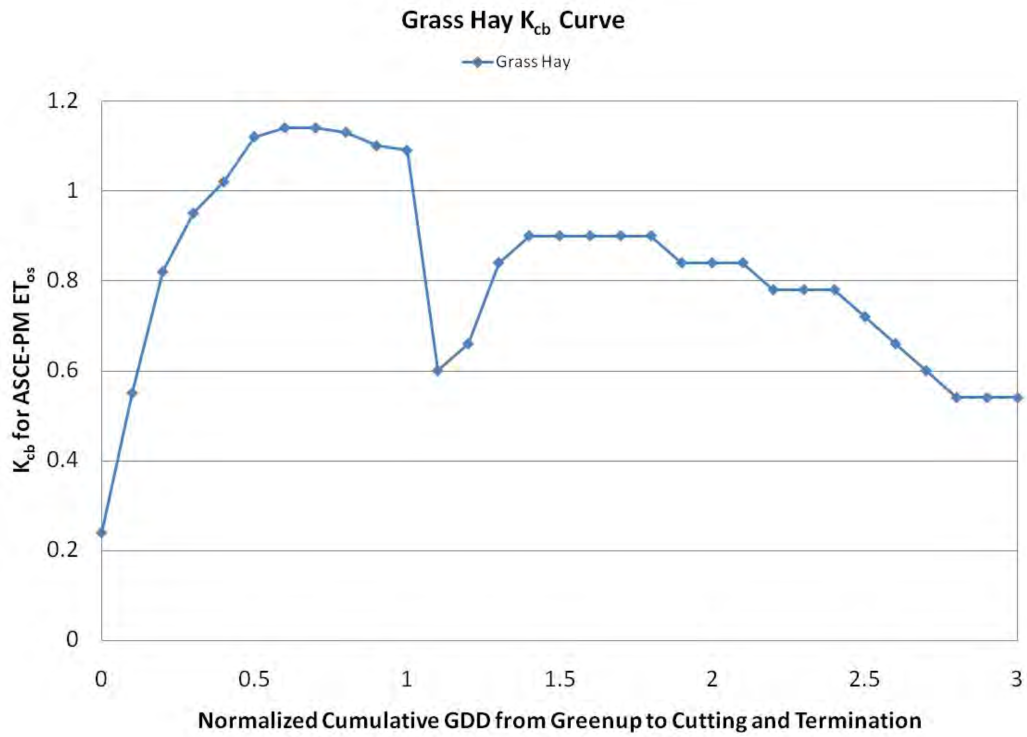


Figure 23. Grass hay K_{cb} curve which assumes one large cutting, and later smaller cuttings or grazing.

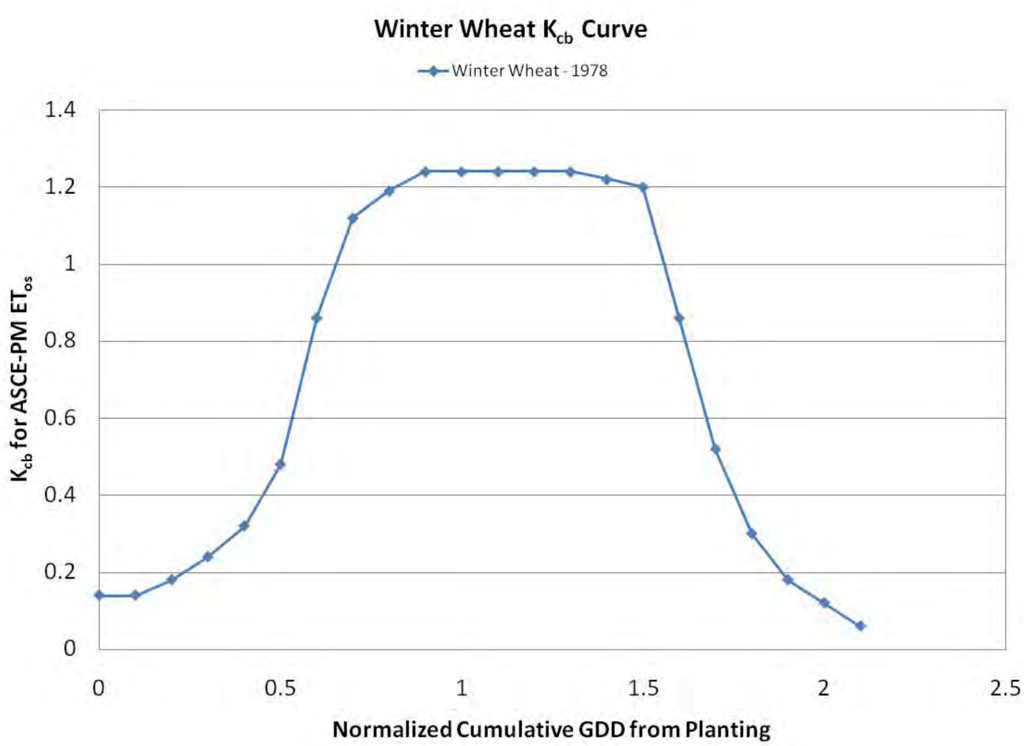


Figure 24. Winter wheat K_{cb} curve.

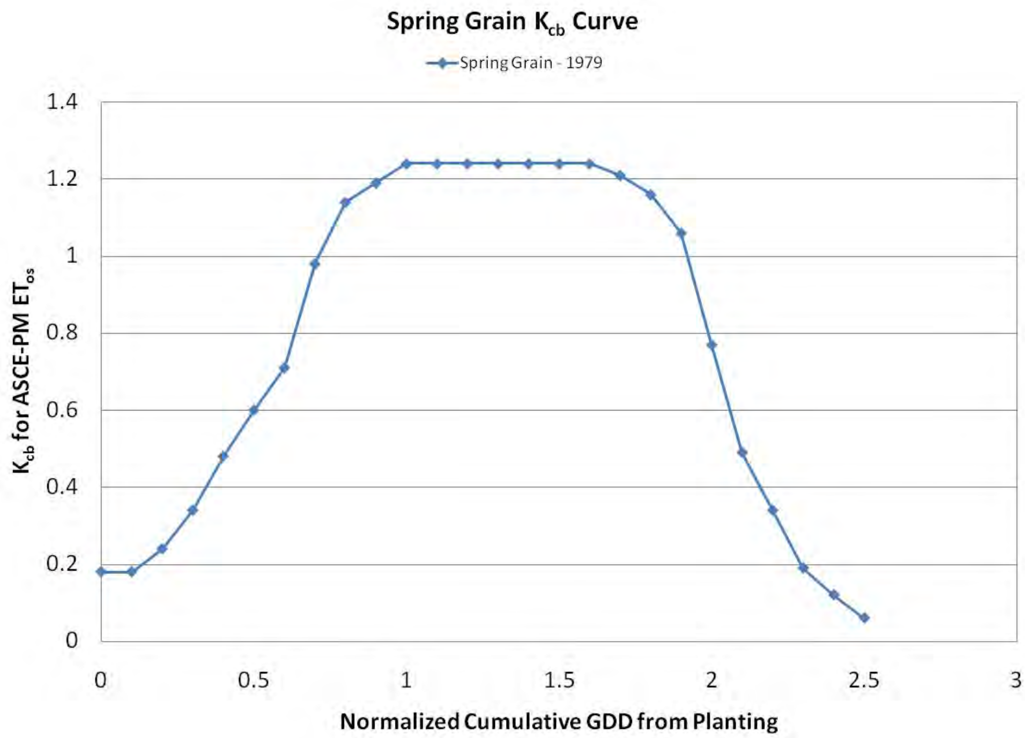


Figure 25. Spring grain K_{cb} curve.

due to cold shock. Finally, if T_{min} was below –4°C, then the GDD for that day was assumed to be zero regardless of the T_{max} or T_{mean} to reflect no growth during the day due to cold shock. These adjustments are from Allen and Robison (2007) and were based on personal communication between Wright and Allen (2002) and observations of winter behavior of winter wheat in southern Idaho by Allen and Robison. No adjustments were made to spring grain.

Potatoes

Potato crops were separated into two classes, a) long season varieties representing baking potatoes and varieties that are harvested in September and October, and b) short season varieties representing processing potatoes that begin to be harvested as early as August. Planting and development dates for both varieties are generally similar and therefore a single curve was used for the period between planting and effective full cover. Separate curves were used from effective full cover to harvest and both are based on a normalized cumulative growing degree-day scale. The K_{cb} vs. NCGDD relationship for the long season class was developed from Wright (1982). The K_{cb} vs. NCGDD relationship for the short season class was developed from the long season variety and modified by shortening the relative time required for maturity and reducing values of K_{cb} beginning at about 1.75 times NCGDD as shown in Figure 26. The recommended CGDD at harvest for the long season variety is about 1800 GDD and the short season variety is about 1600 GDD.

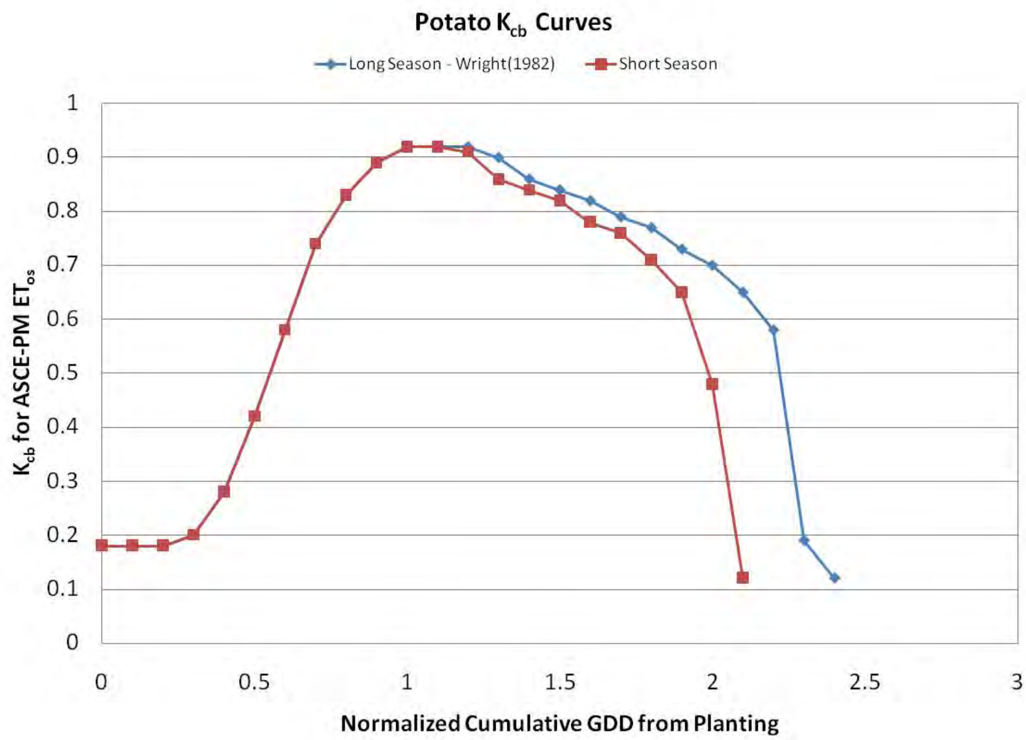


Figure 26. Potato K_{cb} curves for two different classes representing baking (long season) and processing (short season) potatoes.

Corn

Three different corn crops of field corn, sweet corn, and silage corn were simulated using K_{cb} vs. NCGDD curves from Wright (1982) for field corn and sweet corn (Figure 27). The silage corn K_{cb} vs. NCGDD curve was derived from the field corn curve by reducing the field corn K_{cb} beginning at NCGDD = 2.2 and terminating at 0.1 at NCGDD = 2.3. The silage K_{cb} curve ends sooner than field corn due to the abrupt end of the season when it is harvested. Sweet corn also has a shorter life cycle than field corn, since it is harvested during the ‘milk’ stage of the ear as opposed to silage corn that is harvested at a later stage.

Beans

The K_{cb} vs. NCGDD curve for snap beans (also known as dry, edible beans) was derived from Kimberly, ID lysimeter data for a snap bean crop grown in 1973 (Figure 28). The fresh snap beans K_{cb} vs. NCGDD curve was derived from the dry snap beans curve by terminating the curve at NCGDD = 1.6, which represents harvest.

Sugar Beets

The K_{cb} vs. NCGDD curve for sugar beets from Wright (1982) was adopted for this study and was derived from 1975 lysimeter data for a crop of sugar beets (Figure 29).

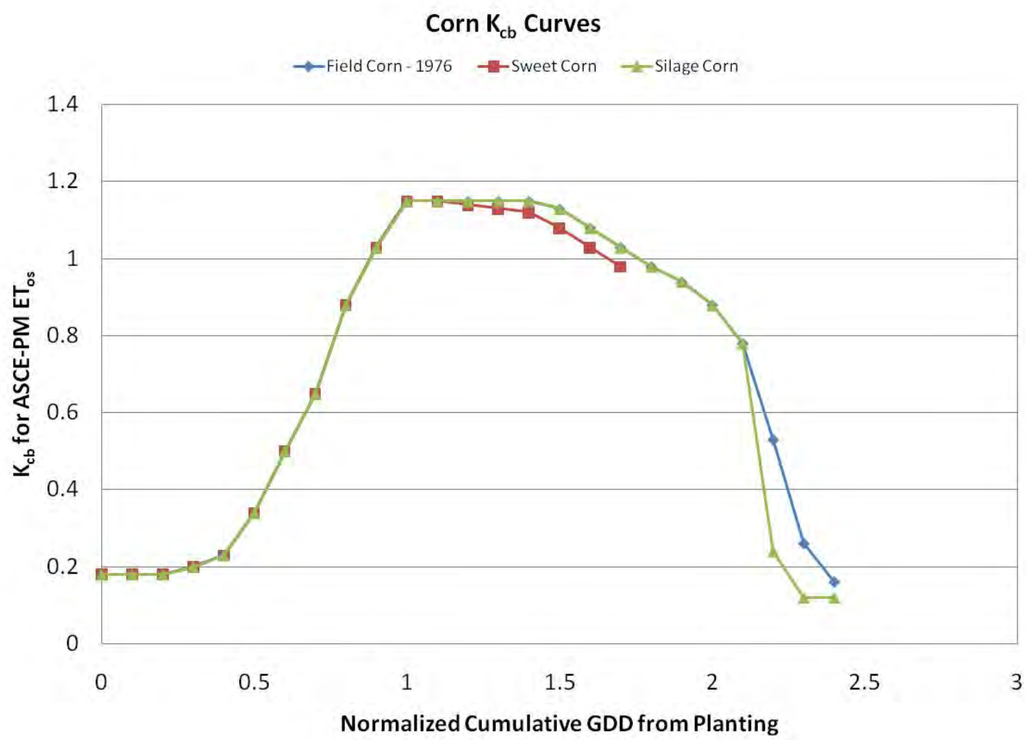


Figure 27. Corn K_{cb} curves for three different classes representing field, sweet, and silage corn.

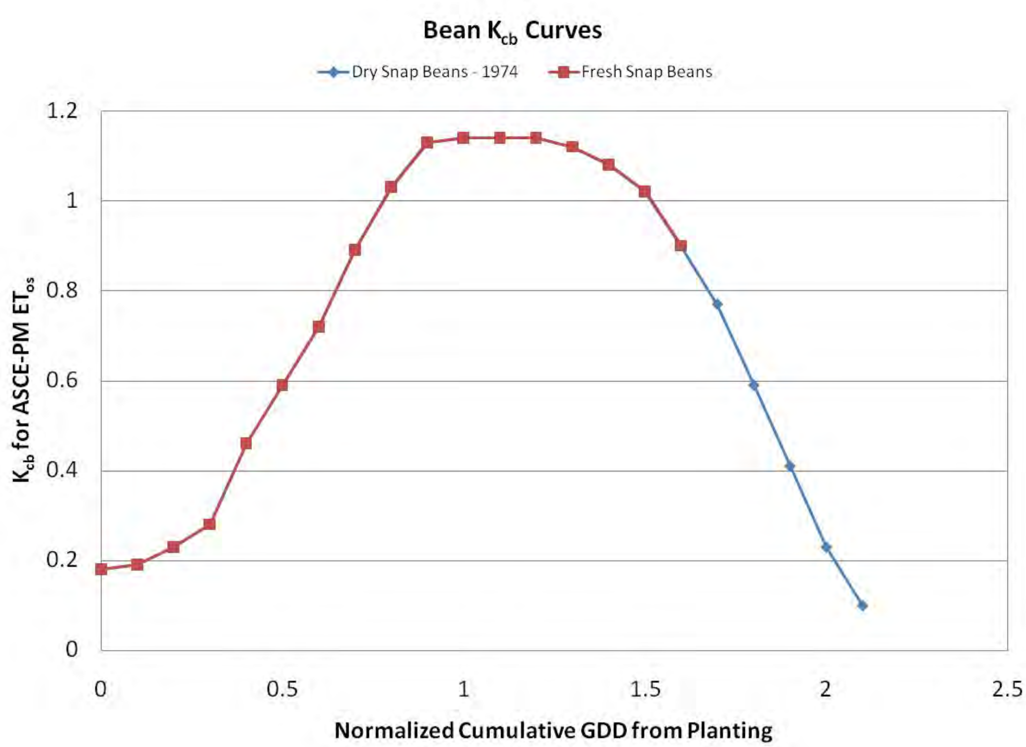


Figure 28. Bean K_{cb} curves representing dry and fresh snap beans, which are harvested earlier than dry beans.

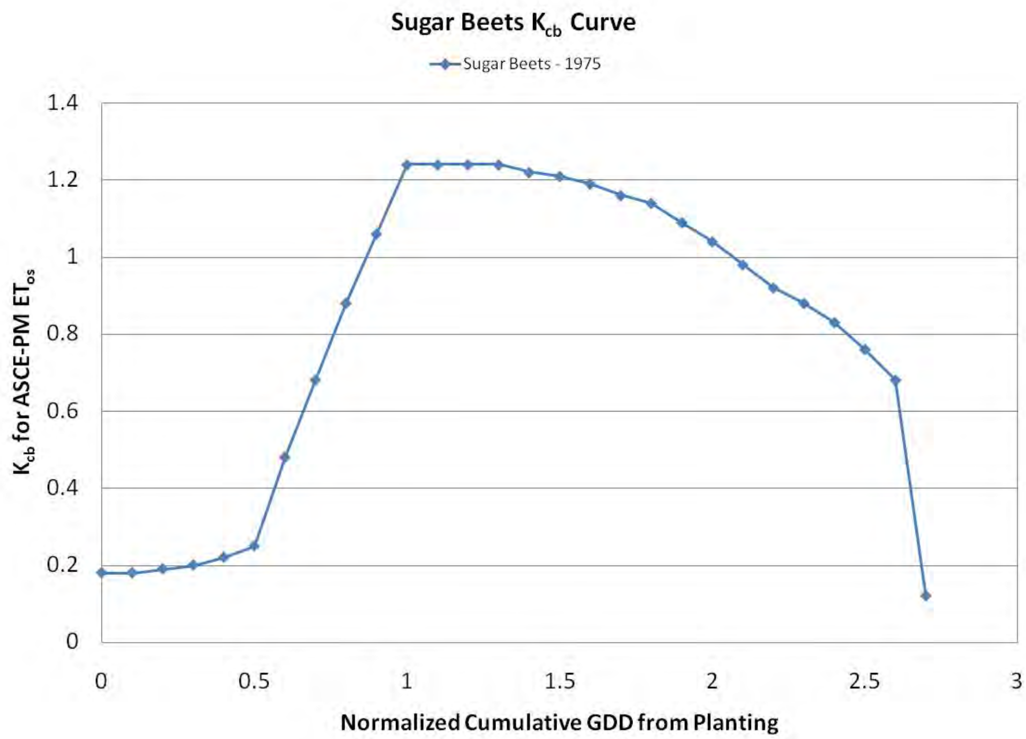


Figure 29. Sugar beet K_{cb} curve.

Peas

Dry peas (for seed) and fresh peas were simulated using the K_{cb} vs. NCGDD curve for dry peas from Wright (1982), derived from lysimeter data from a crop of dry peas in 1977. The K_{cb} vs NCGDD curve for fresh peas was derived from the dry peas curve by terminating the curve at NCGDD = 1.6, which represents harvest (Figure 30).

K_{cb} based on percent time from planting or greenup to effective full cover, with this ratio extended until termination:

Onions and Garlic

The onion and garlic K_{cb} curve (Figure 31) was developed from the K_{cmean} curve of AGRIMET by multiplying by 0.75 to adjust to a basal condition and adding values of 0.15 during the planting to emergence period, as AGRIMET K_{cmean} curves characteristically begin only at emergence. The 25% difference between the AGRIMET mean K_c curve and the K_{cb}

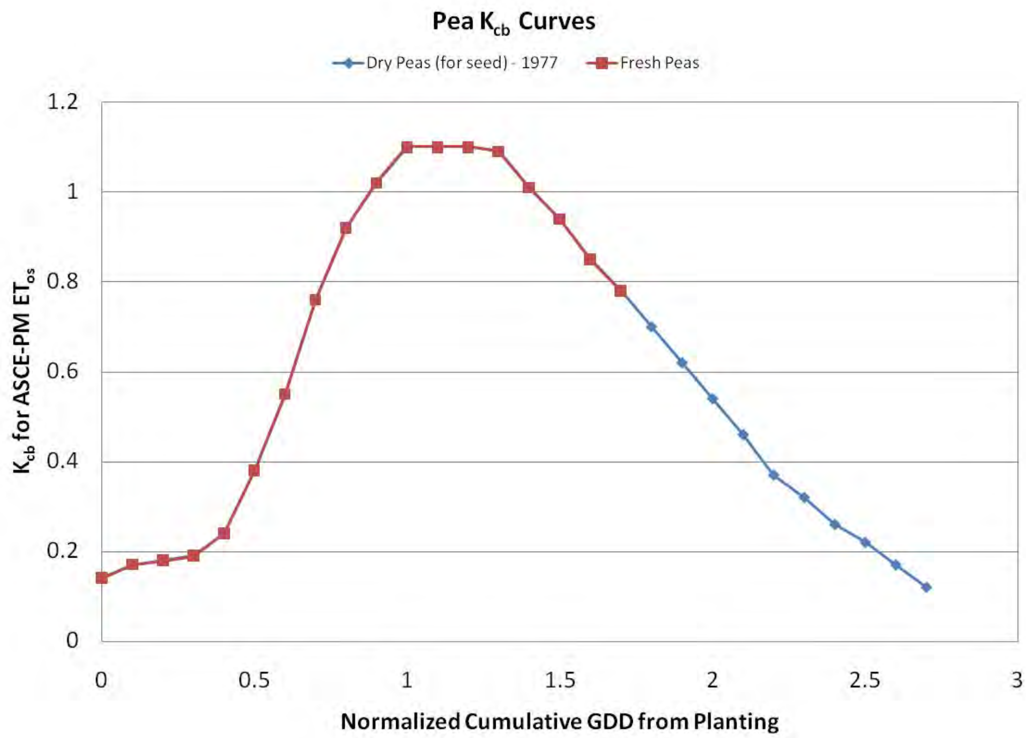


Figure 30. Pea K_{cb} curves for dry peas (for seed) and fresh peas, which are harvested earlier.

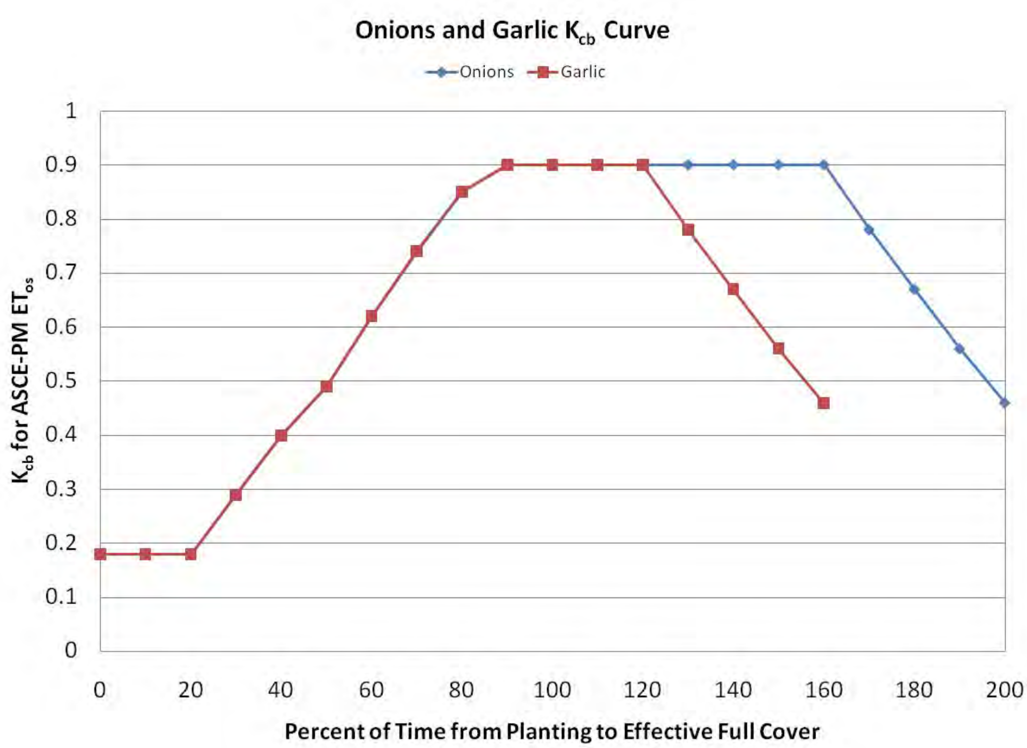


Figure 31. Onion and garlic K_{cb} curves modified from AGRIMET. Garlic was terminated earlier due to earlier harvest.

curve is to account for the evaporation component that is embedded in the AGRIMET mean K_c curve. Evaporation is considered separately in the dual crop coefficient approach employed in this study. The full cover date was approximated by AGRIMET, when half of the onion stand has about 12 leaves. For applications in this report, 80 days from planting to effective full cover was assumed, with generally an early April planting and mid September harvest. The garlic K_{cb} curve was created by shortening the onion curve by 20% to account for the cease in irrigation that takes place to dry the garlic before harvest, which is about 3-4 weeks before onions, usually in mid July to early August in central western Nevada.

Wine Grapes

The K_{cb} curve for wine grapes (Figure 32) is similar to the K_{cmean} curve used by AGRIMET and modified by Allen and Robison (2007), where the AGRIMET curve was extended past 200% of time from greenup to effective full cover to 270% by the addition of K_{cb} = 0.72. This extension is to allow the grape K_{cb} curve to extend until frost, which is when grape leaves in Nevada typically brown.

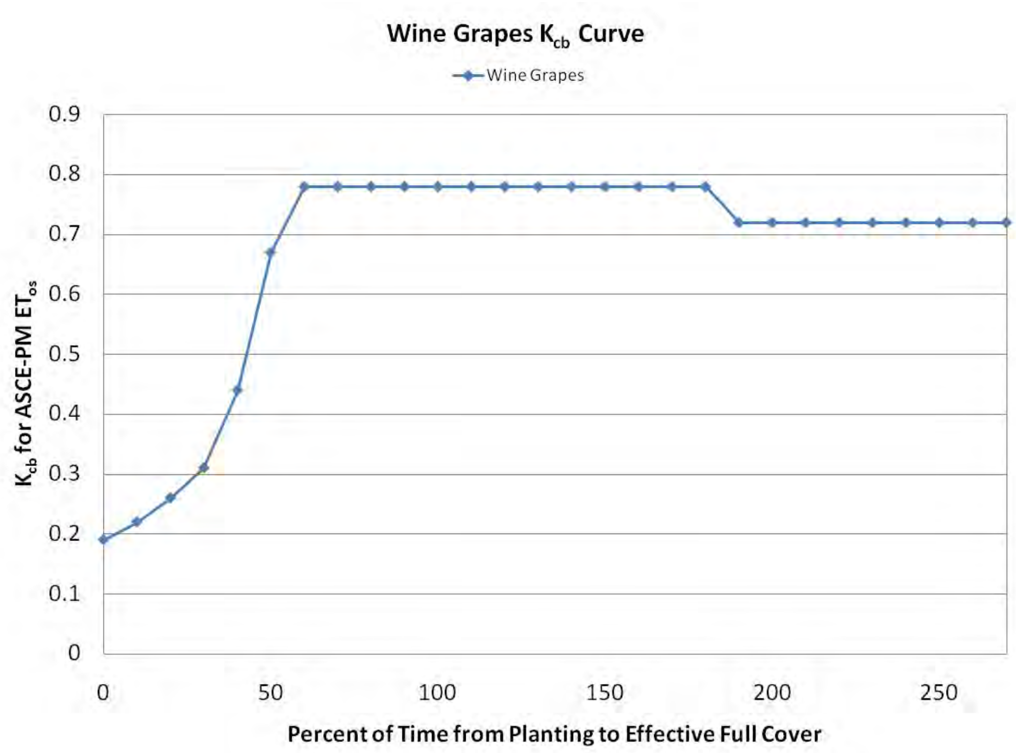


Figure 32. Wine grape K_{cb} curve modified from AGRIMET.

Melons

The melon K_{cb} curve (Figure 33) was derived from AGRIMET by shifting the curve in time by the equivalent of 10 days to account for the period between planting and emergence, as AGRIMET K_{cmean} curves characteristically begin only at emergence.

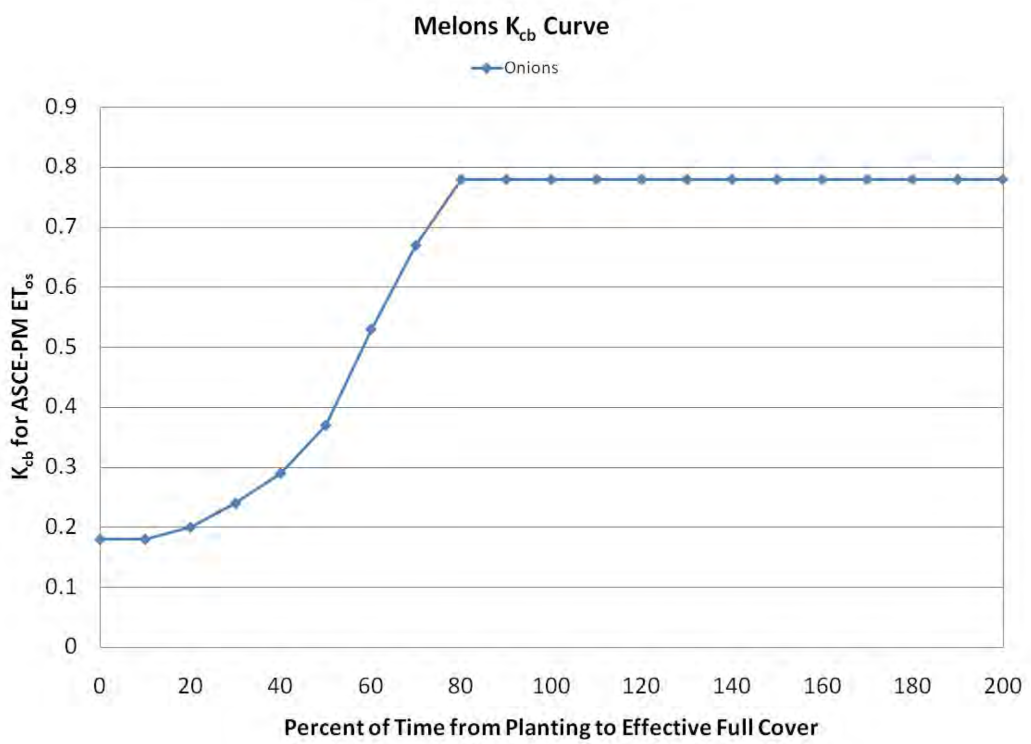


Figure 33. Melon K_{cb} curve modified from AGRIMET.

Hops

The K_{cb} curve for hops (Figure 34) was derived from a K_{cmean} curve developed by Wright (Pers. Comm., 2003) for use with AGRIMET. The K_{cb} curve was derived by subtracting 0.05 from the AGRIMET K_{cmean} curve to convert to a basal curve.

Orchards

The K_{cb} curve for orchards (Figure 35) was developed for apple/cherry orchards having ground cover of grass or other vegetation, and no ground cover, and based on FAO-56 K_{cb} data. The general curve shape was made similar to the AGRIMET apple K_{cmean} curve by approximating the effective full cover to occur approximately 55 days after bloom or greenup. Both K_{cb} curves were progressed through percent of time from greenup to effective full cover until the killing frost. K_{cb} was reduced after 175% of time from greenup to effective full cover to account for leaf aging.

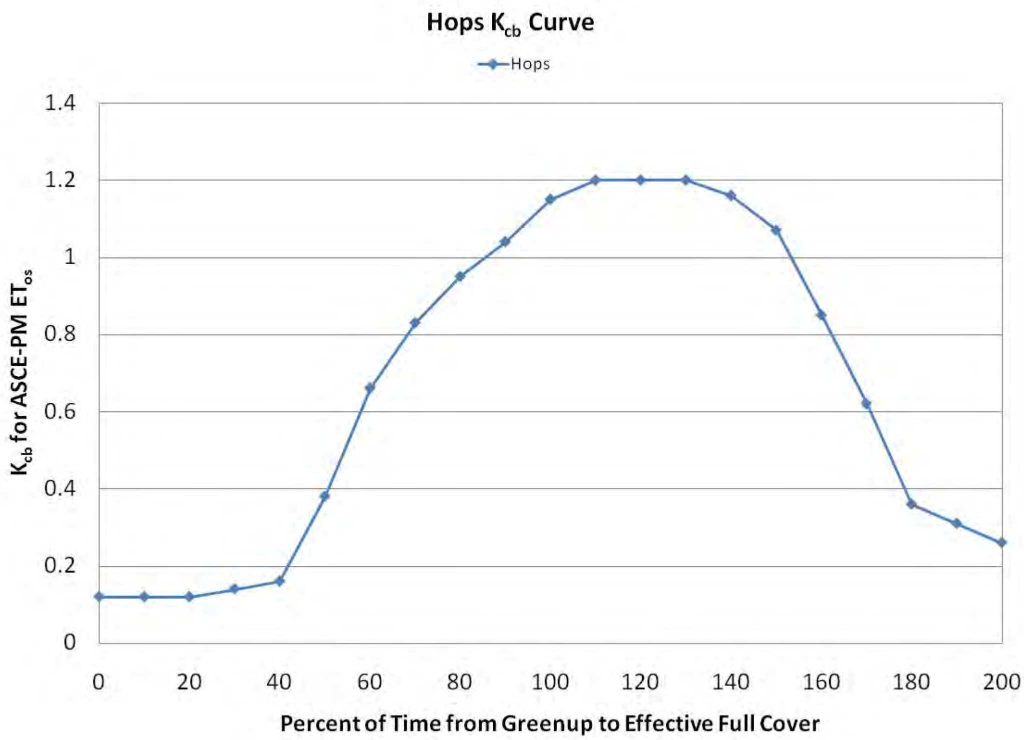


Figure 34. Hops K_{cb} curve modified from AGRIMET.

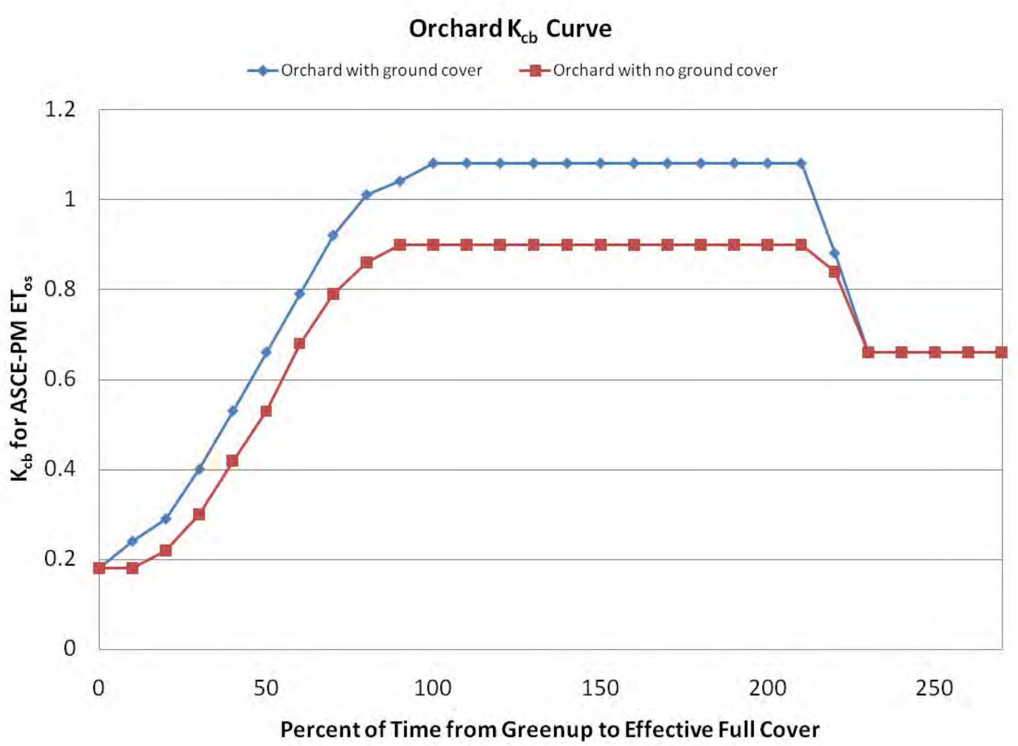


Figure 35. Orchard K_{cb} curves modified from FAO-56 and AGRIMET.

Canola and Sunflower/Safflower

The K_{cb} curve for canola (Figure 36) was patterned after the AGRIMET rapeseed curve, but with 7 days added to the beginning of the curve to account for the planting to emergence period and 0.03 subtracted during the midseason to convert the K_{cmean} AGRIMET curve to a K_{cb} curve. The sunflower/safflower curve was developed by Allen and Robison (2007) from the canola K_{cb} curve by subtracting 0.10 during the peak period to account for less dense planting and ground cover for sunflower and safflower as compared to canola and for the tendency of these plants to exhibit some stomatal control under high vapor pressure deficit conditions (Tardiew et al., 1996).

Turf Grass

The K_{cb} curve for lawn or turf grass (Figure 37) was developed from the AGRIMET turf K_{cmean} curve by subtracting 0.10 during the peak period to convert the curve to a K_{cb} type curve. The curve was progressed at a constant K_{cb} value until killing frost. The resultant K_{cb} values are similar to FAO-56 turf grass K_{cb} values.

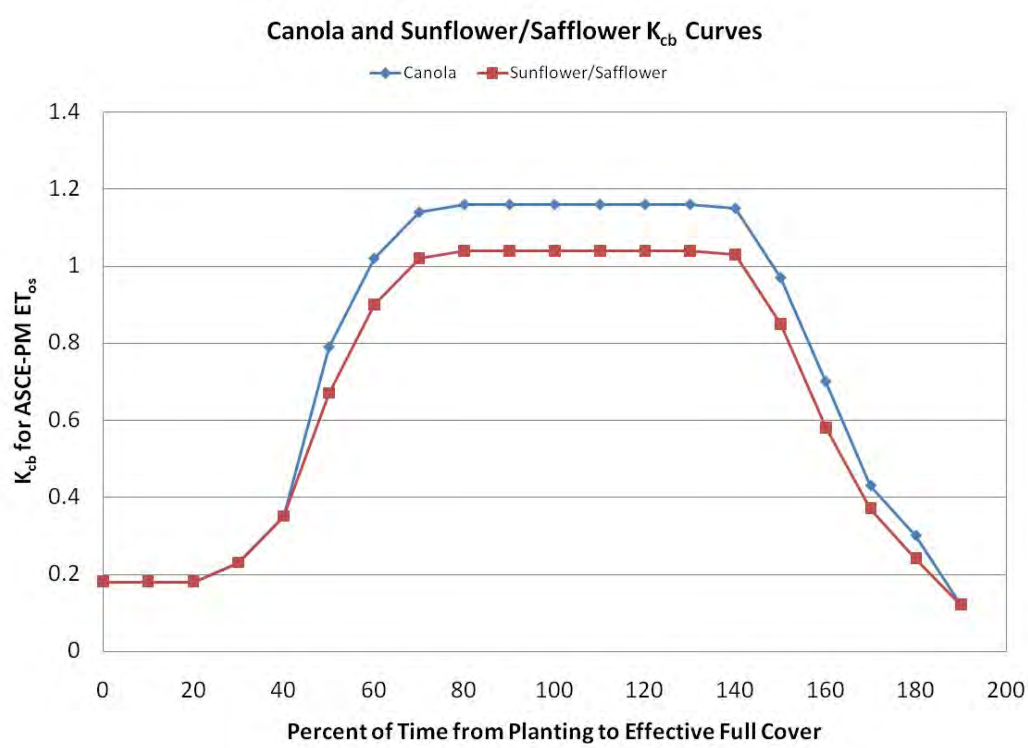


Figure 36. Canola and Sunflower/Safflower K_{cb} curves modified from AGRIMET.

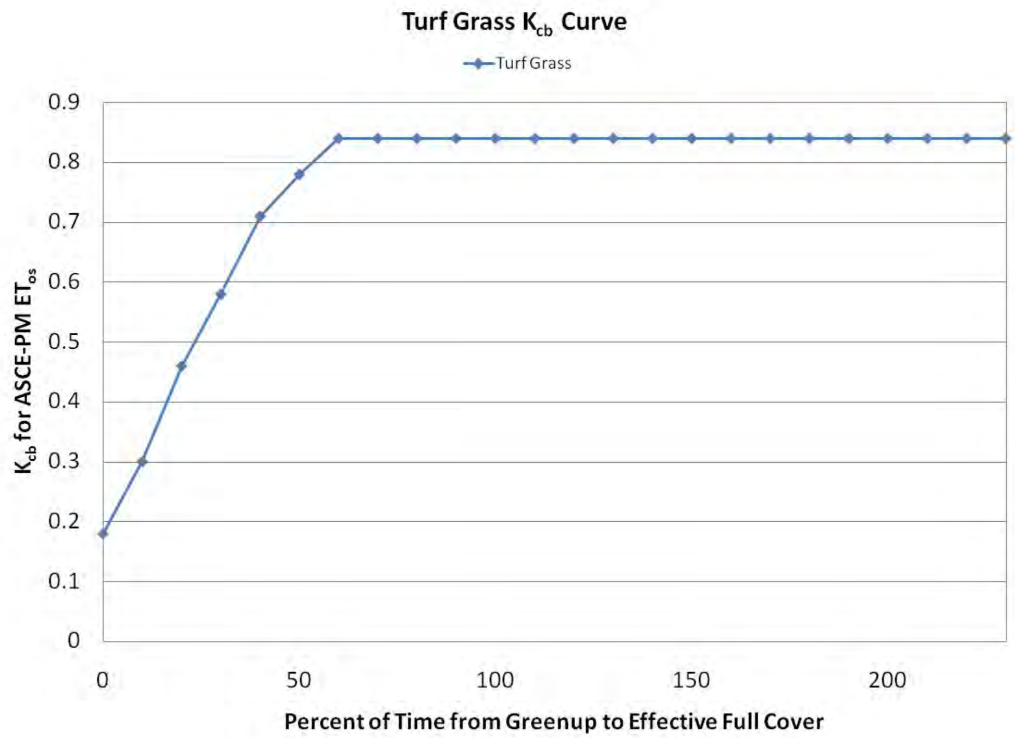


Figure 37. Turf grass K_{cb} curve modified from AGRIMET.

<u>K_{cb} vs. Percent Time from Planting or Greenup until Effective Full Cover and Days After Effective Full Cover:</u>

<u>*Pasture Grass*</u>

Pasture grass was simulated using two different K_{cb} curves (Figure 38). The first K_{cb} curve represents a pasture having high management and rotated grazing, while the second K_{cb} curve represents having relatively low management and with less vigorous growth and with sustained lower grazing height. The two curves were developed by Allen and Robison (2007) from the AGRIMET K_{cmean} curve for pasture by multiplying by 1.17 for the high management K_{cb} curve so that the peak K_{cb} equals 0.96, and by multiplying by 0.88 for the low management K_{cb} curve so that the peak K_{cb} equals 0.72 (these values are equivalent to 0.8 and 0.6 for an alfalfa reference basis). In addition, the AGRIMET curve was converted to a percent time from greenup to effective full cover and days after effective full cover so that the K_{cb} curves would equal 0.48 and 0.36, for highly managed and low managed pasture grass, respectively, during the fall until terminated by a killing frost.

<u>*Alfalfa Seed*</u>

The alfalfa seed K_{cb} curve (Figure 39) was adopted from Allen and Brockway (1983), but with 0.05 subtracted to convert to a K_{cb} curve.

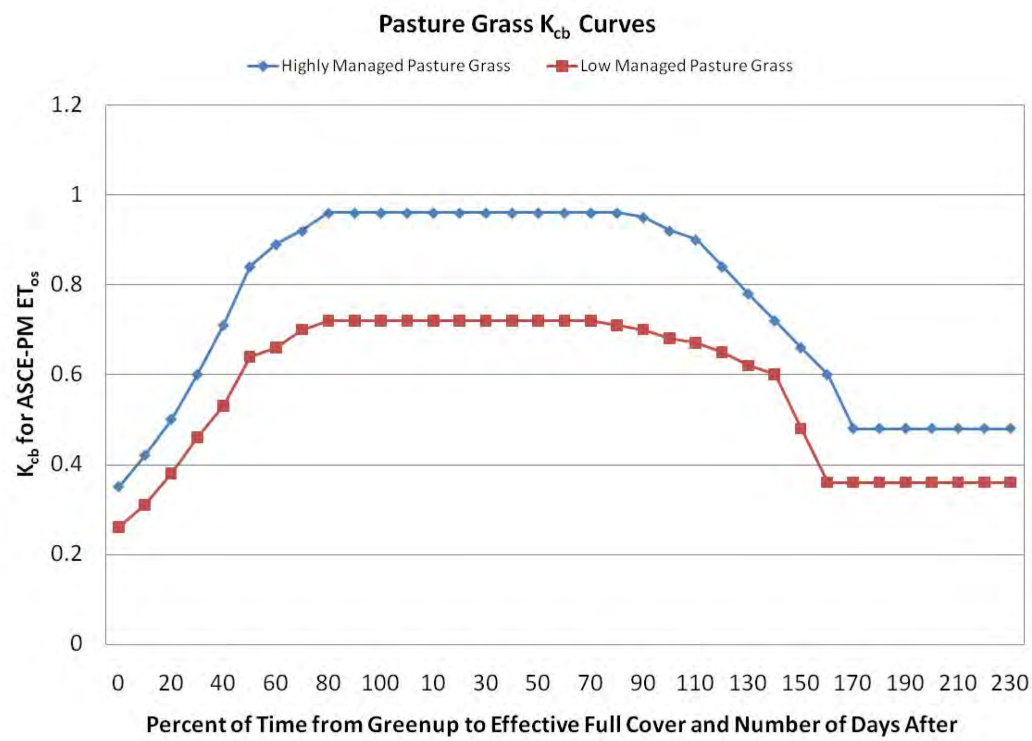


Figure 38. Pasture grass K_{cb} curves representing two classes of highly managed rotated grazing with significant re-growth height, and low management pasture grass with sustained lower grazing height.

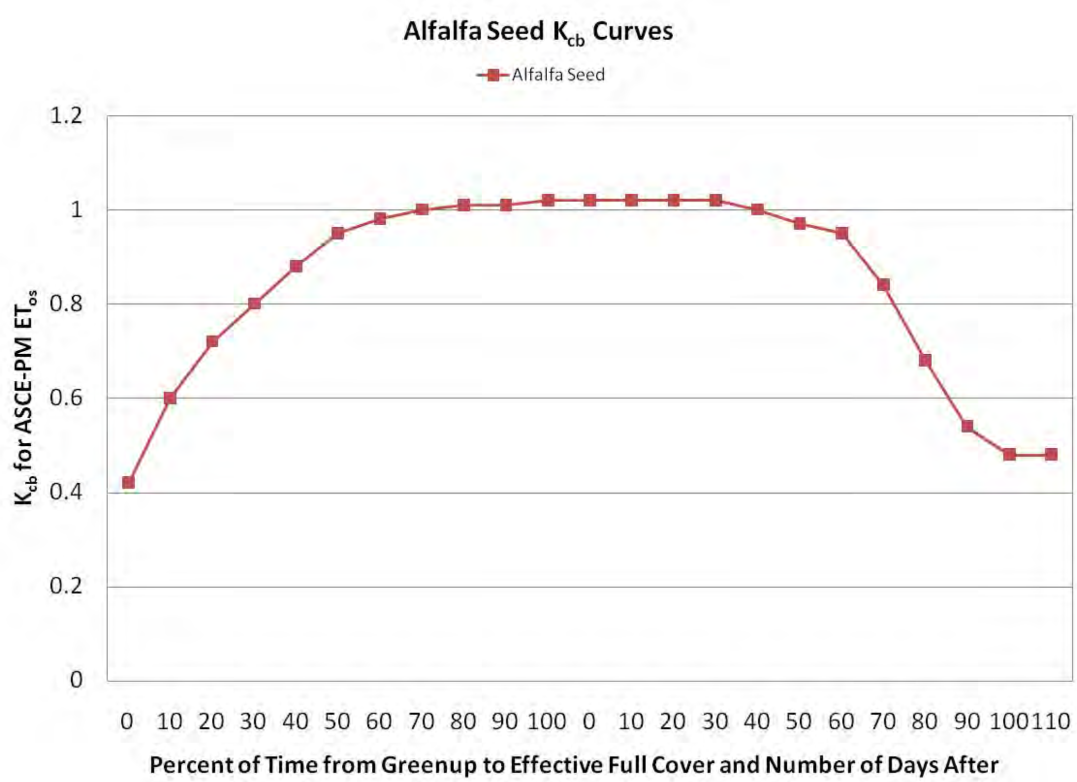


Figure 39. Alfalfa seed K_{cb} curve modified from Allen and Brockway (1983).

Termination and Killing Frosts

Killing frosts can terminate growing seasons prematurely for crops that grow late into fall or for crops that are sensitive to even light frosts. Temperatures for killing frosts were adopted from Allen and Robison (2007), which were derived from literature and internet searches, and personal field observations and notes from southern Idaho. Appendix 5 lists killing frost temperatures as well as all crop parameters used in this study.

Aridity Rating

Most NWS weather stations in Nevada are not located in agricultural areas. Local aridity of the area surrounding the weather station can elevate air temperature measurements above that expected within an agricultural field. This elevation in temperature can cause the progression of CGDD and NCGDD to over-accelerate. Therefore, to account for local aridity effects on CGDD and T_{30} impacting the computation of the beginning and ending of the growing season, the measured average daily temperature was reduced according to estimated station aridity. The amount of maximum adjustment to the measured average daily temperature is listed in Table 5, by month, where adjustments are in proportion to the % aridity. Aridity ratings for weather stations were computed following procedures outlined by Allen and Brockway (1983), where the station, local, and regional aridity is rated from 0-100 (0=irrigated and 100=completely arid), and the cumulative aridity is computed as 0.4(station aridity)+0.5(area aridity)+0.1(regional aridity). The qualitative analysis for assigning aridity ratings was based on NWS weather station photos requested from various NWS Nevada field offices and high resolution imagery, where the station location was analyzed in terms of the degree of aridity or lack of available moisture surrounding the stations. The local station aridity was based on land use within the immediate area of the station (~50m), area aridity of the station (~1500m), and regional aridity of the station (50km) following Allen and Pruitt (1986). The adjustment to temperature was to subtract the adjustment from both T_{max} and T_{min}.

Table 5. Aridity adjustments to the average temperature for stations having aridity ratings of 100% following Allen and Brockway (1983). A linear adjustment was assumed for stations having less than 100% aridity.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Aridity Adjustment (^{o}C)	0	0	0	1	1.5	2	3.5	4.5	3	0	0	0

Aridity ratings for all weather stations used in this study are reported in Appendix 8. The aridity adjustment to the measured average daily temperature was applied before the calculation of CGDD since the CGDD thresholds ‘expect’ to have input from weather stations having relatively well-watered surroundings. Conversely, the aridity adjustment to the average daily temperature was made after computation of ET_{os} because the air temperature and dewpoint temperature used to calculate ET_{os} are already paired, based on K_o, as described earlier, so that the VPD in the ET_{os} calculation is generally representative of a reference condition (Allen et al., 1998; ASCE-EWRI 2005).

Non-growing Season Evapotranspiration

ET during the non-growing season varies widely depending on the availability of soil moisture, freezing of soils, snow cover, condition and amount of dormant vegetation, and availability of energy for ET. Estimation of non-growing season ET is important for maintaining the soil and root zone water balance and estimating the amount of non-growing season precipitation that accumulates during the non-growing season that is available during the start of the subsequent growing season.

Few studies have been performed where ET has been measured from dormant agricultural vegetation during the non-growing season. Wright (1991, 1993) conducted a series of non-growing season measurements of ET using the dual precision weighing lysimeter systems at Kimberly, ID, near Twin Falls, ID. The lysimeter surfaces included clipped fescue grass and bare soil conditions of disked wheat stubble, disked alfalfa, disked soil, dormant alfalfa, and winter wheat. Wright (1991, 1993) found that the K_{cmean} during the non-growing season rarely exceeded 1.0, for an alfalfa reference basis, even during periods having a constant supply of soil moisture from precipitation. Goodrich (1986) compiled water balance lysimeter measurements of non-growing season alfalfa ET at the Nevada Agricultural Experiment Station's Newlands Research Center in Fallon. Goodrich found that the average annual non-growing season (mid October – mid March) dormant alfalfa ET from 1974-1984 was 2.7 inches. Goodrich also reported that bare soil evaporation for the non-growing season of 1985-1986 was 1.2 inches. Unfortunately, no crop coefficients were developed in Goodrich's study.

Non-growing season K_{cb} of 0.12 was assumed in this study for bare soil conditions, surfaces covered with some amount of mulch, and for dormant turf. The K_{cb} represents conditions when these surfaces have a dry soil surface but with sufficient moisture at depth to supply some diffusive evaporation. The value was reduced during calculations if the soil moisture becomes overly dry during extended period of no precipitation. The evaporation component, K_e, is estimated separately in the daily soil water balance, where K_c max during the non-growing season was assumed to equal 1.1 for bare soil, 1.0 for mulched surfaces, and 0.96 for dormant grass cover. The lower value for grass is to account for insulation effects of the grass and higher albedo. The surface of mulch was used to represent surfaces that are part way between bare and grassed conditions. The assumed effective fraction of cover for estimation of K_e (discussed in Annex 1) was 0.7 for dormant grass, 0.4 for mulch, and 0 for bare soil.

The effective rooting zone of 0.10m was assumed during the non-growing season for mulch and dormant turf. A stress coefficient was applied during the non-growing season for all dormant mulch and dormant turf so that when the depletion of soil water dropped below the RAW for the upper 0.10m or effective root zone, the actual K_c was reduced below the K_{cb}, representing the condition when both the ground surface and subsurface soil was dry. The non-growing season was defined as the period beginning at the end of a K_{cb} curve representing the growing cycle for a specific crop or the occurrence of a killing frost, and ending at greenup or planting of the same crop the following season. All crop types were assigned one of the three non-growing season cover conditions of dormant grass, bare soil, or mulch for the estimation of ET during the non-growing season (Appendix 5).

During the non-growing season when ET demands are low, the depth of effective drying by evaporation decreases due to lower transport of heat into the soil profile and lower vapor pressures in the soil. This phenomena was accounted for following recommendations similar to those outlined in Allen et al., (2005) and Allen and Wright (2009), where if the 30 day average ET_{os} ending on the day in question was less than 4mm/day, then

$$TEW_{applied} = TEW\sqrt{\frac{ET_{os30}}{4}} \qquad \text{Eq. 51}$$

and the value for REW was limited to less than or equal to $0.7(TEW_{applied})$. Using ET_{os} as a surrogate for temperature and radiation conditions, this adjustment is recommended to account for cool periods where less energy is available for evaporation and the total effective TEW representing a drying event will typically be smaller than during a warm period.

Snow cover information from NWS stations was used to adjust the K_{cb} value to account for higher albedo of snow and absorption of heat by melt. The following algorithms were applied following Allen and Robison (2007) and Allen and Wright (2009) for the adjustment of K_{cb} as

$$K_{c\_multiplier} = 1 - K_{radiation\_term\_winter} + \frac{(1 - albedo_{snow})}{(1 - albedo_{surface})} K_{radiation\_term\_winter} \qquad \text{Eq. 52}$$

where the $K_{radiation\_term\_winter}$ represents the weighting of, or contribution to, winter time ET_{os} estimates by the radiation term of the ASCE-PM equation, $albedo_{snow}$ is the mean albedo of snow cover, and $albedo_{surface}$ is the mean albedo of the bare surface. Albedo of snow was assumed to be 0.8 and the albedo of the surface was set to 0.25. $K_{radiation\_term\_winter}$ is equivalent to

$$K_{raditation\_term\_winter} = \frac{\Delta}{\Delta + \gamma\left(1 + \frac{r_s}{r_a}\right)} \qquad \text{Eq. 53}$$

where Δ is the slope of the saturation vapor pressure-temperature curve, γ is the psychrometric constant, r_s is the surface resistance to vapor flow, and r_a is the aerodynamic resistance to heat and vapor flow above the surface. The intent of Eq. 52 was to adjust the ET_{os} estimate, which is parameterized to estimate the potential ET for a vegetation surface, not a snow covered surface. The primary adjustment is for albedo of the surface, which is higher for snow cover. For ease of calculation, $K_{radiation\_term\_winter}$ is calculated as a function of day of year based on a relationship derived using full years of Kimberly, ID, weather data and the ASCE-PM equation as

$$K_{radiation\_term\_winter} = (2.2E-08)J^3 - (2.42E-05)J^2 + 0.006J + 0.011. \qquad \text{Eq. 54}$$

An additional reduction in evaporation of 30% was made to account for absorbed latent heat of fusion of any melting snow prior to evaporation.

Some of the NWS stations report daily snowfall but do not report observed accumulated snow depth. In these cases, estimated depth of snow on the ground was made by accumulating snowfall and applying a simple melt rate function, following Allen and Robison (2007), as

$$Snow\_accumulation_i = Snow\_accumulation_{i-1} + \frac{Snowfall}{2} - Melt_i \qquad \text{Eq. 55}$$

and

$$Melt = 4T_{max} \qquad \text{Eq. 56}$$

where Snow_accumulation is the snow depth accumulation in mm, Snowfall is the reported snowfall depth for the day in mm, Melt is the melt rate in mm/day, and T_{max} is the daily maximum air temperature in ^oC. The snowfall amount is reduced by half in Eq. 55 as an approximation to settling of the snow. The snowmelt rate function was based on 50 years of snow cover and temperature observations in Ashton, ID by Allen and Robison (2007). The snow_accumulation parameter was calculated for all stations that reported snowfall.

Evaporation from Small Open Water Bodies

Small water bodies are common components to irrigation and municipal water supply systems. Estimating evaporation from open water bodies is complex. Energy balance variables that control the rate of evaporation include net radiation, heat storage, advection of heat into and out of the water body, and the transfer of sensible heat between the water and air. In addition, the aerodynamics of the water surface, turbidity of the water, and inflow and outflow rates control the rate of transfer between energy balance variables. For example, evaporation from a deep water body can be significantly lower than ET_{os} during the spring and summer due to the storage of heat from penetrating solar radiation beneath the water surface. An example of the effect of lake heat storage causing the lake evaporation to be lower than the ET_{os} in the summer and then higher than ET_{os} in the fall is shown for Walker Lake in Figure 40, where the Bowen ratio energy balance monthly estimated lake evaporation (Allander et al., 2009) is compared to

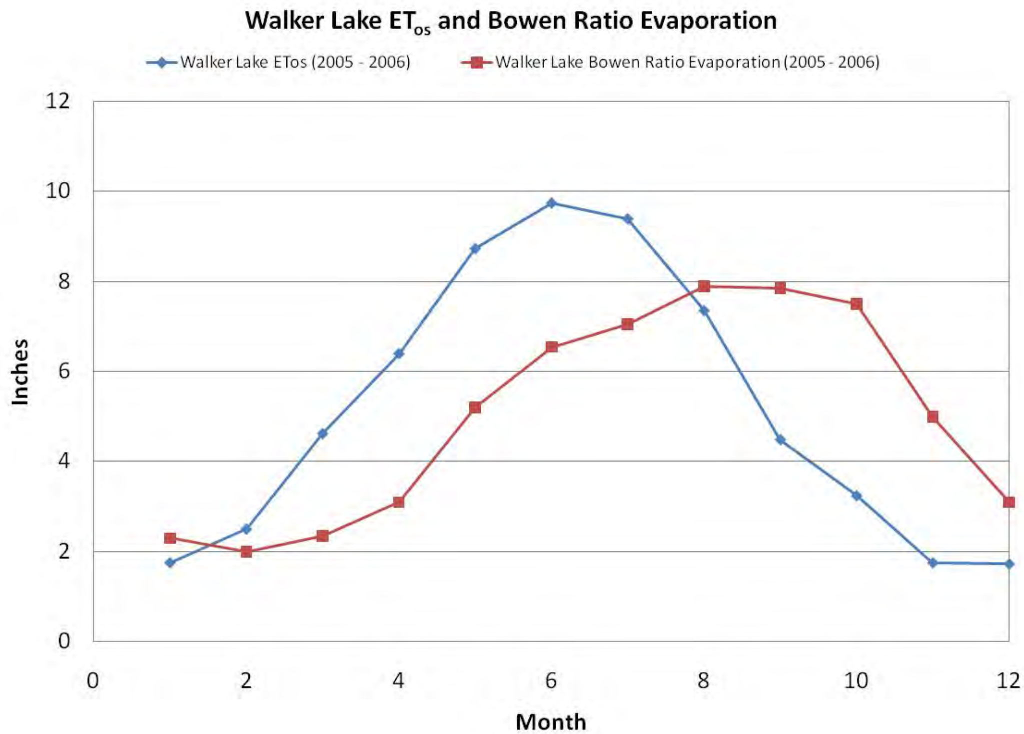


Figure 40. Walker Lake Bowen ratio energy balance estimated evaporation vs. calculated ET_{os} using Bowen ratio weather data. The illustrated shift in estimated Bowen ratio evaporation is due to heat storage in the summer months, and then the release of stored heat later in fall and winter.

the computed ET_{os} using weather variables measured at the Bowen ratio station. Later in the fall stored energy can be partitioned into evaporation, heating of the air, emission of long wave radiation, or advection of heat in the discharging water being released for irrigation. Because evaporation is a surface process, solar radiation stored as heat in the spring and summer months is not readily available for evaporation, rather heat storage is only available to the surface energy balance when transferred there by conduction or convection. During the conduction or convection of heat to the surface, air temperature is sometimes lower than the water temperature causing a large portion of energy to be partitioned from stored heat into sensible heat or long wave emission rather than evaporation, therefore reducing the total evaporation from the water body. In the example of Walker Lake, it appears that the heat stored in the summer is largely being partitioned into sensible heat in the fall when the water skin temperature is warmer than the air temperature. The skin temperature at the Bowen ratio station for respective time periods was estimated using MODIS (Moderate Resolution Imaging Spectrometer) satellite thermal imagery.

A number of recent studies have been conducted estimating evaporation from large open water bodies in Nevada and surrounding states (Allen and Tasumi, 2005; Allander et al., 2009; Westenburg et al., 2006; Trask, 2007). Estimating evaporation from large water bodies without significant amounts of field instrumentation is difficult due to the fact that each lake or reservoir has their own energy storage and energy exchange characteristics with the surrounding environment, which is a function of the hydrologic and physical characteristics of the water body, such as inflow and outflow volumes, water body depth and geometry, water turbidity, and topography and climate of the surrounding environment. For simplicity, this report only focuses on estimating open water evaporation from small, shallow (<5m) open water bodies, where impacts of energy storage are smaller and energy exchange with the surrounding environment is more similar to that of irrigated vegetation. Many studies have estimated evaporation from small, shallow water bodies using combination equations (i.e., combination of mass transfer and energy budget principles such as the Penman and Penman-Monteith equations). Such an approach was used in this report, where the ASCE-PM method was used to calculate the ET_{os}, and the ET_{os} was multiplied by a coefficient of 1.05 following recommendations outlined in FAO-56 (Allen et al., 1998). Evaporation estimates using the ET_{os} approach assume that no freezing occurs. The evaporation rate for open water will tend toward zero during periods of ice cover, therefore open water evaporation estimates in this study could be slightly inflated during winter months because ice coverage was not considered. In addition, deep open water systems could have significantly lower evaporation rates than those published in this report due to reasons summarized above. Additional measurements of evaporation using eddy correlation methods over a variety of open water surfaces are needed to characterize energy balance and physical properties of open water bodies so that more accurate estimates of open water evaporation using simplified methods can be developed and validated.

RESULTS

Reference ET, Actual Crop ET, and Net Irrigation Water Requirements

Reference evapotranspiration (ET_{os}), actual crop ET (ET_{act}), and the net irrigation water requirement (NIWR) were calculated for up to 34 different crop and land cover types at a daily time step using 190 weather stations shown (Figure 1) and the ASCE-PM grass reference equation and dual crop coefficient approach following methods outlined in FAO-56, Allen et al., (2005), and Allen and Robison (2007). Numerous ET and water balance related results for each weather station are organized by time series of daily, monthly, annual, and statistics files, which can be found on Nevada Division of Water Resources' website, water.nv.gov/NVET, and are also available by request. Details and definitions of variables included in daily, monthly, annual time series and statistics files are described in Appendix 9. For the purpose of assessing the amount of water available for water transfers from agriculture to some other use, the most useful result of this report is the mean annual NIWR. The NIWR is defined as the ET_{act} minus precipitation residing in the root zone, and represents the amount of additional water that the crop would evapotranspire beyond precipitation residing in the root zone. The NIWR is synonymous with the terms net consumptive use and precipitation deficit. Precipitation residing in the root zone, P_rz, is the amount of gross reported precipitation that infiltrates into the soil and that remains in the root zone for consumption by evaporation or transpiration. Although P_rz includes precipitation that is later evaporated and not "consumed" by the crop, it is important to note that because ET_{act} includes evaporation of precipitation, ET_{act} – P_rz represents the net irrigation water requirement, and not ET_{act} – P_rz that is effective toward transpiration only (see Appendix 9 for further details). P_rz was computed as P – Runoff – $DPerc_p$ where P is gross reported precipitation, Runoff is estimated surface runoff and $DPerc_p$ is deep percolation of any precipitation below the maximum root zone for the crop or land-use condition. A list of the crops for which ET_{act} and the NIWR were estimated at each weather station is presented in Appendix 10. Crops grown in limited areas in the state, such as onions, were only simulated at weather stations located near areas where they are known to be grown. Crops of alfalfa, pasture grass, grass hay, turf grass, and small shallow open water bodies were simulated at every weather station.

Examples of the daily estimated ET_{os}, ET_{bas}, and ET_{act} at Fallon, Yerington, and Minden for crops of alfalfa, onions, and pasture grass, respectively, are illustrated in Figures 41a-c. Also included in these figures are the simulated K_c and K_{cb} curves, simulated irrigations, and measured precipitation to illustrate the affect of cuttings and wetting events on the K_c curve ($K_{cb}*K_s+K_e$) and ET_{act}. The difference between the ET_{act} and the basal ET ($ET_{bas} = ET_{os} * K_{cb}$) represents the contribution of bare soil evaporation from irrigation and precipitation events. Using time series results for all stations and crops analyzed, the mean annual NIWR were computed for the last 30 years of record available, with a minimum of 4 complete years. Figure 42 illustrates the large spatial variation of the NIWR of alfalfa, which can be attributed to the spatial variability in ET_{os} (Figure 43), growing season length, and precipitation amount. In general, HAs located in southern parts of Nevada experience a NIWR that is larger than the typical permitted irrigation water right of 5ft/yr (1,524mm/yr), and in central and northern areas of Nevada the NIWR is less than the typical permitted irrigation water right of 4ft/yr (1,219mm/yr). Weather station estimates of the mean annual ET_{os} and ET_{act} are listed for alfalfa, grass hay, pasture grass, turf grass, and open water for each station sorted by weather station and HA name in Appendix 11a-b and the NIWR in Appendix 12a-b.

For purposes of estimating the mean annual NIWR per HA, weather stations located in upland and mountain block areas were omitted, and mean annual NIWR estimates for weather stations located on valley floor areas representative of potential agricultural areas were assigned to respective HAs based on single weather station estimates, or period of record weighted average estimates for HAs with multiple weather stations. For an example of the assignment, weighting procedure, and weather stations used in assigning or averaging the ET_{act} and NIWR for each HA, see Appendix 13. Several HAs include weather stations that are not located within the HA, but are near the boundary or considered representative, and therefore were used in assigning or computing the weighted average NIWR.

Of the 256 HAs in the state, 160 are absent of weather stations from which to estimate the ET_{act} and NIWR, therefore spatial interpolation of valley floor weather station estimates of ET_{act} and NIWR was performed for alfalfa, grass hay, pasture grass, turf grass, and small shallow open water bodies using the inverse distance weighting squared technique. Other spatial interpolation techniques that consider independent variables such as elevation were explored, however results were highly variable and inconsistent. Therefore, a simple inverse distance weighting technique was chosen where spatially interpolated surfaces of the ET_{act} and NIWR for the major crops previously discussed were averaged to each HA. Appendix 14 and 15 list the ET_{act} and NIWR of alfalfa, grass hay, pasture grass, turf grass, and small shallow open water bodies for each HA, and denotes the HAs for which the ET_{act} and NIWR were estimated using spatial interpolation. Plate 1 illustrates the estimated NIWR of alfalfa for each HA. The assignment and spatial interpolation of the NIWR for all HAs was limited to crops of alfalfa, grass hay, pasture grass, turf grass, and small shallow open water bodies. For HAs where the NIWR of specific crops are of interest, such as melons in Carson Desert, onions in Mason and Smith Valley, potatoes in Paradise Valley, etc., see Appendix 16 for a limited summary. For additional HAs and crops of interest, see electronic statistical summaries by station number. Descriptions of the statistical summaries are given in Appendix 9.

An interesting but not surprising result worth noting are the trends in simulated growing season lengths for alfalfa, as computed using a CGDD from Jan 1 of 300^{o}C-day and killing frost of -7^{o}C. Results of simulated growing season lengths indicate generally increasing trends over time due to increased average daily temperatures and minimum temperatures. Likewise simulated annual ET_{pot} ($ET_{pot} = ET_{os} * K_{cb} + K_e$) has also increased due to increased temperatures and growing season length. ET_{pot} was analyzed instead of ET_{act} to avoid the effects of any stress (K_s) caused by limiting water conditions that may occur during the non-growing season or early parts of the growing season. Examples of increases in simulated growing season lengths and annual ET_{pot} over time for alfalfa are illustrated in Figure 44a-e for selected weather stations in Nevada that have long periods of record. Several researchers have found similar results of increasing growing season lengths due to earlier spring greenup (Manzel and Fabian, 1999; Walther et al., 2002; Parmesan and Yohe, 2003) and later occurring frosts (Cooter and LeDuc, 1995; Easterling, 2002; Kunkel et al., 2004), resulting in increases in ET and intensification of the global water cycle (Brutsaert and Parlange, 1998; Golubev et al., 2001; Walter et al., 2004; Huntington, 2006). Although it is clear that the annual ET_{pot} is increasing through time for some stations, in this report the last 30 years of record was used to compute the average NIWR for purposes of evaluating the amount of water available for water transfers when converting existing irrigation water rights to some other use. Some of the observed trends in growing season length and ET_{pot} are caused by changes in relative dryness of the local or regional environment due to irrigation development or land-use change, by station location or relocation, or perhaps by change in overall climate. The last 30 years of usable record were considered to be more representative of expected future conditions than prior periods. The full records for each station are preserved in the daily, monthly, and annual time series files. Therefore, statistics for the full periods of record can be computed as needed from these data sets.

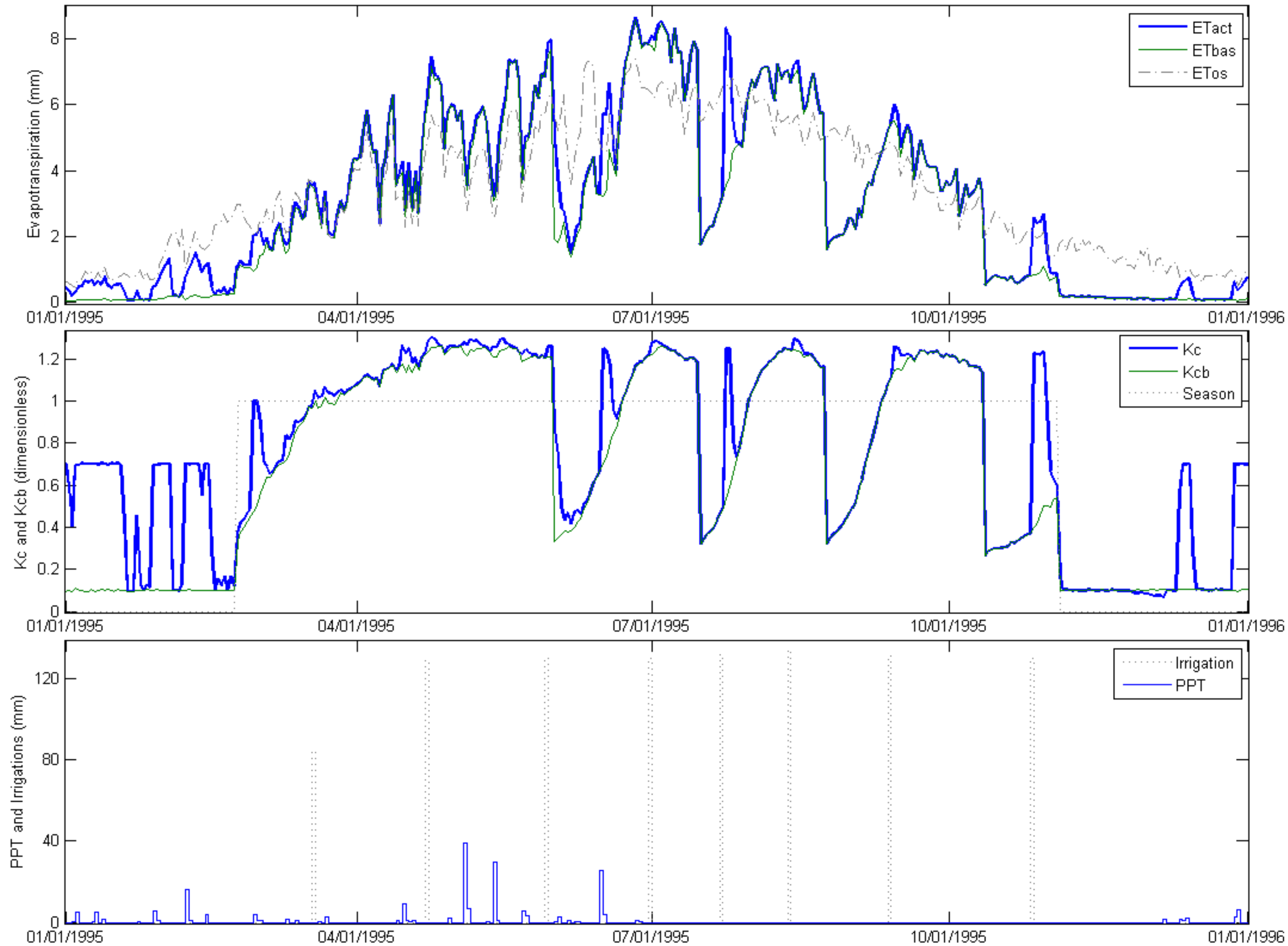


Figure 41a. Simulated alfalfa ET_{act} (top graph) and K_c (middle graph) using the NWS Fallon weather station. The simulated K_c curve, irrigations, and measured precipitation are shown to illustrate the response of the K_c curve and ET_{act} from cuttings and soil evaporation due to wetting events.

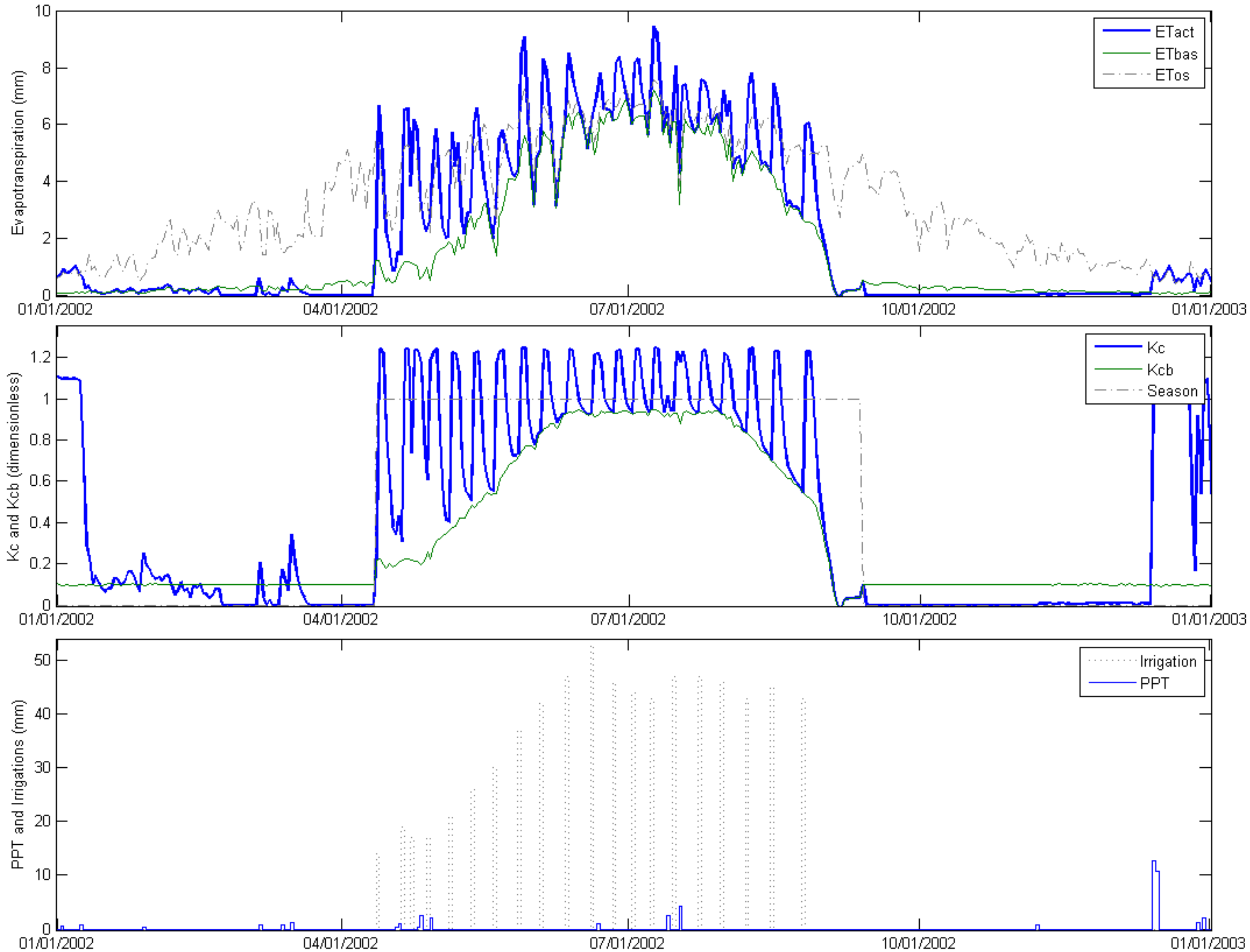


Figure 41b. Simulated onion ET_{act} (top graph) and K_c (middle graph) using the NWS Yerington weather station. Simulated K_c curve, irrigations, and measured precipitation are shown to illustrate the response of the K_c curve and ET_{act} from soil evaporation due to wetting events. More frequent irrigations are simulated compared to alfalfa as a result of the smaller root depth of onions and hence small amounts of available soil water.

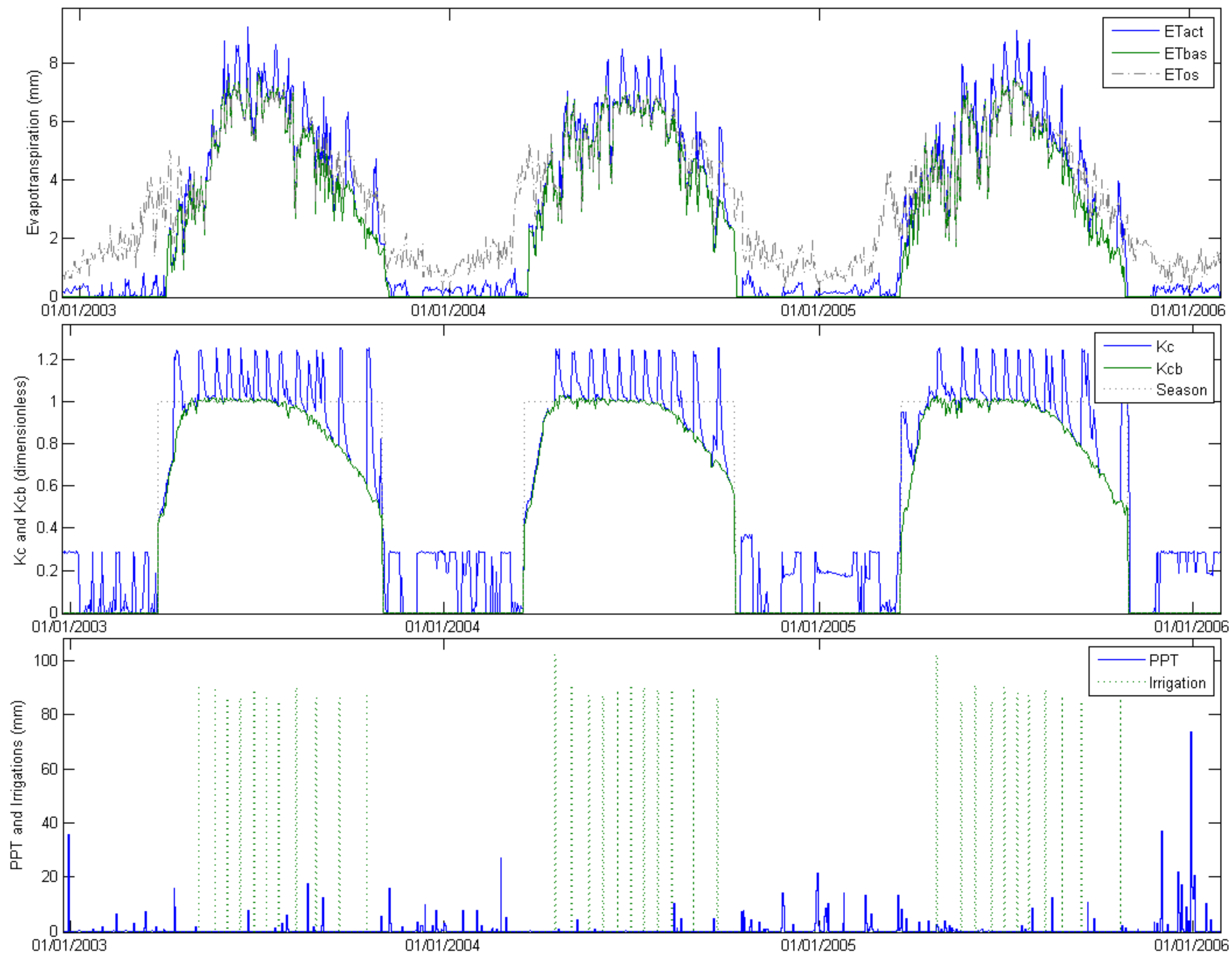


Figure 41c. Simulated pasture grass (highly managed type) ET_{act} (top graph) and K_c (middle graph) using the NWS Minden weather station. Multiple years are shown to illustrate non-growing season ET_{act} in response to precipitation events. Simulation of non-growing season ET_{act} allows for accounting soil moisture storage in the non-growing season and shows suppression of evaporation by dormant mulch.

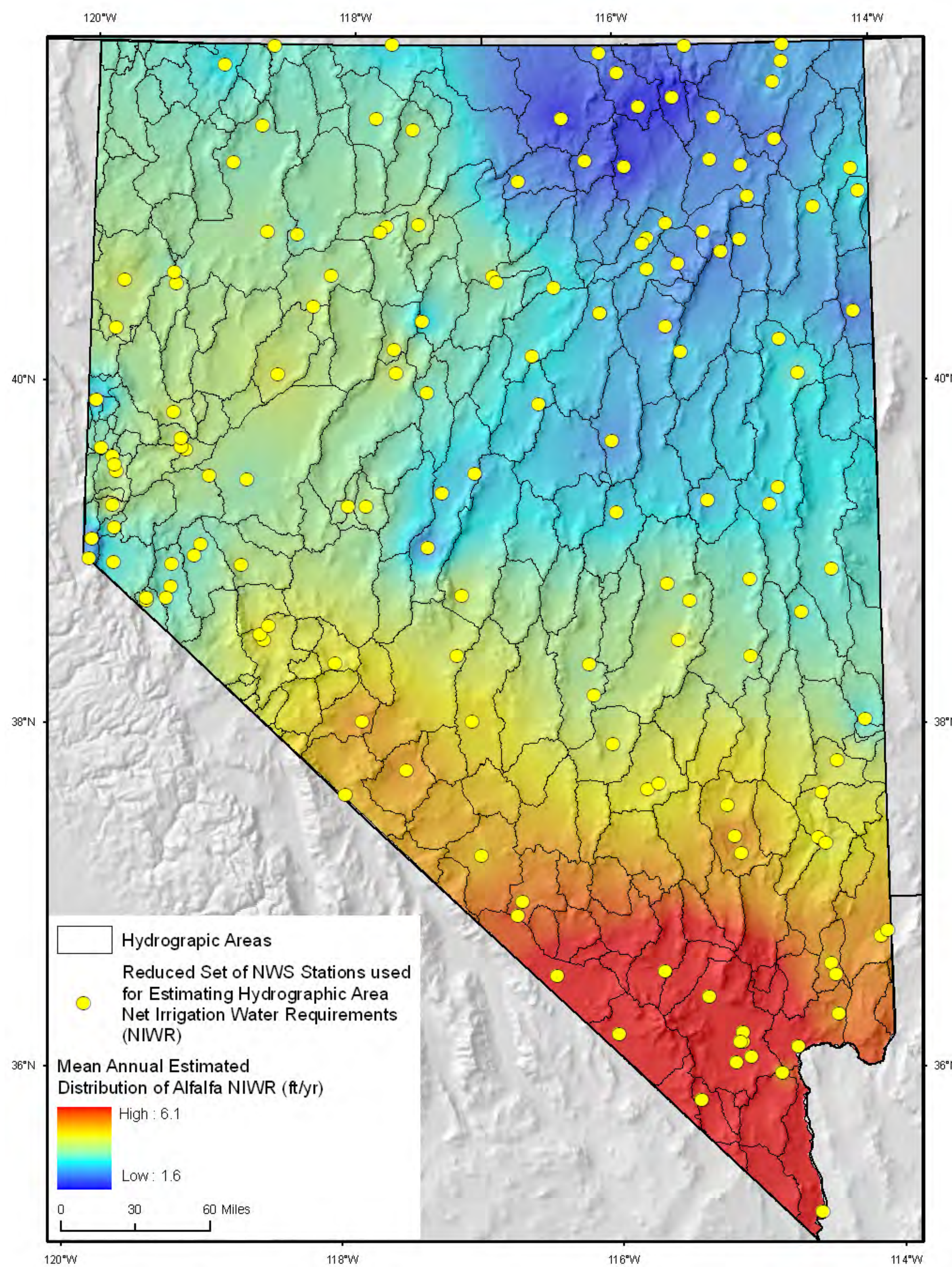


Figure 42. Spatially distributed mean annual alfalfa net irrigation water requirements (i.e. net consumptive use) and NWS stations used for computations and spatial interpolation.

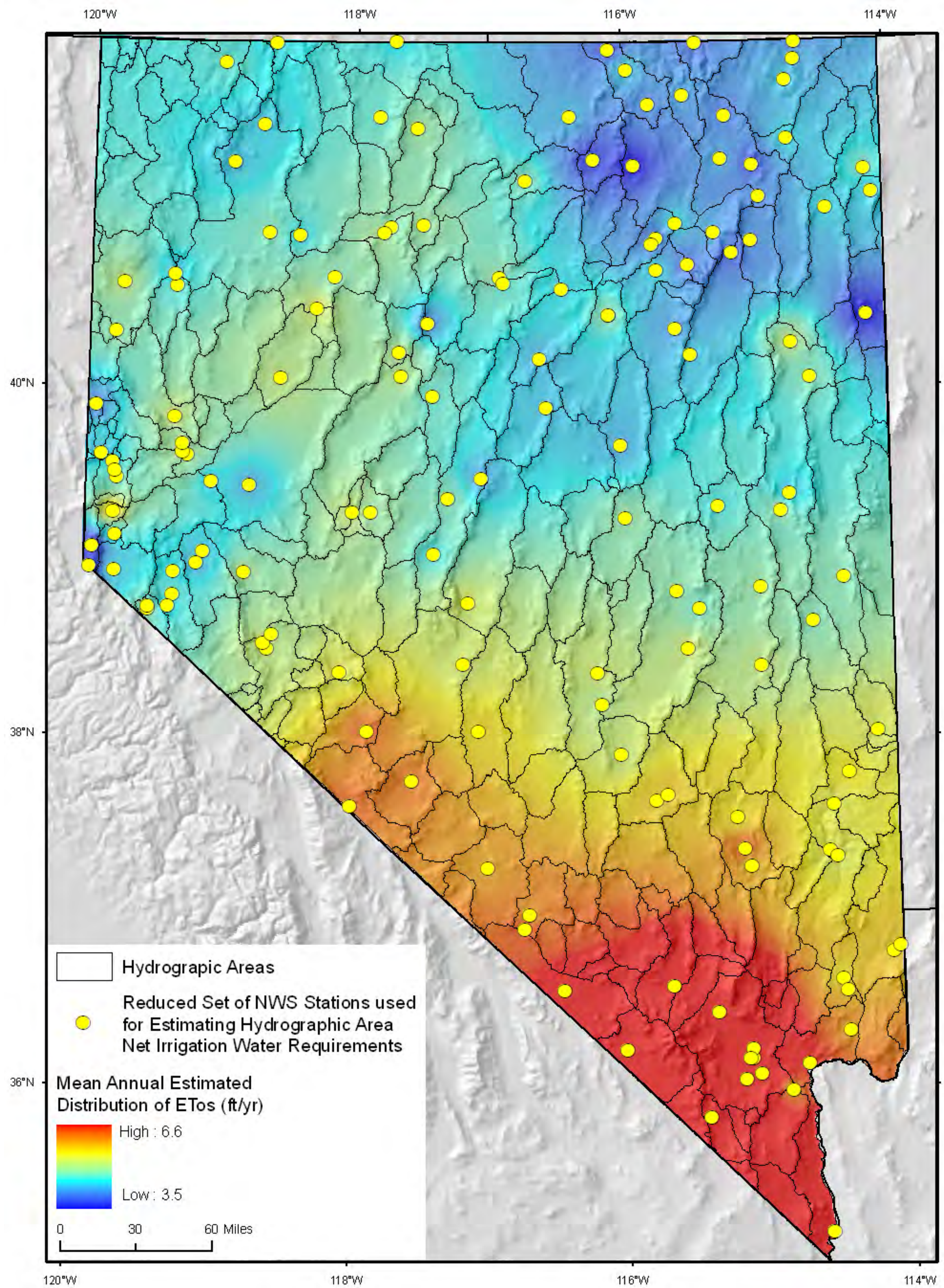


Figure 43. Spatially distributed mean annual ET_{os} using NWS stations used in estimating average hydrographic area net irrigation water requirements.

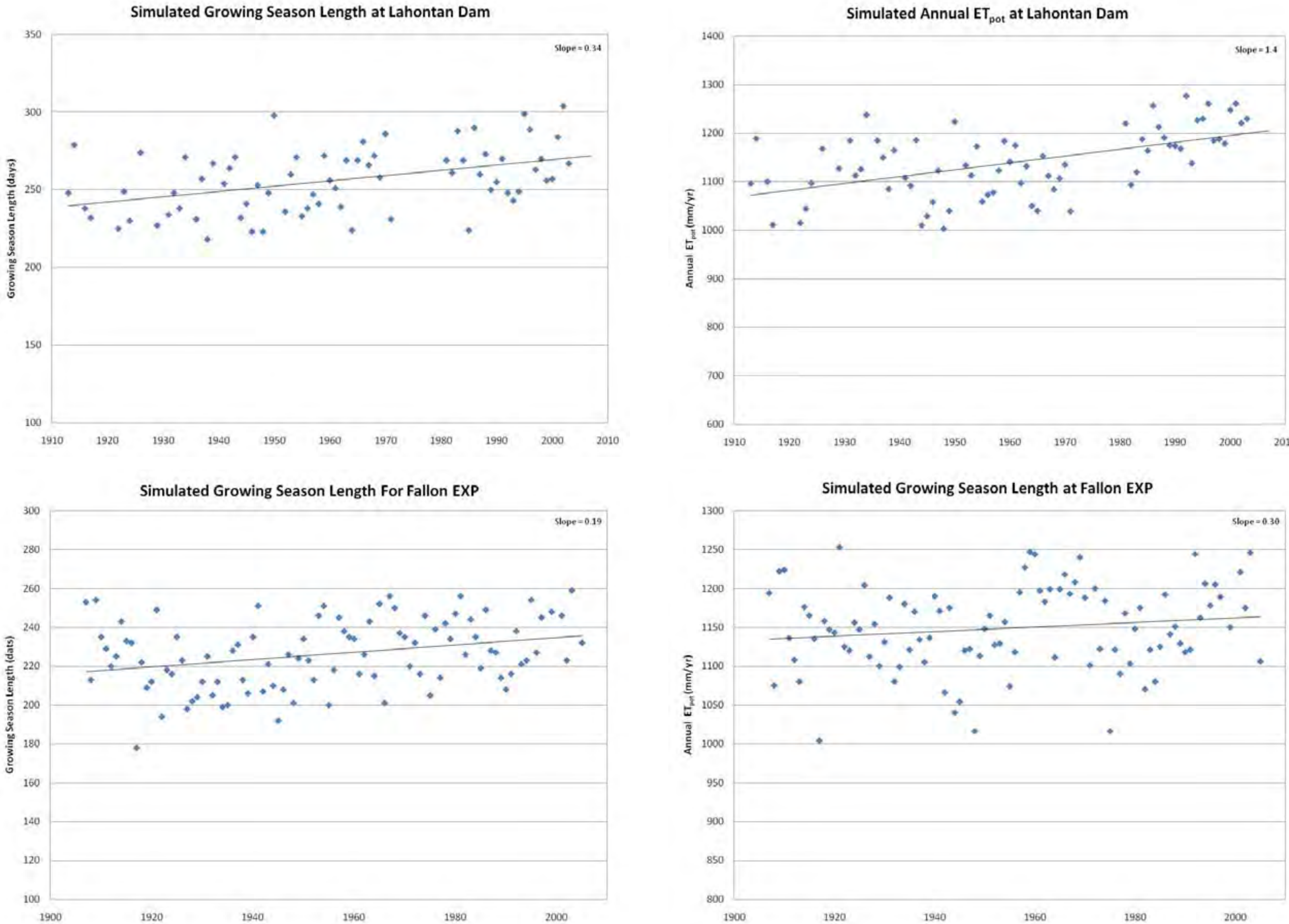
Comparison of Estimated ET_{os} vs. Calculated ET_{os}

Assessing the error in estimated ET_{os} using estimates of R_s, T_{dew}, and U_2, verses using measured data is of significant interest because estimation of these variables provides the ability to use NWS stations allowing for sufficient spatial coverage and statewide application. To address the accuracy of estimating these secondary parameters, a comparison was made between estimated ET_{os} at NWS stations and calculated ET_{os} at nearby stations located in irrigated areas that measure the full suite of weather variables. Results of the comparison indicate that the ratios of annual estimated ET_{os} to calculated ET_{os} range from 1.01 to 1.06, with an average of 1.03, and an average RMSE for daily estimated ET_{os} of 0.036 in/d (0.91 mm/d) (Table 6). These results are acceptable considering the overall uncertainty in the K_c x ET_{os} estimation procedures. The estimated ET_{os} was dependent on spatially interpolated K_o, U_2, and estimated R_s using T_{max} and T_{min}. Unfortunately very few weather stations exist that measure R_s, RH, and U_2 and are located in reference settings to compare estimated ET_{os}. As more weather stations become available that are located in agricultural areas the uncertainty in estimated ET_{os} can be better quantified.

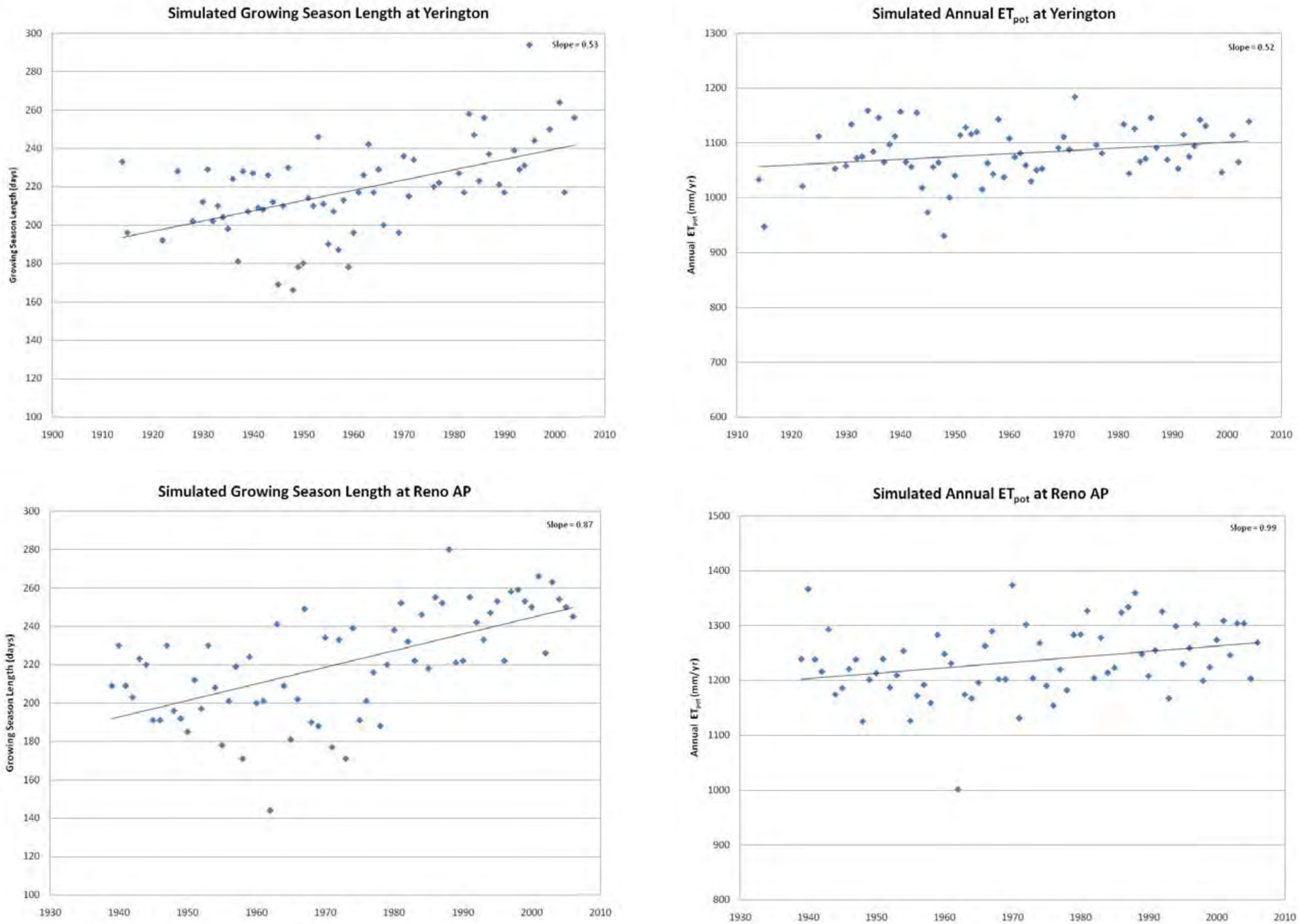
Table 6. ET_{os} from NWS stations where solar radiation, wind speed and dewpoint were estimated vs. ET_{os} at nearby irrigated area weather stations that measure the full suite of weather variables to calculate the 'full-suite' ET_{os}.

Name of NWS Station for ET_{os} Estimation	Basin of NWS Station Location	Name of ET_{os} full-suite Station	Basin of ET_{os} full-suite Station Location	Type of ET_{os} full-suite Station	Period of Record Used for Comparison	Ratio of Estimated Annual ET_{os} for NWS stations to Full-Suite Annual ET_{os}	RMSE for Daily Estimated ET_{os} (in/d)	Mean Annual ET_{os} (in) for full-suite station	Estimated Mean Annual ET_{os} (in)
Diamond Valley USDA	Diamond Valley	Eureka AGRIMET	Diamond Valley	AGRIMET	8/01 - 6/06	1.06	0.03	47.6	50.4
Fallon EXP STN	Carson Desert	Fallon AGRIMET	Carson Desert	AGRIMET	3/01 - 12/05	1.02	0.03	50.1	50.8
Laughlin	Colorado Valley	Mohave	Mohave Valley, AZ	AZMET	1/03 - 5/07	1.01	0.06	76.3	77.1
Yerington	Mason Valley	B11	Mason Valley	USGS Bowen Ratio	3/05 - 3/07	1.04	0.03	47.1	48.9
Minden	Carson Valley	ET-2	Carson Valley	USGS Bowen Ratio	4/03 - 11/04	1.05	0.03	50.2	52.4

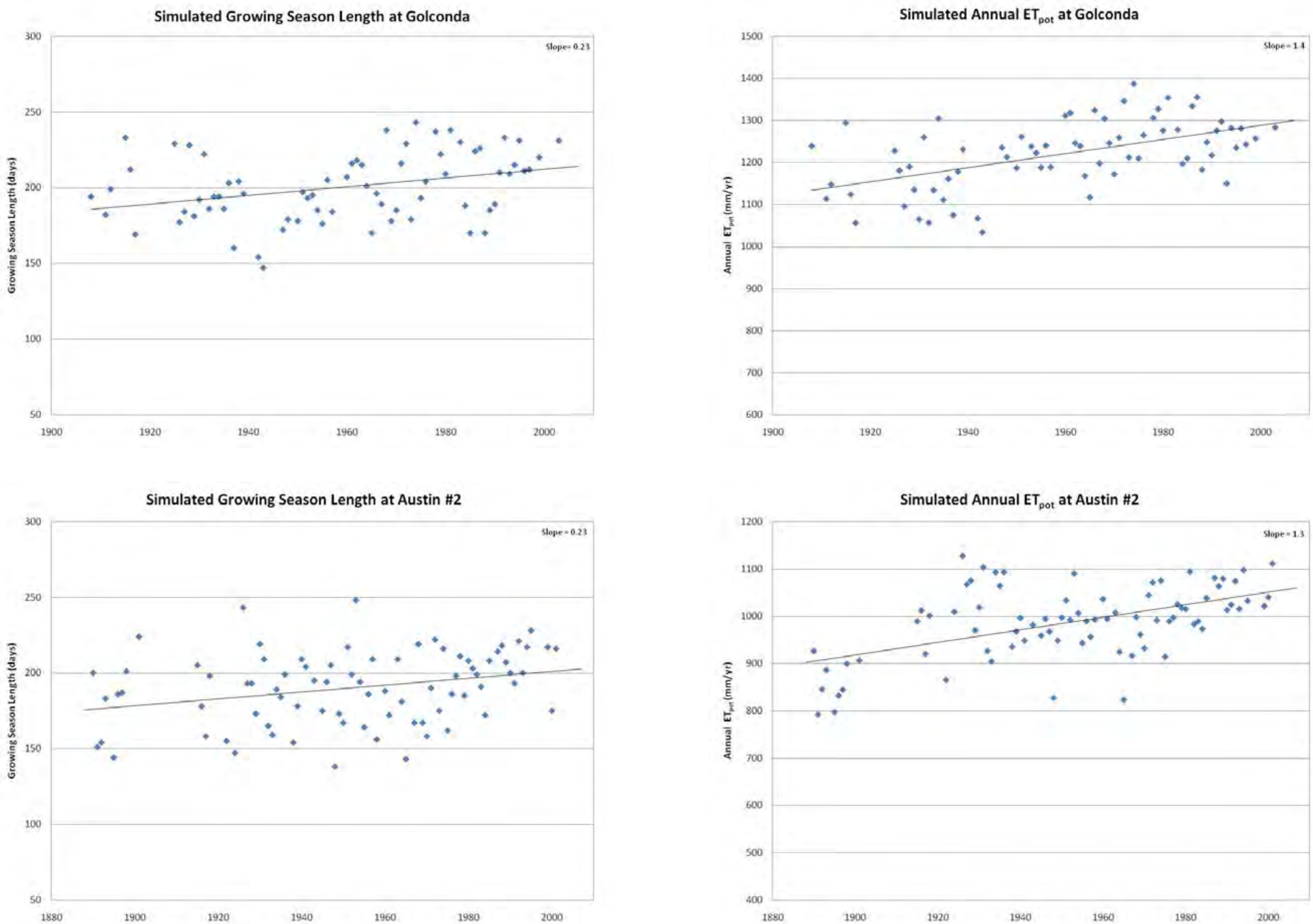
Average of Ratios and RMSE	**1.03**	**0.04**
Std. Dev. of Ratios and RMSE	**0.02**	**0.01**



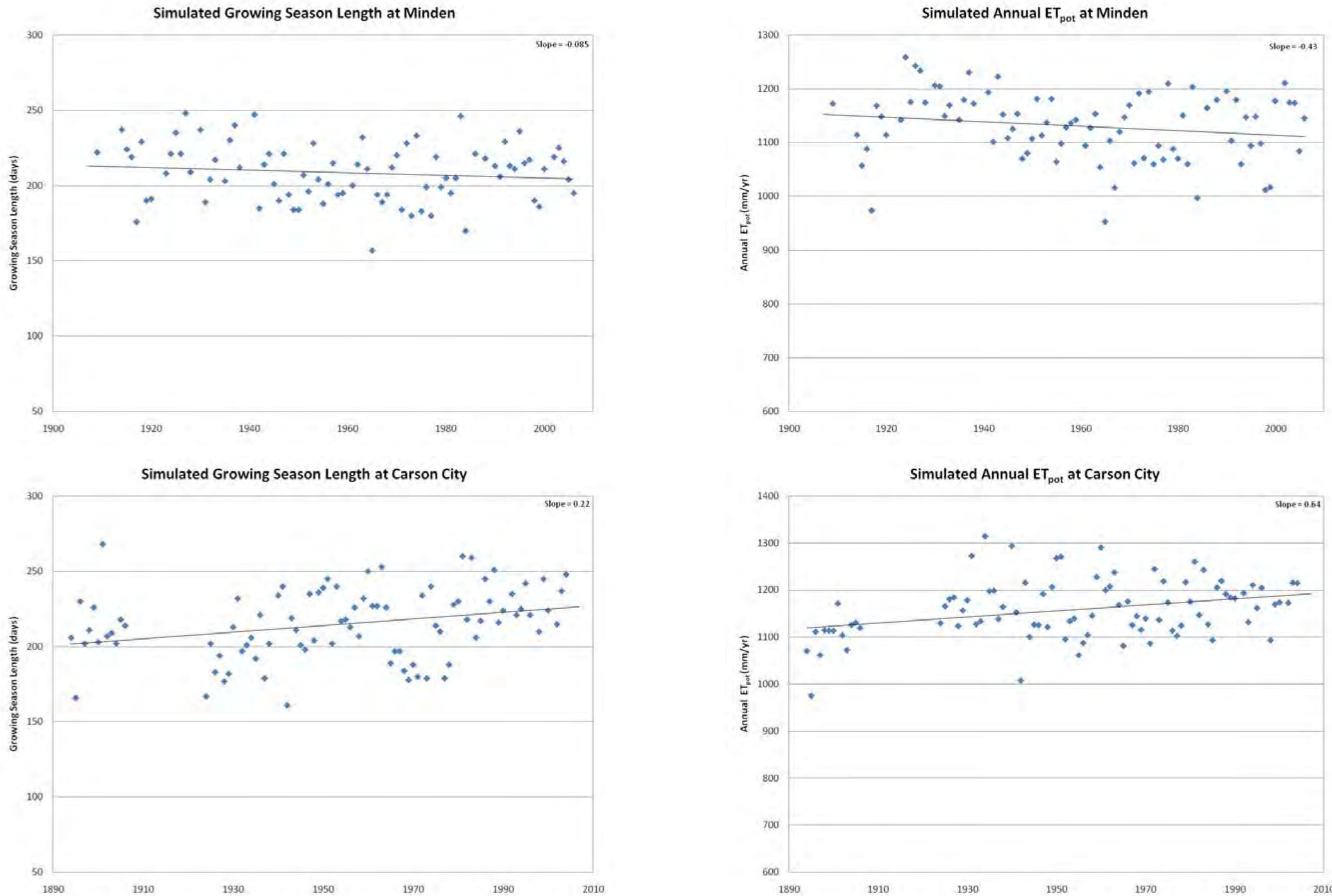
Figures 44a. Alfalfa simulated growing season lengths and ET_{pot} for Lahontan Dam and Fallon NWS weather stations.



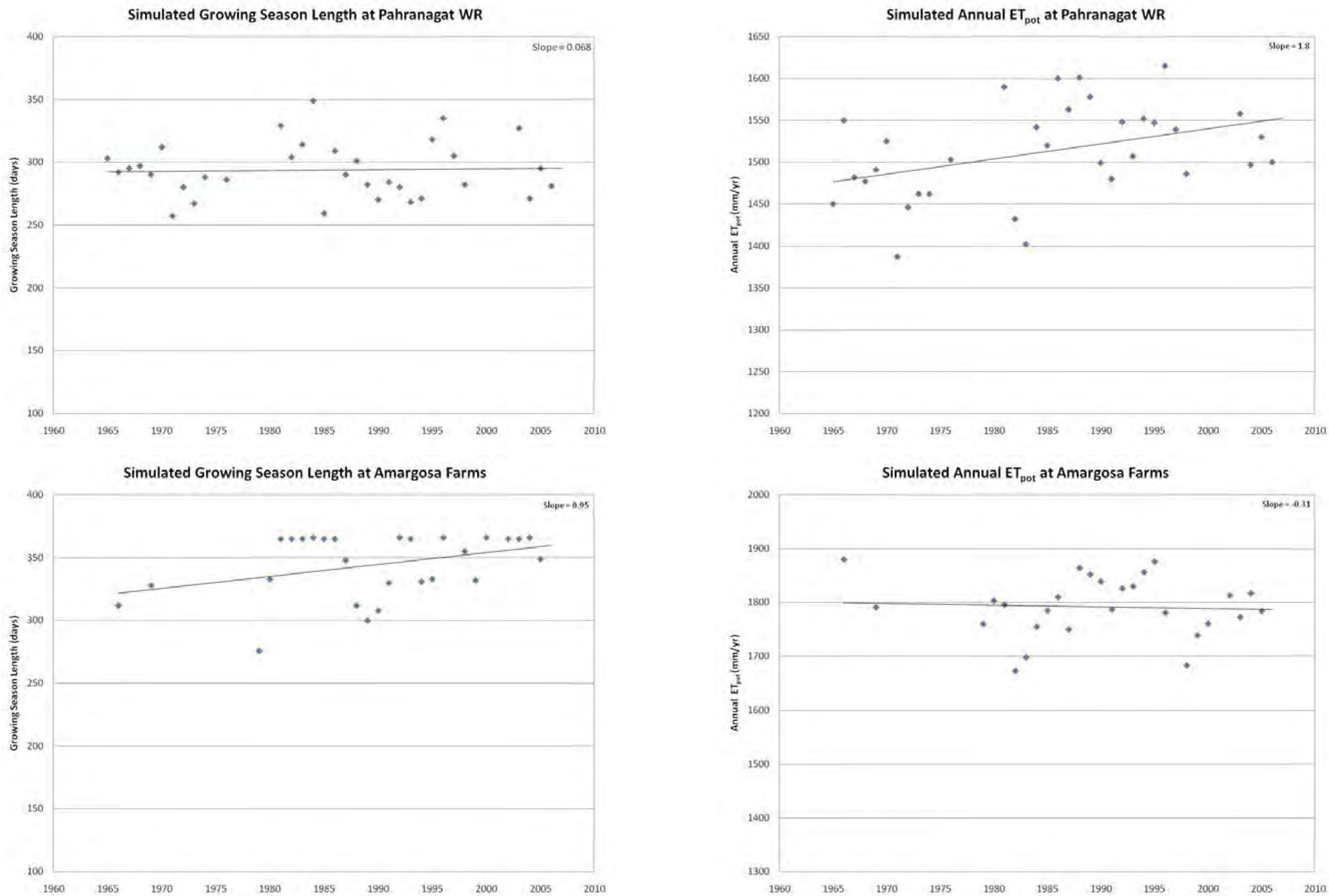
Figures 44b. Alfalfa simulated growing season lengths and ET_{pot} for Yerington and Reno AP NWS weather stations.



Figures 44c. Alfalfa simulated growing season lengths and ET_{pot} for Golconda and Austin NWS weather stations.



Figures 44d. Alfalfa simulated growing season lengths and ET_{pot} for Minden and Carson City NWS weather stations.



Figures 44e. Alfalfa simulated growing season lengths and ET_{pot} for Pahranagat WR and Amargosa Farms NWS weather stations.

Comparison of Estimated ET_{act} vs. Previously Reported ET_{act}

Many studies have investigated the ET of alfalfa in Nevada using multiple techniques such as water balance lysimeters, soil moisture depletion, and micrometeorological methods. Most of the studies were conducted from the 1950's through the 1980's with more recent applications of micrometeorological methods. Houston (1955) used two water balance tank lysimeters to investigate ET of alfalfa from 1951 to 1953 in the Truckee Meadows, at the University of Nevada Valley Road Farm. Houston's lysimeter experiments for 1951, 1952, and 1953 suggested that the estimated ET for alfalfa during the growing season was 42.7, 37.5 and 50 inches, with an oven dry weight yield of 2.5, 4.0, and 4.9 tons per acre, respectively.

Tovey (1963) investigated ET and crop yield of alfalfa in the Truckee Meadows, at the University of Nevada Main Station Farm during the 1959-1961 growing seasons, where he installed 63 water balance tank lysimeters and varied soil texture, lysimeter static water levels, and irrigation treatment (irrigated/non-irrigated). The ET_{act} of alfalfa was estimated by recording and adding the measured surface water irrigation volume applied to lysimeters, volume of water that maintained the static water level in the lysimeters, and volume of precipitation. Tovey (1963) reported an average seasonal ET_{act} of alfalfa to equal 42, 38, 40, and 31 inches, grown with lysimeter static water levels of 2, 4, 8 feet, and no static water level, respectively, where the growing season reported was from mid May to mid October. Yields associated with these ET_{act} estimates were 7.4, 7.1, 7.2, and 6.4 tons per acre, respectively, however it is unclear if these estimates represent the field weight or dry weight.

Many studies have been conducted evaluating lysimeter measurements of ET and crop yields of alfalfa in Fallon at the Nevada Agricultural Experiment Station's Newlands Research Center (Greil, 1974; Neyshabouri, 1976; Tuteur, 1976; Wilcox, 1978; Staubitz, 1978; Guitjens, 1982; Rashedi, 1983; Goodrich, 1986; Guitjens and Goodrich, 1994). These study objectives ranged from evaluating winter water use by seedling alfalfa, ET under conditions of a shallow water table and controlled irrigation, ET for maximum crop yields, crop yields from controlled irrigation, dormant season ET, development of alfalfa yield equations, and estimation of crop coefficients using different reference ET equations. Given that the ET rate will vary depending on the study design, goals and objectives, an average growing season ET rate is difficult to estimate from these studies. However, given that the crop yield of alfalfa is a function of the ET rate, a reported crop yield can be chosen to provide a fair evaluation of the respective ET rate. According to the USDA National Agriculture Statistics Service, the average yield for alfalfa hay for Churchill County, NV from 1969-2005 was 4.4 tons per acre, and the statewide average was 4 tons per acre from 1969-2005. The USDA National Agriculture Statistics Service crop yield estimates for Nevada are derived from mail and phone surveys in which approximately 85% of growers and farmers participated (USDA/Don Breazeale, 2006, verbal communication). Measurements of alfalfa yield from lysimeter studies conducted in Fallon (Greil, 1974; Neyshabouri, 1976; Tuteur, 1976; Wilcox, 1978; Staubitz, 1978; Rashedi, 1983; Goodrich, 1986) are reported to range from 5.0 to 10.5 tons per acre, with all of the years of measurement reporting substantially greater alfalfa yields than the USDA National Agriculture Statistics Service 1969-2005 average estimate for Churchill County, NV. Lysimeter studies conducted in Fallon reported alfalfa yield at the field weight, which is assumed to be at 12% moisture content (Tuteur, 1976). Possible reasons for the discrepancy between reported lysimeter yields and USDA reported statewide yields are 1) likely due to scaling the lysimeter yields from the small area of the lysimeter to 1 acre, 2) lysimeter studies were conducted under excellent agronomic practices and pristine crop conditions, and 3) no dry matter loss occurred, where dry matter loss can be a significant factor in reported low yields (Guitjens, 2006, verbal communication). For the purposes of comparison, 12 lysimeter measurements of ET during the growing season (average of mid March to mid October), summarized by Rashedi (1983, Table 11), were compiled and averaged to produce an average growing season ET of 43 inches and average yield of 9.3 tons per acre from 1974-1982.

Mahannah (1979) summarized multiple multiyear alfalfa ET studies that have been conducted in Carson Valley as part of a written report for U.S. District Court case United States vs. Alpine Land and Reservoir Company. Annual ET estimates for alfalfa and pasture grass were derived using class A evaporation pans, application of various empirical equations (i.e. Blaney Criddle, radiation method, Penman, etc.), and soil moisture depletion techniques (Guitjens and Mahannah, 1977). Findings of the multiyear study (1971-1975) estimated a mean annual ET rate of 43, 44, and 42 inches, using the class A pan, various empirical methods, and soil moisture depletion methods, respectively, and recommended that 44 inches be representative of annual alfalfa and pasture grass ET in Carson Valley. Mahannah (1979) also estimated the NIWR, or the annual ET_{act} minus the effective precipitation, using an ET estimation type approach and valley wide depletion approach. Mahannah (1979) assumed that 54% of the long term precipitation of 9.4 inches was effective, making the NIWR equal to 39 inches. Mahannah's valley wide depletion estimate was 28 inches, however this estimate was qualified as likely being low respective to what the potential consumptive use could be due to water supply and priority issues.

Kimbell et al., (1990) performed a multiyear experiment of alfalfa ET_{act} near Wadsworth, located in the Tracy Segment HA. Like Guitjens' and Mahannah's studies in the Carson Valley, soil moisture depletion methods were used to estimate the annual ET_{act} and associated crop for various water application rates. Findings from the study estimated that the annual alfalfa ET_{act} of 45 inches produced maximum yields of 7.5 tons/acre.

The US Geological Survey has conducted numerous ET studies to estimate the ET_{act} from agricultural areas. Maurer et al., (2005) deployed several micrometeorological stations in Carson Valley from 2003-2004 to quantify ET_{act} from various alfalfa and pasture grass fields. Results from the study suggest that the annual ET_{act} for flood irrigated alfalfa may range from 36 – 37 inches, and annual ET for flood irrigated pasture grass may range from 34 – 52 inches. As part of a water resource study of the Walker River basin, Allander et al., (2009) deployed several micrometeorological stations, two of which were located in alfalfa fields in Mason Valley and operated from 2005-2007. Results from Allander's study suggest that the ET_{act} from the monitored alfalfa may range from 40 - 49 inches.

Table 7 summarizes the comparison of previous estimates of alfalfa and pasture ET_{act} and ET_{act} simulated in this study. Comparisons were made at NWS weather stations near study areas for respective time periods. The average ratio of simulated ET_{act} to the average of previously published ET_{act} is 1.04, and standard deviation of the ratios is 0.12. Results generally agree however there are significant differences in some instances. For example, Carson Valley alfalfa annual ET_{act} of 36 – 37 inches, estimated by Maurer et al., (2005), does not compare well with the simulated alfalfa ET_{act} of 47 inches. There could be several reasons for this discrepancy. Given that pasture ET_{act} from the same study was estimated at 52 inches, the most likely reason for the discrepancy is that the 2 alfalfa fields monitored were water limited and not under optimal agronomic management. It is important to note that simulated ET_{act} in this study represents the ET that would occur under near-pristine crop conditions and not limited by water supply. In practice, this condition is difficult to achieve unless the water supply is not limited, and excellent irrigation system designs and agronomic management strategies are practiced.

Uncertainties of the accuracy of reported ET estimates exist and are not quantifiable in most cases. The accuracy of water balance lysimeters is limited to the accuracy of measuring individual water budget components, of which the most uncertain are soil moisture measurements used to calculate the change in soil moisture storage over time and how representative the lysimeter vegetation and immediate environment are to the surrounding field condition. Allen et al., (1991) described a range of management problems with lysimeters that impact the ET measurement, including bloom or clothesline effects that can cause substantial overstatement of ET. Likewise, the soil moisture depletion technique is limited by the accuracy of the soil moisture measurement and estimation of deep percolation past the root zone. Application of the Bowen ratio energy balance technique calculates ET as a residual of the radiation energy balance, transferring all the uncertainty and bias from net radiation and soil heat flux measurements into the estimate of ET. If all energy balance variables are measured, uncertainty in the ET estimate using the eddy correlation technique, where the ET calculated from vapor flux measurements, can be compared to the ET calculated as a residual of the energy balance. The uncertainty in ET estimates from micrometeorological sites used for comparisons made in this study is assumed to be accurate to within about 12 percent (Allander et al., 2009; Maurer et al., 2006). The most accurate and least uncertain measurement of ET is obtained using well-managed precision weighing lysimeter techniques, however no precision weighing lysimeter measurements exist in Nevada.

Table 7. Previously reported alfalfa and pasture ET_{act} based from measurement techniques vs. estimated alfalfa and pasture ET_{act} made in this study. Comparisons are made for respective time periods and hydrographic areas.

Reference	Period of Study	Location	Method	Crop	Yield (tons/acre)	Ranges of Reported ET_{act} (in)	Average of Reported ET_{act} (in)	ET_{act} From This Study (in)	Ratio of Estimated to Average of Reported ET_{act}	Weather Station Used for Comparison	Notes on ET_{act} Estimated in This Study Used for Comparisons
Houston (1955)	1951-1953	Truckee Meadows	Water Balance Lysimeters	Alfalfa	2.5 - 4.9	37.5 - 50 (Growing Season)	43.4	44	1.01	Reno AP	Average simulated growing season ET_{act} from 1951-1953
Tovey (1963)	1959-1961	Truckee Meadows	Water Balance Lysimeters	Alfalfa	6.4 - 7.4	31 - 42 (Growing Season)	37.9	46.3	1.22	Reno AP	Average simulated growing season ET_{act} from 1959-1961
Mahannah (1979)	1971-1975	Carson Valley	Soil Moisture Depletion	Alfalfa	NA	42.2 (Annual)	42.2	42.8	1.01	Minden	Average simulated annual ET_{act} from 1971-1975
Rashedi (1983)	1974-1982	Carson Desert	Water Balance Lysimeters	Alfalfa	8.1 - 10.5	36.8 - 55.1 (Growing Season)	42.7	40.5	0.95	Fallon EXP	Average simulated growing season ET_{act} from 1974-1982
Goodrich (1990)	1974-1986	Carson Desert	Water Balance Lysimeters	Alfalfa	NA	1.2 - 3.6 (Non-Growing Season)	2.6	2.5	0.96	Fallon EXP	Average simulated non-growing season ET_{act} of 1.6 and 3.5 inches from 1974-1986, which represent simulated ET_{act} during simulated non-growing dates, and simulated ETact during Goodrich's non-growing season dates, respectively
Kimbell et al., (1990)	1984-1986	Tracy Segment	Soil Moisture Depletion	Alfalfa	7.5	44.5 (Annual)	44.5	45.8	1.03	Wadsworth 4N	Average simulated annual ET_{act} from 1984-1986
Maurer et al., (2005)	2003-2004	Carson Valley	Bowen Ratio & Eddy Correlation	Alfalfa	NA	36.4 - 37.1 (Annual)	36.8	46.9	1.28	Minden	Average simulated annual ET_{act} from water year 2004
Maurer et al., (2005)	2003-2004	Carson Valley	Bowen Ratio & Eddy Correlation	Pasture	NA	33.6 - 52.2 (Annual)	41.3	41.7	1.01	Minden	Average simulated annual ET_{act} of low and highly managed pasture grass of 37.4 and 46.1 inches from water year 2004, respectively
Allender et al., (2009)	2005-2007	Mason Valley	Bowen Ratio	Alfalfa	NA	40.1 - 48.8 (Annual)	44.5	41.2	0.93	Yerington	Average simulated annual ET_{act} from 2005-2007

Average of Ratios	**1.04**
Std. Dev. Of Ratios	**0.12**

SUMMARY and CONCLUSIONS

Accurate estimates of evapotranspiration (ET) are becoming more important as increasing demands are placed on finite water supplies in Nevada and across the western U.S. Local, state, and federal water resource agencies require accurate crop ET (ET_{act}) and net irrigation water requirement (NIWR) estimates for evaluating irrigation development, transfers of irrigation water for municipal use, and litigation of water right applications and protests. The ET_{act} is equal to the reference ET multiplied by crop specific crop coefficients. In this study, the NIWR is equal to the annual ET_{act} minus precipitation that resides in the root zone that is available for evaporation or transpiration (i.e. ET_{act} – (PPT – runoff – deep percolation of precipitation)). The major objective of this study was to update estimates of ET_{act} and NIWR for Nevada. The methods for estimating the reference ET followed the new ASCE-EWRI Standardized Penman-Monteith approach, while the ET_{act} and NIWR was estimated using a dual crop coefficient and daily soil water balance. The dual crop coefficient and daily soil water balance approach allows for the consideration of evaporation from surface wetting by irrigation and precipitation in the computation of the crop coefficient value, which provides a more refined estimate of the ET_{act} and NIWR than previous studies. Estimates of the ET_{act} and NIWR for major crops grown in Nevada were made for daily, monthly, and annual time steps at 190 locations using National Weather Service weather stations located throughout the state for available periods of record. Evaporation from small shallow open water bodies was also estimated at all weather stations evaluated.

The ASCE standardized Penman-Monteith reference ET equation is a nationally standardized method (ASCE-EWRI 2005), is well regarded, and serves as a reproducible index approximating the climatic demand for water vapor. Reference ET is the ET rate from an extensive surface of reference vegetation having a standardized uniform height, is actively growing, completely shading the ground, has a dry but healthy and dense leaf surface, and is not short of water. The ASCE Penman-Monteith (ASCE-PM) equation was recently standardized by ASCE-EWRI (2005) for application to a tall full cover alfalfa crop and to a clipped grass reference. Because the grass reference is being widely applied by Arizona and California State agencies for computing ET_{act} (i.e. AZMET and CIMIS), as well as the U.S. Bureau of Reclamation for their Lower Colorado River Accounting System (LCRAS) model, the State of Nevada has adopted the daily time step grass reference evapotranspiration equation as the basis for computing the ET_{act} and NIWR in this study. Daily calculation time steps allow for the calculation and refined accounting of evaporation from wet soil surfaces following precipitation or irrigation events. ET_{act} for monthly, growing season, and annual periods were summed from the daily calculation results.

Because only maximum and minimum air temperature are observed at National Weather Service cooperative stations, solar radiation, humidity, and wind speed variables required in the ASCE-PM equation were estimated using methods similar to recommendations in ASCE-EWRI

(2005). Estimates of solar radiation were based on an empirical relationship of differences between daily maximum and minimum air temperature and solar radiation, where maximum air temperatures generally decrease during cloud cover, and the minimum temperature is increased due to increased downward emission of long wave radiation by clouds at night. Estimates of daily dewpoint temperature representative of agricultural areas were based on measured mean monthly differences between the daily minimum air temperature and the dewpoint temperature, otherwise known as the dewpoint depression, which was calculated at 17 weather stations located in agricultural areas in Nevada and neighboring states. Similarly, estimates of wind speed were based on measured mean monthly wind speed from 58 weather stations located in valley floor areas representative of where agriculture potentially occurs.

Greenup and planting dates and growing season lengths for most crops were determined year by year according to cumulative growing degree days following January 1, or according to mean air temperature over 30-day periods prior to the start date. Growing seasons were terminated by predicted maturation of the crop or by a killing frost. Basal crop coefficient curves (K_{cb}) used to scale the reference ET and to calculate the ET_{act} were expressed on relative time scales or relative thermal unit scales to allow K_{cb} curves to be scaled differently each year, according to weather conditions. Three different methods were used to express the base K_{cb} curves depending on the crop: 1) percent time from planting or greenup to harvest; 2) percent time from planting to effective full cover, with this ratio extended until termination; and 3) percent time from planting to effective full cover and then days after full cover. Basal crop coefficient curves were developed and organized for 34 crop and land cover types.

A modified FAO-56 dual crop coefficient method for estimating evaporation from bare soil was utilized, where a daily soil water balance was computed from the top 10 cm of soil to account for the reduction of evaporation as the soil surface dries. Irrigations were simulated to account for evaporation from wet soil surfaces. Scheduling of irrigations were made using a root zone water balance, where the root zone was estimated from a simple root growth model limited to specified maximum root depths, and the irrigation event was specified when the depletion of soil water exceeds the maximum allowable depletion level before plant stress occurred. Simulated irrigations are typically like those practiced with ‘low frequency’ surface irrigation such as hand line or wheel line sprinkler systems. Available water holding capacity and texture properties of soils for each station needed for parameterizing the soil and root zone water balance model were estimated from the USDA national STATSGO soils database using GIS. Runoff from precipitation was estimated using the USDA NRCS Curve Number method, where antecedent moisture was computed from the daily surface soil water balance. The curve number was estimated from soil texture based on the STATSGO soils GIS information at each station. Snow cover information was used to modify wintertime estimates of evaporation caused by high albedo of snow and energy required for heat of fusion and was also used during adjustment of cumulative growing degree days for winter wheat during winter.

Results of daily, monthly, and annual time series of the ET_{act} and NIWR were compiled into output files for each station, in addition to files containing tables of statistics describing the

ET_{act} and NIWR over the latest 30 years, or period of record available. These tables include means, standard deviations and 20 and 80% exceedence values that describe the expected variation within populations of the ET_{act} and NIWR. Statistics were computed for time period lengths of 3, 7, 15, and 30 days within each month. These period lengths were selected to encapsulate expected lengths of irrigation intervals or drying periods that are of interest in irrigation system design and operation. The statistics were computed over the most recent 30 years for stations having extensive periods of record rather than the entire period of record due to the fact that the periods of record vary widely from station to station and trends in air temperature and growing season length were evident. Some of these trends are caused by changes in relative dryness of the local or regional environment due to irrigation development or land-use change, by station location or relocation, or perhaps by change in overall climate. The last 30 years of usable record were considered to be more representative of expected future conditions than prior periods. The full records for each station were preserved in the daily, monthly, and annual time series files. Therefore, statistics for the full periods of record can be computed as needed from these data sets.

Assessment of error in estimated ASCE-PM reference ET using estimates of solar radiation, dewpoint, and wind speed, versus using measured data was done to determine whether estimation of these weather variables supports the use of NWS stations to provide sufficient spatial coverage and statewide application. To address this issue, a comparison was made between estimated reference ET at NWS stations and calculated reference ET at nearby stations located in irrigated areas that measure the full suite of weather variables. Results of the comparison indicate that the ratios of annual estimated reference ET to calculated reference ET range from 1.01 to 1.06, with an average of 1.03. These results are acceptable considering the overall error, and that estimated reference ET is entirely dependent on estimated dewpoint depression, wind speed, and solar radiation.

To explore the representativeness of estimated ET_{act} of alfalfa, a comparison was made to measured ET_{act} of alfalfa using results from previous studies for respective HAs and time periods. The average ratio of estimated ET_{act} to the average of the reported ET_{act} is 1.04, and the standard deviation of the ratios is 0.12 inches. Results generally agree well, however there are significant differences in some instances where published estimates of ET_{act} may have been impacted by water limiting conditions.

For purposes of estimating the mean annual ET_{act} and NIWR for each HA, the analysis was limited to weather stations on valley floor areas representative of potential agricultural areas. Mean annual values of the ET_{act} and NIWR were assigned to HAs if a single station was available, or if multiple stations were available, a period of record weighted average of the ET_{act} and NIWR was assigned to HAs. Of the 259 HAs in the state, 160 are absent of weather stations to estimate the ET_{act} and NIWR from, therefore spatial interpolation of valley floor weather station estimates of the mean annual ET_{act} and NIWR was performed for alfalfa, grass hay, pasture grass, turf grass, and small shallow open water bodies. Results of the NIWR per HA (Appendix 15 and Plate 1) indicate that in central and northern parts of Nevada, the NIWR for alfalfa is less than the typical permitted irrigation water right of 4 ac-ft/ac. However, in southern NV the NIWR may exceed the typical irrigation water right of 5 ac-ft/ac. These results represent the NIWR for pristine crop conditions under full water supply and should be considered the maximum.

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Appendix 1a. Weather stations used for estimating ET and net irrigation water requirements (sorted by station name). * indicates station was used for basin average.

STATION NAME	STATION NUMBER	LAT (NAD83)	LONG (NAD83)	ELEVATION (feet)	DATA FILE START YEAR	DATA FILE END YEAR	NUMBER OF YEARS WITH INSIGNIFICANT MISSING DATA	BASIN NAME	BASIN NUMBER
ADAVEN	260046	38.12	-115.58	6250	1914	1981	53	Garden Valley	172
ALAMO*	260099	37.37	-115.17	3517	1921	1962	29	Pahranagat Valley	209
AMARGOSA FARMS-GAREY*	260150	36.57	-116.47	2450	1965	2006	28	Amargosa Desert	230
ANTELOPE VALLEY FARR*	260282	39.97	-117.43	4900	1984	1998	8	Antelope Valley	57
ARTHUR 4 NW*	260438	40.78	-115.18	6300	1963	2007	34	Ruby Valley	176
AUSTIN #2*	260507	39.50	-117.07	6780	1887	2007	82	Upper Reese River Valley	56
BASALT	260668	38.00	-118.27	6355	1941	1957	10	Teels Marsh Valley	114
BATTLE MTN*	260688	40.65	-116.93	4514	1898	1945	25	Clovers Area	64
BATTLE MTN AP*	260691	40.62	-116.90	4540	1944	2007	55	Lower Reese River Valley	59
BEATTY*	260715	36.92	-116.75	3304	1917	1972	32	Oasis Valley	228
BEATTY 8 N*	260718	37.00	-116.72	3550	1972	2007	28	Oasis Valley	228
BEOWAWE*	260795	40.58	-116.47	4700	1908	2007	60	Crescent Valley	54
BEOWAWE U OF N RCH*	260800	39.90	-116.58	5740	1972	2007	28	Grass Valley	138
BLUE EAGLE RCH HANKS*	260955	38.52	-115.55	4780	1978	2007	23	Railroad Valley	173B
BLUE JAY HWY STN*	260961	38.38	-116.22	5322	1963	1984	7	Hot Creek	156
BOULDER CITY*	261071	35.98	-114.85	2500	1931	2004	64	Eldorado Valley	167
BRINKERHOFF RCH*	261160	40.08	-117.67	3661	1966	1981	7	Dixie Valley	128
BUFFALO RCH*	261311	40.38	-117.47	5430	1966	1981	7	Buffalo Valley	131
BUNKERVILLE*	261327	36.77	-114.12	1550	1979	2007	6	Virgin River Valley	222
CALIENTE*	261358	37.62	-114.52	4400	1903	2007	22	Clover Valley	204
CALLVILLE BAY*	261371	36.13	-114.73	1270	1989	2007	8	Black Moutains Area	215
CARLIN NEWMONT MINE	261415	40.92	-116.32	6520	1966	2002	24	Boulder Flat	61
CARSON CITY*	261485	39.15	-119.77	4651	1893	2007	90	Eagle Valley	104
CATHEDRAL GORGE SP*	261590	37.80	-114.40	4830	2003	2007	4	Panaca Valley	203
CENTRAL NEVADA FLD LAB*	261630	39.38	-117.32	5950	1965	1986	13	Upper Reese River Valley	56
CHARLESTON*	261660	41.68	-115.53	5947	1961	2007	4	Bruneau River Area	38
CLOVER VALLEY*	261740	40.85	-115.03	5750	1900	2007	39	Clover Valley	177
COALDALE JUNCTION*	261755	38.05	-117.90	4603	1941	1965	6	Columbus Salt Marsh Valley	118
CONTACT*	261905	41.77	-114.75	5350	1949	1999	33	Salmon Falls Creek Area	40

Appendix 1a cont. Weather stations used for estimating ET and net irrigation water requirements (sorted by station name). * indicates station was used for basin average.

STATION NAME	STATION NUMBER	LAT (NAD83)	LONG (NAD83)	ELEVATION (feet)	DATA FILE START YEAR	DATA FILE END YEAR	NUMBER OF YEARS WITH INSIGNIFICANT MISSING DATA	BASIN NAME	BASIN NUMBER
CORTEZ GOLD MINE*	261975	40.18	-116.63	4905	1968	1979	10	Crescent Valley	54
CURRANT*	262078	38.75	-115.47	5184	1941	1949	4	Railroad Valley	173B
CURRANT HWY STN	262091	38.80	-115.35	6243	1963	1977	7	Railroad Valley	173B
CURRIE HWY STN*	262096	40.27	-114.75	5820	1961	1991	10	Steptoe Valley	179
DAGGET PASS	262119	38.98	-119.88	7334	1988	2007	5	Lake Tahoe Basin	90
DENIO*	262229	41.98	-118.63	4190	1951	2006	39	Pueblo Valley	1
DESERT NWR*	262243	36.43	-115.37	2920	1940	2007	60	Las Vegas Valley	212
DIABLO*	262276	37.92	-116.05	5105	1959	1978	10	Railroad Valley	173A
DIAMOND VALLEY USDA*	262296	39.68333	-116.0333	5970	1979	2007	19	Diamond Valley	153
DUCKWATER*	262390	38.85	-115.63	5550	1966	2003	19	Railroad Valley	173B
DUFURRENA*	262394	41.87	-119.02	4800	1959	2005	30	Virgin Valley	4
DYER*	262431	37.62	-118.02	4900	1903	2007	55	Fish Lake Valley	117
EASTGATE*	262477	39.30	-117.88	5023	1956	1964	4	Eastgate Valley Area	127
ECHO BAY*	262497	36.32	-114.43	1250	1989	2007	10	Black Moutains Area	215
ELGIN*	262557	37.35	-114.55	3420	1985	2007	20	Lower Meadow Valley Wash	205
ELGIN 3 SE*	262562	37.32	-114.50	3301	1965	1985	15	Lower Meadow Valley Wash	205
ELKO*	262570	40.87	-115.75	5235	1999	2007	6	Elko Segment	49
ELKO RGNL AP*	262573	40.83	-115.78	5050	1888	2007	94	Elko Segment	49
ELY 6 NE	262626	39.30	-114.83	6263	1999	2005	5	Steptoe Valley	179
ELY YELLAND FLD AP*	262631	39.30	-114.85	6262	1893	2005	68	Steptoe Valley	179
EMIGRANT PASS HWY STN	262656	40.65	-116.30	5760	1963	2001	27	Boulder Flat	61
EMPIRE*	262662	40.58	-119.35	3953	1951	1976	6	San Emidio Desert	22
EUREKA	262708	39.52	-115.97	6540	1888	2007	67	Diamond Valley	153
FALLON EXP STN*	262780	39.45	-118.78	3965	1903	2007	96	Carson Desert	101
FERGUSON SPRINGS HMS*	262820	40.42	-114.18	5840	1972	1982	7	Great Salt Lake Desert	192
FERNLEY*	262840	39.62	-119.25	4163	1907	1974	21	Fernley Area	76
FISH CREEK RCH*	262860	39.27	-116.00	6053	1943	1964	14	Little Smoky Valley	155A
GERLACH*	263090	40.65	-119.37	3950	1948	2007	27	San Emidio Desert	22
GEYSER RCH*	263101	38.67	-114.63	6020	1904	2002	19	Lake Valley	183

Appendix 1a cont. Weather stations used for estimating ET and net irrigation water requirements (sorted by station name). * indicates station was used for basin average.

STATION NAME	STATION NUMBER	LAT (NAD83)	LONG (NAD83)	ELEVATION (feet)	DATA FILE START YEAR	DATA FILE END YEAR	NUMBER OF YEARS WITH INSIGNIFICANT MISSING DATA	BASIN NAME	BASIN NUMBER
GIBBS RCH*	263114	41.57	-115.22	6000	1953	2007	43	Marys River Area	42
GLENBROOK*	263205	39.08	-119.93	6350	1909	2007	50	Lake Tahoe Basin	90
GOLCONDA*	263245	40.95	-117.50	4415	1906	2007	71	Winnemucca Segment	70
GOLDFIELD	263285	37.70	-117.23	5690	1906	2007	66	Alkali Spring Valley	142
GOODSPRINGS*	263316	35.83	-115.43	4000	1999	2007	6	Ivanpah Valley	164A
GREAT BASIN NP	263340	39.02	-114.23	6830	1987	2007	16	Snake Valley	195
HAWTHORNE*	263512	38.52	-118.63	4330	1954	2007	13	Walker Lake Valley	110C
HAWTHORNE AP*	263515	38.55	-118.67	4220	1888	1991	39	Walker Lake Valley	110C
HIKO*	263671	37.55	-115.22	3900	1989	2007	15	Pahranagat Valley	209
HUMBOLDT FLD	263853	40.08	-118.15	4160	1940	1947	7	Buena Vista Valley	129
I-L RCH*	263940	41.57	-116.40	5203	1962	1969	3	South Fork Owyhee River Area	35
IMLAY*	263957	40.65	-118.17	4260	1914	2007	56	Imlay Area	72
INDIAN SPRINGS*	263980	36.58	-115.68	3123	1913	1964	23	Indian Springs Valley	161
JACKPOT*	264016	41.98	-114.67	5290	1986	2007	15	Salmon Falls Creek Area	40
JARBRIDGE 4 N	264038	41.93	-115.43	6168	1916	1995	22	Jarbidge River Area	39
JARBIDGE 7 N*	264039	41.98	-115.43	6050	1995	2007	11	Jarbidge River Area	39
JIGGS 8 SSE ZAGA*	264095	40.35	-115.62	5800	1978	2007	19	Huntington Valley	47
JUNGO MEYER RCH*	264108	40.88	-118.43	4200	1968	1986	7	Desert Valley	31
KIMBERLY	264199	39.27	-115.03	7234	1928	1958	28	White River Valley	207
KNOLL CREEK FLD STN	264268	41.63	-114.73	6004	1971	1979	6	Salmon Falls Creek Area	40
KYLE CANYON RS	264314	36.25	-115.60	7205	1939	1948	4	Las Vegas Valley	212
LAGES*	264341	40.07	-114.62	5960	1984	2007	21	Steptoe Valley	179
LAHONTAN DAM*	264349	39.47	-119.07	4150	1911	2007	72	Churchill Valley	102
LAKE VALLEY STEWARD	264384	38.32	-114.65	6350	1971	1998	22	Lake Valley	183
LAMOILLE YOST*	264394	40.72	-115.52	5840	1975	2004	22	Lamoille Valley	45
LAMOILLE PH	264395	40.68	-115.47	6293	1916	1972	35	Lamoille Valley	45
LAS VEGAS*	264429	36.17	-115.13	2011	1895	1956	36	Las Vegas Valley	212
LAS VEGAS*	23112	36.17	-115.15	1867	1949	1970	22	Las Vegas Valley	212
LAS VEGAS WB AP*	264436	36.08	-115.07	2160	1948	2005	57	Las Vegas Valley	212

Appendix 1a cont. Weather stations used for estimating ET and net irrigation water requirements (sorted by station name). * indicates station was used for basin average.

STATION NAME	STATION NUMBER	LAT (NAD83)	LONG (NAD83)	ELEVATION (feet)	DATA FILE START YEAR	DATA FILE END YEAR	NUMBER OF YEARS WITH INSIGNIFICANT MISSING DATA	BASIN NAME	BASIN NUMBER
LAS VEGAS NWFO*	264439	36.05	-115.18	2170	1996	2007	9	Las Vegas Valley	212
LATHROP WELLS	264457	36.65	-116.40	2671	1942	1963	8	Fortymile Canyon	227A
LAUGHLIN*	264480	35.17	-114.58	605	1988	2007	10	Colorado Valley	213
LEHMAN CAVES NM	264514	39.00	-114.22	6826	1937	1987	44	Snake Valley	195
LEONARD CREEK RCH*	264527	41.52	-118.72	4224	1954	2007	44	Black Rock Desert	28
LEWERS RCH	264542	39.23	-119.85	5203	1893	1938	15	Washoe Valley	89
LITTLE RED ROCK	264600	36.15	-115.42	3802	1965	1970	4	Las Vegas Valley	212
LOGANDALE*	264651	36.62	-114.48	1410	1968	1992	20	Lower Moapa Valley	220
LOVELOCK DERBY FLD*	264700	40.07	-118.57	3902	1948	2005	49	Lovelock Valley	73
LUND*	264745	38.87	-115.02	5560	1957	2007	47	White River Valley	207
MALA VISTA RCH*	264824	41.32	-115.25	5594	1939	1965	16	Marys River Area	42
MARLETTE LAKE	264858	39.17	-119.92	8005	1916	1952	19	Lake Tahoe Basin	90
MCDERMITT*	264935	42.00	-117.72	4527	1892	2007	29	Quinn River Valley	33B
MCGILL*	264950	39.40	-114.78	6270	1892	2007	90	Steptoe Valley	179
MESQUITE*	265085	36.80	-114.07	1570	1942	2006	13	Virgin River Valley	222
METROPOLIS*	265092	41.28	-115.02	5800	1965	1995	18	Marys River Area	42
MIDAS 4 SE*	265105	41.20	-116.73	5203	1961	1969	4	Willow Creek Valley	63
MIDDLEGATE-LOWERY*	265132	39.30	-118.02	4600	1988	2007	15	Cowkick Valley	126
MINA*	265168	38.38	-118.10	4550	1896	2007	79	Soda Spring Valley	121A
MINDEN*	265191	38.95	-119.77	4720	1906	2007	86	Carson Valley	105
MONTELLO 2 SE*	265352	41.25	-114.17	4890	1902	2007	67	Thousand Springs Valley	189D
MONTGOMERY MNTC STN	265362	37.97	-118.32	7100	1960	1980	10	Queen Valley	116
MOORMAN RCH*	265371	39.33	-115.32	6539	2002	2007	4	Jakes Valley	174
MTN CITY RS*	265392	41.83	-115.97	5650	1955	1999	35	Owyhee River Area	37
MT CHARLESTON FS	265400	36.27	-115.65	7600	1949	2007	6	Las Vegas Valley	212
MT ROSE BOWL	265440	39.35	-119.87	7500	1973	1987	8	Pleasant Valley	88
NIXON*	265605	39.83	-119.35	3904	1928	1974	30	Pyramid Lake Valley	81
NORTH LAS VEGAS*	265705	36.22	-115.13	1888	1951	2007	20	Las Vegas Valley	212
OASIS*	265722	41.03	-114.47	5830	1987	2007	17	Goshute Valley	187
OLD RUTH	265760	39.27	-114.98	7034	1978	1985	5	Steptoe Valley	179

Appendix 1a cont. Weather stations used for estimating ET and net irrigation water requirements (sorted by station name). * indicates station was used for basin average.

STATION NAME	STATION NUMBER	LAT (NAD83)	LONG (NAD83)	ELEVATION (feet)	DATA FILE START YEAR	DATA FILE END YEAR	NUMBER OF YEARS WITH INSIGNIFICANT MISSING DATA	BASIN NAME	BASIN NUMBER
OROVADA 3 W*	265818	41.57	-117.83	4200	1911	2007	74	Quinn River Valley	33A
OVERTON*	265846	36.55	-114.45	1250	1939	2007	35	Lower Moapa Valley	220
OWYHEE*	265869	41.95	-116.10	5397	1948	1984	30	Owyhee River Area	37
PAHRANAGAT WR*	265880	37.27	-115.12	3400	1964	2007	33	Pahranagat Valley	209
PAHRUMP*	265890	36.22	-116.02	2700	1914	2007	42	Pahrump Valley	162
PAHUTE MEADOWS RCH*	265907	41.30	-118.93	4383	1963	1976	4	Black Rock Desert	28
PALMETTO	265931	37.47	-117.77	5906	1890	1911	14	Fish Lake Valley	117
PARADISE VALLEY 1 NW*	266005	41.50	-117.55	4675	1894	2007	47	Paradise Valley	69
PARIS RCH*	266055	40.22	-117.68	4140	1966	1991	22	Pleasant Valley	130
PENOYER VALLEY*	266130	37.65	-115.80	4800	1967	2006	5	Penoyer Valley	170
PEQUOP	266148	41.07	-114.53	6033	1959	1985	23	Goshute Valley	187
PILOT VALLEY-LEE*	266228	41.12	-114.12	4905	2000	2007	6	Pilot Creek Valley	191
PINE VALLEY BAILEY RCH*	266242	40.43	-116.12	5047	1982	2006	11	Pine Valley	53
PIOCHE	266252	37.95	-114.47	6180	1888	2006	61	Patterson Valley	202
QUINN RVR CROSSING	266504	41.57	-118.43	4091	1901	1951	10	Pine Forest Valley	29
RAND RCH PALISADE*	266574	40.43	-116.12	5046	1957	1982	19	Pine Valley	53
RATTLESNAKE	266630	38.45	-116.17	5915	1948	1966	13	Hot Creek	156
RED ROCK WC*	29999	39.892	-119.9345	4708	2004	2008	4	Red Rock Valley	99
RED ROCK CANYON SP	266691	36.08	-115.45	3780	1977	2007	20	Las Vegas Valley	212
REESE RIVER*	266746	39.07	-117.42	6550	1972	2007	26	Upper Reese River Valley	56
REESE VALLEY CARPER	266748	40.05	-117.23	4898	1976	1983	6	Middle Reese River Valley	58
RENO TAHOE INTL AP*	266779	39.48	-119.77	4410	1937	2007	69	Truckee Meadows	87
RENO WFO*	266791	39.57	-119.80	4974	1996	2007	10	Truckee Meadows	87
RUBY LAKE*	267123	40.20	-115.50	6010	1940	2007	61	Ruby Valley	176
RUTH	267175	39.28	-114.98	6850	1958	2007	30	Steptoe Valley	179
RYNDON*	267188	40.95	-115.60	5150	1999	2007	6	North Fork Area	44
RYE PATCH DAM*	267192	40.47	-118.30	4135	1935	2007	63	Imlay Area	72
SAND PASS*	267261	40.32	-119.80	3904	1913	1971	41	Smoke Creek Desert	21
SAN JACINTO*	267284	41.88	-114.68	5203	1904	1948	21	Salmon Falls Creek Area	40
SARCOBATUS*	267319	37.27	-117.02	4022	1941	1961	14	Sarcobatus Flat	146

Appendix 1a cont. Weather stations used for estimating ET and net irrigation water requirements (sorted by station name). * indicates station was used for basin average.

STATION NAME	STATION NUMBER	LAT (NAD83)	LONG (NAD83)	ELEVATION (feet)	DATA FILE START YEAR	DATA FILE END YEAR	NUMBER OF YEARS WITH INSIGNIFICANT MISSING DATA	BASIN NAME	BASIN NUMBER
SAVAL RCH*	267324	41.28	-115.92	6365	1960	1967	5	North Fork Area	44
SCHURZ*	267358	38.95	-118.82	4124	1920	1957	30	Walker Lake Valley	110A
SEARCHLIGHT	267369	35.47	-114.92	3540	1913	2007	73	Piute Valley	214
SEVENTY ONE RCH*	267397	40.90	-115.32	5453	1939	1952	4	Starr Valley Area	43
SHELDON	267443	41.85	-119.63	6506	1933	1972	35	Guano Valley	6
SHOSHONE 5 N*	267450	38.92	-114.40	5930	1988	2007	17	Spring Valley	184
SILVERPEAK*	267463	37.77	-117.57	4260	1967	2007	31	Clayton Valley	143
SMITH 1 N*	267609	38.82	-119.33	4754	1937	1966	23	Smith Valley	107
SMITH 6 N*	267612	38.95	-119.33	5000	1973	2007	23	Smith Valley	107
SMOKE CREEK ESPIL*	267618	40.60	-119.75	3850	1987	2006	14	Smoke Creek Desert	21
SMOKEY VALLEY*	267620	38.78	-117.17	5625	1949	2007	46	Big Smoky Valley	137B
SNOWBALL RCH	267640	39.03	-116.20	7160	1966	2002	33	Little Smoky Valley	155A
SOUTH FORK SP*	267690	40.68	-115.75	5270	1993	2007	8	Dixie Creek Tenmile	48
SPRING VALLEY SP*	267750	38.03	-114.18	5950	1974	2007	24	Spring Valley	201
STATELINE-HARRAH'S*	267806	38.97	-119.95	6248	1984	1998	13	Lake Tahoe Basin	90
STEAD*	267820	39.62	-119.88	5120	1985	2007	14	Lemmon Valley	92B
SULPHUR*	267873	40.90	-118.67	4042	1914	1953	21	Black Rock Desert	28
SUNNYSIDE*	267908	38.42	-115.02	5300	1891	2007	35	White River Valley	207
SUTCLIFFE	267953	39.95	-119.60	3900	1967	2007	27	Pyramid Lake Valley	81
TEMPIUTE 4 NW*	267983	37.68	-115.72	4889	1972	1985	12	Penoyer Valley	170
THORNE*	268034	38.60	-118.60	4203	1914	1950	24	Walker Lake Valley	110C
TONOPAH*	268170	38.05	-117.08	5395	1954	2005	49	Ralston Valley	141
TOPAZ LAKE 3N*	268186	38.73	-119.52	5105	1957	2007	19	Antelope Valley	106
TOPAZ LAKE 4 N*	268202	38.75	-119.52	5577	1986	2000	11	Antelope Valley	106
TUSCARORA*	268346	41.32	-116.22	6170	1958	2007	40	Independence Valley	36
TWIN SPRING FALLINI*	268443	38.20	-116.18	5300	1985	2005	10	Hot Creek	156
UNIV OF NEVADA EXP FM*	268500	39.52	-119.78	4514	1949	1954	4	Truckee Meadows	87
URSINE	268538	37.98	-114.22	5833	1964	1972	4	Eagle Valley	200
VALLEY OF FIRE SP	268588	36.43	-114.52	2000	1972	2007	33	Black Moutains Area	215
VIRGINIA CITY	268761	39.32	-119.65	6340	1887	2007	41	Dayton Valley	103
VYA	268810	41.58	-119.92	5663	1959	1980	14	Surprise Valley	14
WABUSKA 6 SE*	268822	39.07	-119.12	4300	1972	2007	27	Mason Valley	108

Appendix 1a cont. Weather stations used for estimating ET and net irrigation water requirements (sorted by station name). * indicates station was used for basin average.

STATION NAME	STATION NUMBER	LAT (NAD83)	LONG (NAD83)	ELEVATION (feet)	DATA FILE START YEAR	DATA FILE END YEAR	NUMBER OF YEARS WITH INSIGNIFICANT MISSING DATA	BASIN NAME	BASIN NUMBER
WADSWORTH*	268834	39.63	-119.28	4081	1902	1948	6	Tracy Segment	83
WADSWORTH 4 N*	268838	39.68	-119.28	4200	1974	2007	21	Dodge Flat	82
WASHOE VALLEY WC*	39999	39.285	-119.789	5050	2004	2008	4	Washoe valley	89
WELLINGTON RS*	268977	38.75	-119.37	4843	1942	1973	27	Smith Valley	107
WELLS*	268988	41.10	-114.97	5700	1895	2004	66	Marys River Area	42
WILDHORSE RSVR*	269072	41.63	-115.80	6226	1982	2007	18	Owyhee River Area	37
WILKINS*	269122	41.43	-114.75	5643	1948	1980	16	Thousand Springs Valley	189A
WILLOW SPRINGS*	269137	38.43	-117.20	6125	1941	1948	4	Big Smoky Valley	137A
WINNEMUCCA #2*	269168	40.93	-117.75	4300	1999	2007	6	Grass Valley	71
WINNEMUCCA MUNI AP*	269171	40.90	-117.80	4296	1949	2007	57	Winnemucca Segment	70
YERINGTON*	269229	39.00	-119.17	4380	1894	2007	66	Mason Valley	108

Appendix 1b. Weather stations used for estimating ET and net irrigation water requirements (sorted by basin name). * indicates station was used for basin average.

STATION NAME	STATION NUMBER	LAT (NAD83)	LONG (NAD83)	ELEVATION (feet)	DATA FILE START YEAR	DATA FILE END YEAR	NUMBER OF YEARS WITH INSIGNIFICANT MISSING DATA	BASIN NAME	BASIN NUMBER
GOLDFIELD	263285	37.70	-117.23	5690	1906	2007	66	Alkali Spring Valley	142
AMARGOSA FARMS-GAREY*	260150	36.57	-116.47	2450	1965	2006	28	Amargosa Desert	230
ANTELOPE VALLEY FARR*	260282	39.97	-117.43	4900	1984	1998	8	Antelope Valley	57
TOPAZ LAKE 3N*	268186	38.73	-119.52	5105	1957	2007	19	Antelope Valley	106
TOPAZ LAKE 4 N*	268202	38.75	-119.52	5577	1986	2000	11	Antelope Valley	106
SMOKEY VALLEY*	267620	38.78	-117.17	5625	1949	2007	46	Big Smoky Valley	137B
WILLOW SPRINGS*	269137	38.43	-117.20	6125	1941	1948	4	Big Smoky Valley	137A
CALLVILLE BAY*	261371	36.13	-114.73	1270	1989	2007	8	Black Moutains Area	215
ECHO BAY*	262497	36.32	-114.43	1250	1989	2007	10	Black Moutains Area	215
VALLEY OF FIRE SP	268588	36.43	-114.52	2000	1972	2007	33	Black Moutains Area	215
LEONARD CREEK RCH*	264527	41.52	-118.72	4224	1954	2007	44	Black Rock Desert	28
PAHUTE MEADOWS RCH*	265907	41.30	-118.93	4383	1963	1976	4	Black Rock Desert	28
SULPHUR*	267873	40.90	-118.67	4042	1914	1953	21	Black Rock Desert	28
CARLIN NEWMONT MINE	261415	40.92	-116.32	6520	1966	2002	24	Boulder Flat	61
EMIGRANT PASS HWY STN	262656	40.65	-116.30	5760	1963	2001	27	Boulder Flat	61
CHARLESTON*	261660	41.68	-115.53	5947	1961	2007	4	Bruneau River Area	38
HUMBOLDT FLD	263853	40.08	-118.15	4160	1940	1947	7	Buena Vista Valley	129
BUFFALO RCH*	261311	40.38	-117.47	5430	1966	1981	7	Buffalo Valley	131
FALLON EXP STN*	262780	39.45	-118.78	3965	1903	2007	96	Carson Desert	101
MINDEN*	265191	38.95	-119.77	4720	1906	2007	86	Carson Valley	105
LAHONTAN DAM*	264349	39.47	-119.07	4150	1911	2007	72	Churchill Valley	102
SILVERPEAK*	267463	37.77	-117.57	4260	1967	2007	31	Clayton Valley	143
CALIENTE*	261358	37.62	-114.52	4400	1903	2007	22	Clover Valley	204
CLOVER VALLEY*	261740	40.85	-115.03	5750	1900	2007	39	Clover Valley	177
BATTLE MTN*	260688	40.65	-116.93	4514	1898	1945	25	Clovers Area	64
LAUGHLIN*	264480	35.17	-114.58	605	1988	2007	10	Colorado Valley	213
COALDALE JUNCTION*	261755	38.05	-117.90	4603	1941	1965	6	Columbus Salt Marsh Valley	118

Appendix 1b cont. Weather stations used for estimating ET and net irrigation water requirements (sorted by basin name). * indicates station was used for basin average.

STATION NAME	STATION NUMBER	LAT (NAD83)	LONG (NAD83)	ELEVATION (feet)	DATA FILE START YEAR	DATA FILE END YEAR	NUMBER OF YEARS WITH INSIGNIFICANT MISSING DATA	BASIN NAME	BASIN NUMBER
MIDDLEGATE-LOWERY*	265132	39.30	-118.02	4600	1988	2007	15	Cowkick Valley	126
BEOWAWE*	260795	40.58	-116.47	4700	1908	2007	60	Crescent Valley	54
CORTEZ GOLD MINE*	261975	40.18	-116.63	4905	1968	1979	10	Crescent Valley	54
VIRGINIA CITY	268761	39.32	-119.65	6340	1887	2007	41	Dayton Valley	103
JUNGO MEYER RCH*	264108	40.88	-118.43	4200	1968	1986	7	Desert Valley	31
DIAMOND VALLEY USDA*	262296	39.683	-116.03	5970	1979	2007	19	Diamond Valley	153
EUREKA	262708	39.52	-115.97	6540	1888	2007	67	Diamond Valley	153
SOUTH FORK SP*	267690	40.68	-115.75	5270	1993	2007	8	Dixie Creek Tenmile	48
BRINKERHOFF RCH*	261160	40.08	-117.67	3661	1966	1981	7	Dixie Valley	128
WADSWORTH 4 N*	268838	39.68	-119.28	4200	1974	2007	21	Dodge Flat	82
CARSON CITY*	261485	39.15	-119.77	4651	1893	2007	90	Eagle Valley	104
URSINE	268538	37.98	-114.22	5833	1964	1972	4	Eagle Valley	200
EASTGATE*	262477	39.30	-117.88	5023	1956	1964	4	Eastgate Valley Area	127
BOULDER CITY*	261071	35.98	-114.85	2500	1931	2004	64	Eldorado Valley	167
ELKO*	262570	40.87	-115.75	5235	1999	2007	6	Elko Segment	49
ELKO RGNL AP*	262573	40.83	-115.78	5050	1888	2007	94	Elko Segment	49
FERNLEY*	262840	39.62	-119.25	4163	1907	1974	21	Fernley Area	76
DYER*	262431	37.62	-118.02	4900	1903	2007	55	Fish Lake Valley	117
PALMETTO	265931	37.47	-117.77	5906	1890	1911	14	Fish Lake Valley	117
LATHROP WELLS	264457	36.65	-116.40	2671	1942	1963	8	Fortymile Canyon	227A
ADAVEN	260046	38.12	-115.58	6250	1914	1981	53	Garden Valley	172
OASIS*	265722	41.03	-114.47	5830	1987	2007	17	Goshute Valley	187
PEQUOP	266148	41.07	-114.53	6033	1959	1985	23	Goshute Valley	187
BEOWAWE U OF N RCH*	260800	39.90	-116.58	5740	1972	2007	28	Grass Valley	138
WINNEMUCCA #2*	269168	40.93	-117.75	4300	1999	2007	6	Grass Valley	71
FERGUSON SPRINGS HMS*	262820	40.42	-114.18	5840	1972	1982	7	Great Salt Lake Desert	192
SHELDON	267443	41.85	-119.63	6506	1933	1972	35	Guano Valley	6
BLUE JAY HWY STN*	260961	38.38	-116.22	5322	1963	1984	7	Hot Creek	156
RATTLESNAKE	266630	38.45	-116.17	5915	1948	1966	13	Hot Creek	156
TWIN SPRING FALLINI*	268443	38.20	-116.18	5300	1985	2005	10	Hot Creek	156
JIGGS 8 SSE ZAGA*	264095	40.35	-115.62	5800	1978	2007	19	Huntington Valley	47
IMLAY*	263957	40.65	-118.17	4260	1914	2007	56	Imlay Area	72

Appendix 1b cont. Weather stations used for estimating ET and net irrigation water requirements (sorted by basin name). * indicates station was used for basin average.

STATION NAME	STATION NUMBER	LAT (NAD83)	LONG (NAD83)	ELEVATION (feet)	DATA FILE START YEAR	DATA FILE END YEAR	NUMBER OF YEARS WITH INSIGNIFICANT MISSING DATA	BASIN NAME	BASIN NUMBER
RYE PATCH DAM*	267192	40.47	-118.30	4135	1935	2007	63	Imlay Area	72
TUSCARORA*	268346	41.32	-116.22	6170	1958	2007	40	Independence Valley	36
INDIAN SPRINGS*	263980	36.58	-115.68	3123	1913	1964	23	Indian Springs Valley	161
GOODSPRINGS*	263316	35.83	-115.43	4000	1999	2007	6	Ivanpah Valley	164A
MOORMAN RCH*	265371	39.33	-115.32	6539	2002	2007	4	Jakes Valley	174
JARBRIDGE 4 N	264038	41.93	-115.43	6168	1916	1995	22	Jarbidge River Area	39
JARBIDGE 7 N*	264039	41.98	-115.43	6050	1995	2007	11	Jarbidge River Area	39
DAGGET PASS	262119	38.98	-119.88	7334	1988	2007	5	Lake Tahoe Basin	90
GLENBROOK*	263205	39.08	-119.93	6350	1909	2007	50	Lake Tahoe Basin	90
MARLETTE LAKE	264858	39.17	-119.92	8005	1916	1952	19	Lake Tahoe Basin	90
STATELINE-HARRAH'S*	267806	38.97	-119.95	6248	1984	1998	13	Lake Tahoe Basin	90
GEYSER RCH*	263101	38.67	-114.63	6020	1904	2002	19	Lake Valley	183
LAKE VALLEY STEWARD	264384	38.32	-114.65	6350	1971	1998	22	Lake Valley	183
LAMOILLE YOST*	264394	40.72	-115.52	5840	1975	2004	22	Lamoille Valley	45
LAMOILLE PH	264395	40.68	-115.47	6293	1916	1972	35	Lamoille Valley	45
DESERT NWR*	262243	36.43	-115.37	2920	1940	2007	60	Las Vegas Valley	212
KYLE CANYON RS	264314	36.25	-115.60	7205	1939	1948	4	Las Vegas Valley	212
LAS VEGAS*	264429	36.17	-115.13	2011	1895	1956	36	Las Vegas Valley	212
LAS VEGAS*	23112	36.17	-115.15	1867	1949	1970	22	Las Vegas Valley	212
LAS VEGAS WB AP*	264436	36.08	-115.07	2160	1948	2005	57	Las Vegas Valley	212
LAS VEGAS NWFO*	264439	36.05	-115.18	2170	1996	2007	9	Las Vegas Valley	212
LITTLE RED ROCK	264600	36.15	-115.42	3802	1965	1970	4	Las Vegas Valley	212
MT CHARLESTON FS	265400	36.27	-115.65	7600	1949	2007	6	Las Vegas Valley	212
NORTH LAS VEGAS*	265705	36.22	-115.13	1888	1951	2007	20	Las Vegas Valley	212
RED ROCK CANYON SP	266691	36.08	-115.45	3780	1977	2007	20	Las Vegas Valley	212
STEAD*	267820	39.62	-119.88	5120	1985	2007	14	Lemmon Valley	92B
FISH CREEK RCH*	262860	39.27	-116.00	6053	1943	1964	14	Little Smoky Valley	155A
SNOWBALL RCH	267640	39.03	-116.20	7160	1966	2002	33	Little Smoky Valley	155A
LOVELOCK DERBY FLD*	264700	40.07	-118.57	3902	1948	2005	49	Lovelock Valley	73

Appendix 1b cont. Weather stations used for estimating ET and net irrigation water requirements (sorted by basin name). * indicates station was used for basin average.

STATION NAME	STATION NUMBER	LAT (NAD83)	LONG (NAD83)	ELEVATION (feet)	DATA FILE START YEAR	DATA FILE END YEAR	NUMBER OF YEARS WITH INSIGNIFICANT MISSING DATA	BASIN NAME	BASIN NUMBER
ELGIN*	262557	37.35	-114.55	3420	1985	2007	20	Lower Meadow Valley Wash	205
ELGIN 3 SE*	262562	37.32	-114.50	3301	1965	1985	15	Lower Meadow Valley Wash	205
LOGANDALE*	264651	36.62	-114.48	1410	1968	1992	20	Lower Moapa Valley	220
OVERTON*	265846	36.55	-114.45	1250	1939	2007	35	Lower Moapa Valley	220
BATTLE MTN AP*	260691	40.62	-116.90	4540	1944	2007	55	Lower Reese River Valley	59
GIBBS RCH*	263114	41.57	-115.22	6000	1953	2007	43	Marys River Area	42
MALA VISTA RCH*	264824	41.32	-115.25	5594	1939	1965	16	Marys River Area	42
METROPOLIS*	265092	41.28	-115.02	5800	1965	1995	18	Marys River Area	42
WELLS*	268988	41.10	-114.97	5700	1895	2004	66	Marys River Area	42
WABUSKA 6 SE*	268822	39.07	-119.12	4300	1972	2007	27	Mason Valley	108
YERINGTON*	269229	39.00	-119.17	4380	1894	2007	66	Mason Valley	108
REESE VALLEY CARPER	266748	40.05	-117.23	4898	1976	1983	6	Middle Reese River Valley	58
SOLDIERS MEADOW*	267682	41.35	-119.17	4554	1962	1966	8	Mud Meadow	26
RYNDON*	267188	40.95	-115.60	5150	1999	2007	6	North Fork Area	44
SAVAL RCH*	267324	41.28	-115.92	6365	1960	1967	5	North Fork Area	44
BEATTY*	260715	36.92	-116.75	3304	1917	1972	32	Oasis Valley	228
BEATTY 8 N*	260718	37.00	-116.72	3550	1972	2007	28	Oasis Valley	228
MTN CITY RS*	265392	41.83	-115.97	5650	1955	1999	35	Owyhee River Area	37
OWYHEE*	265869	41.95	-116.10	5397	1948	1984	30	Owyhee River Area	37
WILDHORSE RSVR*	269072	41.63	-115.80	6226	1982	2007	18	Owyhee River Area	37
ALAMO*	260099	37.37	-115.17	3517	1921	1962	29	Pahranagat Valley	209
HIKO*	263671	37.55	-115.22	3900	1989	2007	15	Pahranagat Valley	209
PAHRANAGAT WR*	265880	37.27	-115.12	3400	1964	2007	33	Pahranagat Valley	209
PAHRUMP*	265890	36.22	-116.02	2700	1914	2007	42	Pahrump Valley	162
CATHEDRAL GORGE SP*	261590	37.80	-114.40	4830	2003	2007	4	Panaca Valley	203
PARADISE VALLEY 1 NW*	266005	41.50	-117.55	4675	1894	2007	47	Paradise Valley	69
PIOCHE	266252	37.95	-114.47	6180	1888	2006	61	Patterson Valley	202

Appendix 1b cont. Weather stations used for estimating ET and net irrigation water requirements (sorted by basin name). * indicates station was used for basin average.

STATION NAME	STATION NUMBER	LAT (NAD83)	LONG (NAD83)	ELEVATION (feet)	DATA FILE START YEAR	DATA FILE END YEAR	NUMBER OF YEARS WITH INSIGNIFICANT MISSING DATA	BASIN NAME	BASIN NUMBER
PENOYER VALLEY*	266130	37.65	-115.80	4800	1967	2006	5	Penoyer Valley	170
TEMPIUTE 4 NW*	267983	37.68	-115.72	4889	1972	1985	12	Penoyer Valley	170
PILOT VALLEY-LEE*	266228	41.12	-114.12	4905	2000	2007	6	Pilot Creek Valley	191
QUINN RVR CROSSING	266504	41.57	-118.43	4091	1901	1951	10	Pine Forest Valley	29
PINE VALLEY BAILEY RCH*	266242	40.43	-116.12	5047	1982	2006	11	Pine Valley	53
RAND RCH PALISADE*	266574	40.43	-116.12	5046	1957	1982	19	Pine Valley	53
SEARCHLIGHT	267369	35.47	-114.92	3540	1913	2007	73	Piute Valley	214
MT ROSE BOWL	265440	39.35	-119.87	7500	1973	1987	8	Pleasant Valley	88
PARIS RCH*	266055	40.22	-117.68	4140	1966	1991	22	Pleasant Valley	130
DENIO*	262229	41.98	-118.63	4190	1951	2006	39	Pueblo Valley	1
NIXON*	265605	39.83	-119.35	3904	1928	1974	30	Pyramid Lake Valley	81
SUTCLIFFE	267953	39.95	-119.60	3900	1967	2007	27	Pyramid Lake Valley	81
MONTGOMERY MNTC STN	265362	37.97	-118.32	7100	1960	1980	10	Queen Valley	116
MCDERMITT*	264935	42.00	-117.72	4527	1892	2007	29	Quinn River Valley	33B
OROVADA 3 W*	265818	41.57	-117.83	4200	1911	2007	74	Quinn River Valley	33A
BLUE EAGLE RCH HANKS*	260955	38.52	-115.55	4780	1978	2007	23	Railroad Valley	173B
CURRANT*	262078	38.75	-115.47	5184	1941	1949	4	Railroad Valley	173B
CURRANT HWY STN	262091	38.80	-115.35	6243	1963	1977	7	Railroad Valley	173B
DIABLO*	262276	37.92	-116.05	5105	1959	1978	10	Railroad Valley	173A
DUCKWATER*	262390	38.85	-115.63	5550	1966	2003	19	Railroad Valley	173B
TONOPAH*	268170	38.05	-117.08	5395	1954	2005	49	Ralston Valley	141
RED ROCK WC*	29999	39.892	-119.9345	4708	2004	2008	4	Red Rock Valley	99
ARTHUR 4 NW*	260438	40.78	-115.18	6300	1963	2007	34	Ruby Valley	176
RUBY LAKE*	267123	40.20	-115.50	6010	1940	2007	61	Ruby Valley	176
CONTACT*	261905	41.77	-114.75	5350	1949	1999	33	Salmon Falls Creek Area	40
JACKPOT*	264016	41.98	-114.67	5290	1986	2007	15	Salmon Falls Creek Area	40
KNOLL CREEK FLD STN	264268	41.63	-114.73	6004	1971	1979	6	Salmon Falls Creek Area	40
SAN JACINTO*	267284	41.88	-114.68	5203	1904	1948	21	Salmon Falls Creek Area	40
EMPIRE*	262662	40.58	-119.35	3953	1951	1976	6	San Emidio Desert	22
GERLACH*	263090	40.65	-119.37	3950	1948	2007	27	San Emidio Desert	22

Appendix 1b cont. Weather stations used for estimating ET and net irrigation water requirements (sorted by basin name). * indicates station was used for basin average.

STATION NAME	STATION NUMBER	LAT (NAD83)	LONG (NAD83)	ELEVATION (feet)	DATA FILE START YEAR	DATA FILE END YEAR	NUMBER OF YEARS WITH INSIGNIFICANT MISSING DATA	BASIN NAME	BASIN NUMBER
SARCOBATUS*	267319	37.27	-117.02	4022	1941	1961	14	Sarcobatus Flat	146
SMITH 1 N*	267609	38.82	-119.33	4754	1937	1966	23	Smith Valley	107
SMITH 6 N*	267612	38.95	-119.33	5000	1973	2007	23	Smith Valley	107
WELLINGTON RS*	268977	38.75	-119.37	4843	1942	1973	27	Smith Valley	107
SAND PASS*	267261	40.32	-119.80	3904	1913	1971	41	Smoke Creek Desert	21
SMOKE CREEK ESPIL*	267618	40.60	-119.75	3850	1987	2006	14	Smoke Creek Desert	21
GREAT BASIN NP	263340	39.02	-114.23	6830	1987	2007	16	Snake Valley	195
LEHMAN CAVES NM	264514	39.00	-114.22	6826	1937	1987	44	Snake Valley	195
MINA*	265168	38.38	-118.10	4550	1896	2007	79	Soda Spring Valley	121A
I-L RCH*	263940	41.57	-116.40	5203	1962	1969	3	South Fork Owyhee River Area	35
SHOSHONE 5 N*	267450	38.92	-114.40	5930	1988	2007	17	Spring Valley	184
SPRING VALLEY SP*	267750	38.03	-114.18	5950	1974	2007	24	Spring Valley	201
SEVENTY ONE RCH*	267397	40.90	-115.32	5453	1939	1952	4	Starr Valley Area	43
CURRIE HWY STN*	262096	40.27	-114.75	5820	1961	1991	10	Steptoe Valley	179
ELY 6 NE	262626	39.30	-114.83	6263	1999	2005	5	Steptoe Valley	179
ELY YELLAND FLD AP*	262631	39.30	-114.85	6262	1893	2005	68	Steptoe Valley	179
LAGES*	264341	40.07	-114.62	5960	1984	2007	21	Steptoe Valley	179
MCGILL*	264950	39.40	-114.78	6270	1892	2007	90	Steptoe Valley	179
OLD RUTH	265760	39.27	-114.98	7034	1978	1985	5	Steptoe Valley	179
RUTH	267175	39.28	-114.98	6850	1958	2007	30	Steptoe Valley	179
VYA	268810	41.58	-119.92	5663	1959	1980	14	Surprise Valley	14
BASALT	260668	38.00	-118.27	6355	1941	1957	10	Teels Marsh Valley	114
MONTELLO 2 SE*	265352	41.25	-114.17	4890	1902	2007	67	Thousand Springs Valley	189D
WILKINS*	269122	41.43	-114.75	5643	1948	1980	16	Thousand Springs Valley	189A
WADSWORTH*	268834	39.63	-119.28	4081	1902	1948	6	Tracy Segment	83
RENO TAHOE INTL AP*	266779	39.48	-119.77	4410	1937	2007	69	Truckee Meadows	87
RENO WFO*	266791	39.57	-119.80	4974	1996	2007	10	Truckee Meadows	87
UNIV OF NEVADA EXP FM*	268500	39.52	-119.78	4514	1949	1954	4	Truckee Meadows	87
AUSTIN #2*	260507	39.50	-117.07	6780	1887	2007	82	Upper Reese River Valley	56

Appendix 1b cont. Weather stations used for estimating ET and net irrigation water requirements (sorted by basin name). * indicates station was used for basin average.

STATION NAME	STATION NUMBER	LAT (NAD83)	LONG (NAD83)	ELEVATION (feet)	DATA FILE START YEAR	DATA FILE END YEAR	NUMBER OF YEARS WITH INSIGNIFICANT MISSING DATA	BASIN NAME	BASIN NUMBER
CENTRAL NEVADA FLD LAB*	261630	39.38	-117.32	5950	1965	1986	13	Upper Reese River Valley	56
REESE RIVER*	266746	39.07	-117.42	6550	1972	2007	26	Upper Reese River Valley	56
BUNKERVILLE*	261327	36.77	-114.12	1550	1979	2007	6	Virgin River Valley	222
MESQUITE*	265085	36.80	-114.07	1570	1942	2006	13	Virgin River Valley	222
DUFURRENA*	262394	41.87	-119.02	4800	1959	2005	30	Virgin Valley	4
HAWTHORNE*	263512	38.52	-118.63	4330	1954	2007	13	Walker Lake Valley	110C
HAWTHORNE AP*	263515	38.55	-118.67	4220	1888	1991	39	Walker Lake Valley	110C
SCHURZ*	267358	38.95	-118.82	4124	1920	1957	30	Walker Lake Valley	110A
THORNE*	268034	38.60	-118.60	4203	1914	1950	24	Walker Lake Valley	110C
LEWERS RCH	264542	39.23	-119.85	5203	1893	1938	15	Washoe Valley	89
WASHOE VALLEY WC*	39999	39.285	-119.789	5050	2004	2008	4	Washoe valley	89
KIMBERLY	264199	39.27	-115.03	7234	1928	1958	28	White River Valley	207
LUND*	264745	38.87	-115.02	5560	1957	2007	47	White River Valley	207
SUNNYSIDE*	267908	38.42	-115.02	5300	1891	2007	35	White River Valley	207
MIDAS 4 SE*	265105	41.20	-116.73	5203	1961	1969	4	Willow Creek Valley	63
GOLCONDA*	263245	40.95	-117.50	4415	1906	2007	71	Winnemucca Segment	70
WINNEMUCCA MUNI AP*	269171	40.90	-117.80	4296	1949	2007	57	Winnemucca Segment	70

Appendix 2. Details of supplementary Washoe County weather data and modifications made to 2 NWS weather station data sets due to poor station siting.

Non NWS Weather Station Analysis

Two weather data sets from ‘full sweet’ weather stations not part of the NWS network were added to this analysis to provide ET and net irrigation water Requirement estimates in basins where information is needed to address current and future water rights applications. These stations are operated and maintained by Washoe County Department of Water Resources and are located in Washoe Valley and Redrock Valley. Weather data used from these stations were compiled and formatted to be used in the computer program developed to read NWS station data.

Measured daily wind speed, calculated daily dew point from measured RH, and measured precipitation for the Redrock weather station were used to calculate daily ET_{os} and the net irrigation water requirement for the period of record. After analyzing the dewpoint depression for the Redrock weather station it was determined that no adjustment was needed to reflect reference conditions due to the fact that the computed mean annual dewpoint depression was 2.5^{o}C, which generally represents near reference conditions.

Washoe Valley contains two weather stations that Washoe County maintains and operates. One of the weather stations is located near Old Franktown road on the west side of Washoe Valley, while the other is located near Washoe Lake on the east central side of Washoe Valley. The location of the weather station located near Old Franktown road is not ideal, as it is located in an area where the predominant upwind fetch is obstructed by tall timber. Conversely, the east side weather station is located downwind of Washoe Lake and experiences high winds, partly due to the smooth surface of the lake. Additionally, the precipitation gradient from the west side to the east side of the valley is large. According to the 800m version 2 PRISM (Parameter-elevation Regressions on Independent Slopes Model) precipitation map (Daly et al., 1996) the west side weather station averages 15.4 inches verses the east side weather station of 12.1 inches. Measured mean annual precipitation of 16 and 9 inches (2004-2008) from the west and east side weather stations, respectively, confirm this gradient. Because ET_{os} is a function of wind speed, and the net irrigation water requirement is a function of ET_{os} and the precipitation amount, averaging and developing basin wide representative variables of wind speed and precipitation was required to obtain one dataset that could be used to calculate the ET_{os} and the net irrigation water requirement that is representative of the entire valley. This approach was chosen rather than calculating separate net irrigation water requirement estimates for each station and averaging the two, due to the questionable quality and representativeness of measured wind speed, missing data, and having access to Nevada Department of Transportation (NDOT) weather data located near the center of the valley in a more valley wide representative area of pasture grass. The single weather dataset was constructed for the period of 2004-2008 and consisted of daily T_{max}, T_{min}, and calculated dew point collected from the east side weather station, mean monthly wind speed from the NDOT station, and daily precipitation, which was calculated by averaging daily measurements of precipitation from the west and east side weather stations. Average precipitation for 2004-2008 (i.e. average of east and west stations) was 12.7 inches, similar to the 1971-2000 PRISM 800m version 2 (Parameter-elevation Regressions on Independent Slopes Model) precipitation map (Daly et al., 1996) spatial average for the valley floor of 12.8 inches. Calculated mean annual dewpoint depression from the east side station represented near reference conditions of 2.4^{o}C, therefore no adjustment were made to the calculated dewpoint.

NWS Station Data Adjustment

Two NWS stations were identified in the Nevada dataset that had questionable temperature data. The first station identified was the Laughlin station (264480). Questionable temperature data were identified when comparing estimated solar radiation to measured solar radiation at a nearby weather station in Mohave, AZ. Figure AP1 and AP2 illustrate the estimated and measured solar radiation for Laughlin and Mohave, respectively, where it is obvious that the estimated solar radiation is below the measured solar radiation and does not ever approach the clear sky solar radiation "envelope" that it should for that elevation and latitude. Given that estimated R_s from T_{max} and T_{min} compares well with measurements at other stations, and that the estimated daily R_s is a function of the daily difference between T_{max} and T_{min}, investigation of Laughlin measured T_{max} and T_{min} was pursued to explain the underestimation. When comparing mean monthly measured T_{min} and T_{max} for Laughlin and Mohave it was evident that the maximum temperatures compared well but the Laughlin T_{min} was significantly higher than Mohave (Figure AP3).

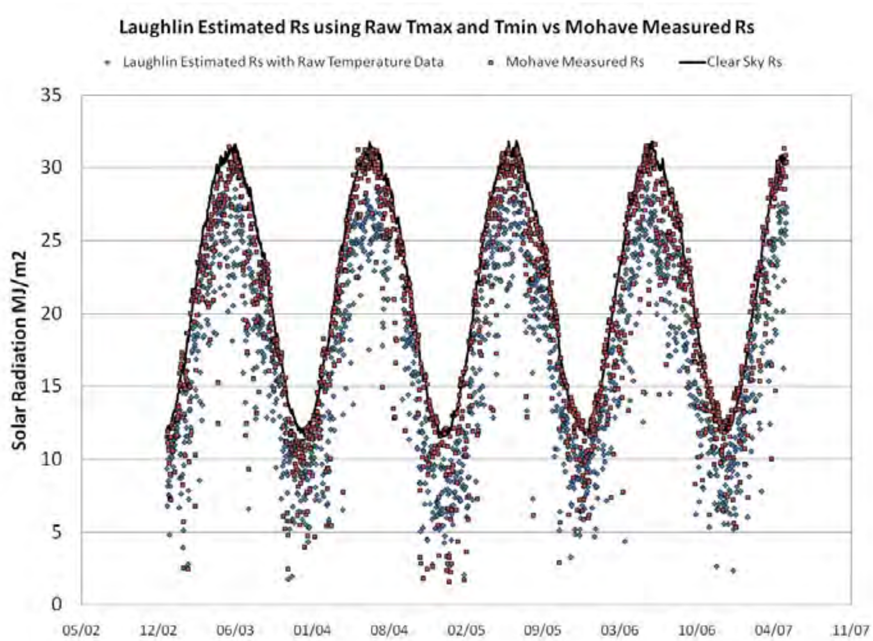

Figure AP1. Daily measured, estimated, and clear sky solar radiation for Mohave and Laughlin weather stations. The estimated solar radiation for Laughlin using T_{max} and T_{min} is underestimated when compared to the Mohave measured solar radiation.

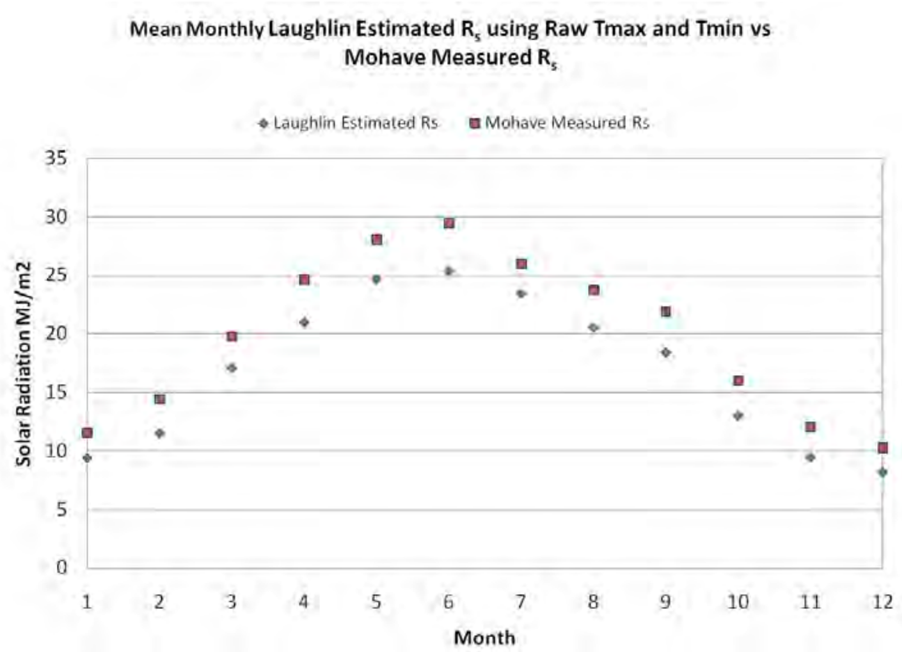

Figure AP2. Mean monthly measured and estimated solar radiation for Mohave and Laughlin weather stations.

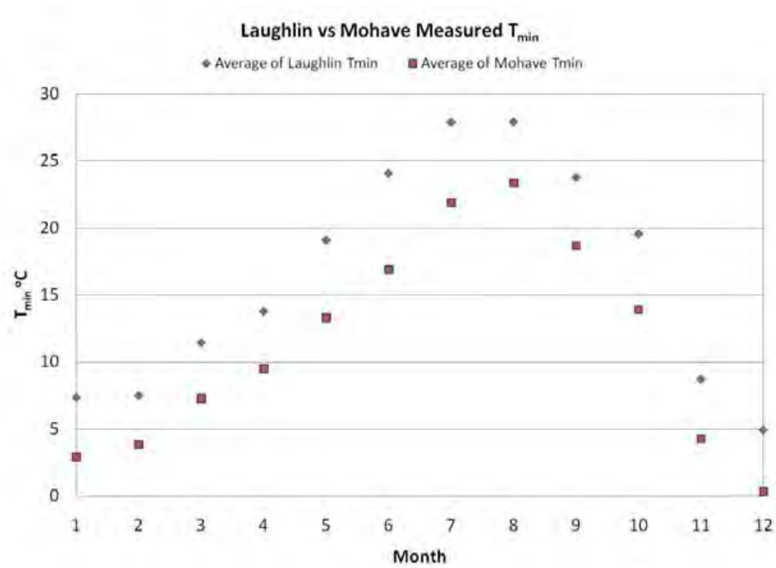

Figure AP3. Mean monthly T_{min} comparison between the Mohave and Laughlin weather stations.

The Mohave weather station is in an irrigated area along the Colorado River, so it is logical that there would be less sensible heat surrounding this station, which is illustrated in Figure AP4, where Mohave T_{max} is slightly lower than Laughlin in the spring and summer months due to evaporative cooling.

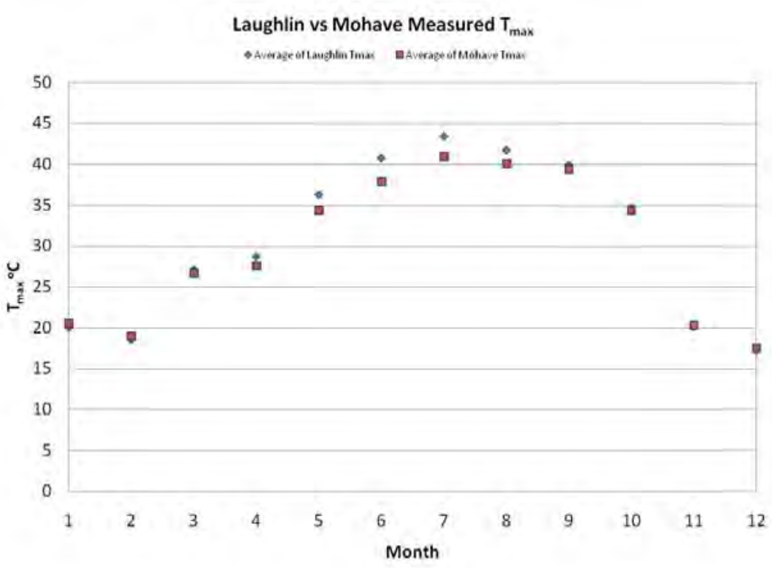

Figure AP4. Mean monthly T_{max} comparison between the Mohave and Laughlin weather stations.

The fact that Laughlin T_{min} is significantly higher than Mohave for all times of the year led to question if the area surrounding the Laughlin station could possibly be storing heat during the day and emitting it at night, such as from pavement or asphalt, thereby affecting the T_{min}. Photographs of the Laughlin station indicate that the station is indeed surrounded by asphalt and darker colored gravel (Figures AP5-AP6) perhaps having low thermal radiation emissivity and could be causing inflated T_{min} measurement. Miss calibration of the temperature sensor could also be causing inflated T_{min} measurement.

Figure AP5. Photo of the Laughlin weather station looking north.

Figure AP6. Photo of the Laughlin weather station looking south.

Artificially inflated T_{min} measurements are the primary reason why the estimated R_s did not compare well with the measured R_s nearby at the Mohave weather station. As previously mentioned, the empirical method used to estimate R_s (Thornton and Running, 1999) is based on the daily difference between T_{max} and T_{min}. The physical basis for the method is based from the fact that during cloud cover maximum air temperatures generally decrease and the minimum temperature is increased due to increased downward emission of reflection of long wave radiation by clouds at night (Allen, 1997). Because the T_{min} was abnormally inflated at Laughlin and not characteristic of an agricultural (evaporating) surface, the Thornton and Running equation, generally calibrated for more reference conditions, predicted that conditions were typically cloudy, when clearly from comparing to the Mohave measured R_s, it was not as cloudy as predicted in the region. To adjust the Laughlin T_{min} the mean monthly difference between the Laughlin and Mohave measured T_{min} was calculated and then subtracted from the Laughlin T_{min} time series for the period of record (1988-2007). After adjustment of the Laughlin T_{min} time series, estimated R_s compared well with measured R_s at the Mohave weather station.

During the QAQC process it was noted that the Minden weather station (265191) had significantly higher measured T_{max} than USGS micrometeorological weather station (ET-2) measured T_{max}, which was collected in a field of irrigated alfalfa when compared for respective time periods (Figure AP7). Measured T_{min} for both stations were very similar (Figure AP8). It is expected that the T_{max} measured over irrigated alfalfa would be somewhat lower due to less sensible heat and more ET occurring as compared to the area immediately surrounding Minden station which is a residential setting. However, the magnitudes of mean monthly differences of T_{max}, peaking at 7.8 ^oC in August for T_{max}, (Figure AP9) were considered significant given that the town of Minden is largely

Figure AP7. USGS Bowen Ratio micrometeorological weather station located in a field of irrigated alfalfa (modified from Maurer et al., 2005).

surrounded by irrigated alfalfa and pasture grass. These issues warranted an investigation of the area surrounding the Minden weather station. Figures AP10 and AP11 illustrate that the immediate area surrounding the Minden weather station is composed of a darker colored gravel, and is located within a residential area. Given that the Minden measured T_{min} compared well with measured T_{min} at the ET-2 site, the site surroundings of Mindin likely caused the increased T_{max} measurements. The affect of gravel surrounding the Minden weather station on T_{min} is smaller than the Laughlin station due to the limited extent of the gravel, where the Laughlin grave area immediately surrounding the station was large and included large areas of asphalt. In addition to the gravel surface in the vicinity of the Minden station, where there is no evaporative cooling to reduce air temperatures, there was probably substantial heat loading of the air temperature sensors due to thermal radiation emissions from the gravel, adjacent fence, and building shown in Figure AP11. The fence and building face the sun and would warm during the daytime, emitting substantial radiation toward the temperature shelter. In addition, the fence and building restricted air flow past the temperature shelter.

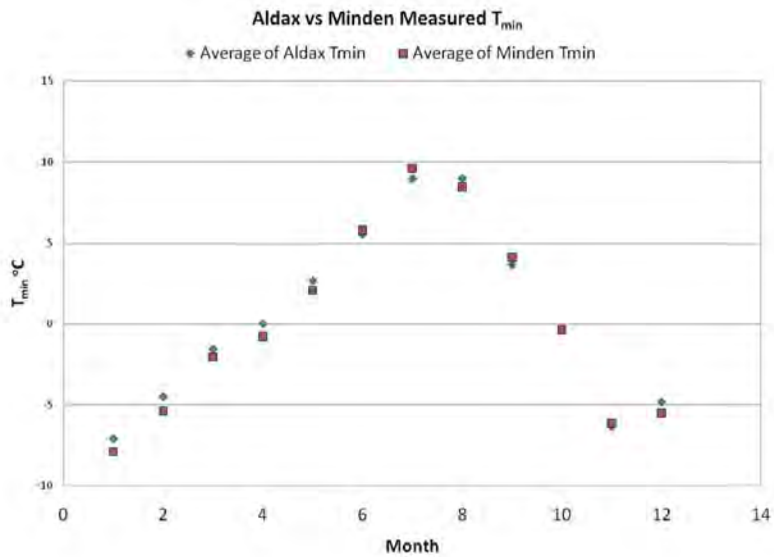

Figure AP8. Mean monthly T_{min} comparison between the ET-2 Aldax and Minden weather stations.

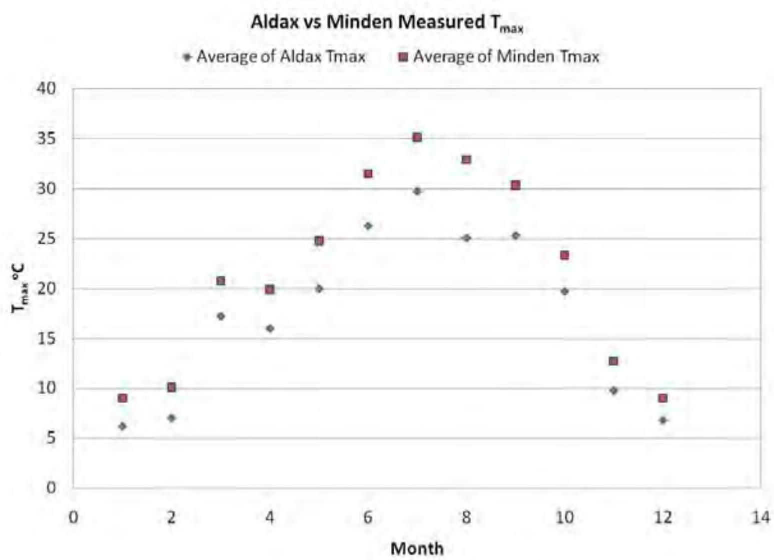

Figure AP9. Mean monthly T_{max} comparison between the ET-2 Aldax and Minden weather stations.

Figure AP10. Gravel area surrounding the Minden NWS weather station looking northwest.

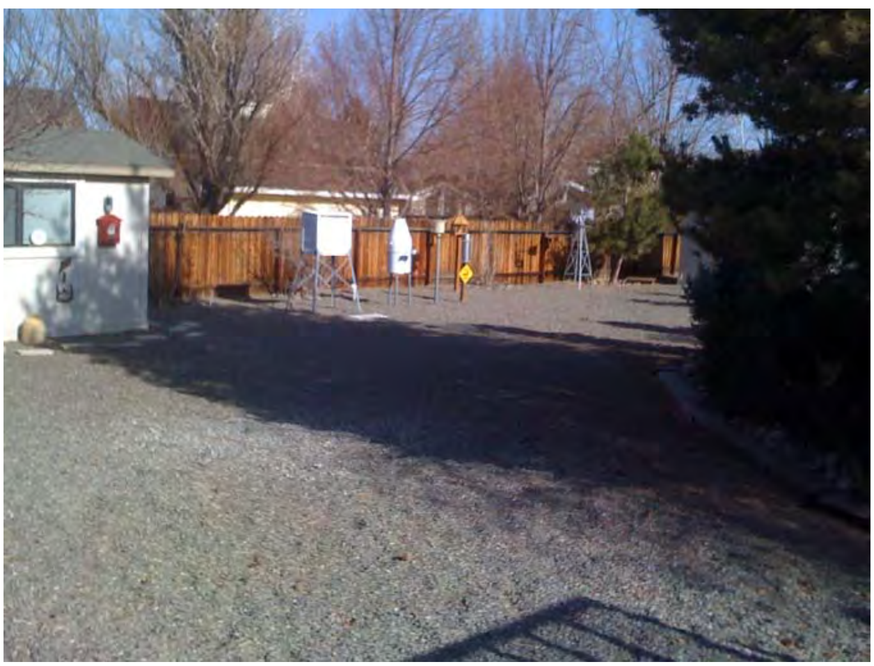

Figure AP11. Gravel area surrounding the Minden NWS weather station looking northeast

To adjust the Minden measured T_{max}, one half of the mean monthly difference between the Minden and the ET-2 site T_{max} were subtracted from the Minden T_{max} time series, beginning in 1991 when the station was relocated to the present site. Only one half of the T_{max} difference was used to adjust the Minden T_{max} time series based on findings that by using the full T_{max} difference produced unreasonable simulated greenup and harvest dates for Minden. Greenup and harvest date cumulative growing degree day parameters were calibrated to many areas of the state (see greenup and harvest date calibration section of report) using mostly NWS data that generally have a small amount of aridity bias due to siting near residential developments or non reference type settings. Therefore, the calibration may not perform well with T_{max} and T_{min} data collected in centers of irrigated fields that tend to run cooler. Because many NWS weather stations are not located in large irrigated areas, or directly over alfalfa or irrigated pasture grass, the adjustment was selected to replicate temperature measurements that would be more representative of typical NWS station site locations.

Appendix 3a. Mean monthly dew point depression (^oC) for stations used in spatial interpolation and assignment to NWS weather stations.

STATION	NETWORK	STATE	ELEVATION (ft)	LAT	LONG	PERIOD OF RECORD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Aberdeen, ID	BOR Agrimet	ID	4400	42.95	-112.83	1992-2004	-2.4	-2.2	-0.5	1.4	1.6	1.0	0.6	1.9	1.2	0.6	-1.6	-2.7	-0.1
Fairfield, ID	BOR Agrimet	ID	5038	43.31	-114.83	1990-2004	-4.3	-4.4	-2.4	0.5	0.8	0.4	1.4	2.2	1.6	0.5	-2.3	-4.2	-0.9
Malta, ID	BOR Agrimet	ID	4410	42.44	-113.41	1990-2002	-1.1	-1.3	0.1	1.1	0.9	1.3	2.5	2.9	1.3	0.8	-1.1	-1.7	0.5
Rupert, ID	BOR Agrimet	ID	4154	42.60	-113.84	1988-2008	-1.4	-1.0	0.4	1.5	1.7	1.3	1.2	2.0	1.2	0.8	-0.7	-1.4	0.5
Twin Falls, ID	BOR Agrimet	ID	3919	42.55	-114.35	1990-2008	-0.6	-0.3	1.3	2.0	2.4	3.0	3.3	3.0	2.6	1.9	0.0	-0.7	1.5
Grand View, ID	BOR Agrimet	ID	2579	42.91	-116.06	1993-2008	-1.6	-1.2	0.6	1.4	2.2	3.2	4.6	3.5	1.4	0.1	-1.3	-1.8	0.9
Bishop, CA	CIMIS	CA	4170	37.36	-118.40	1996-2007	1.6	2.0	4.3	5.0	4.4	4.4	4.0	3.7	2.7	2.5	2.0	2.0	3.2
Buntingville, CA	CIMIS	CA	4005	40.29	-120.43	1986-2007	-1.5	-0.6	0.4	0.9	0.9	2.2	3.3	4.0	2.4	0.6	-1.8	-1.8	0.7
Beryl Junction, UT	Utah Agmet	UT	5186	37.72	-113.70	2003-2007	-3.1	-1.4	0.5	2.4	3.1	5.8	4.3	2.9	3.1	1.2	0.3	-2.0	1.4
Drainage Farm, UT	Utah Agmet	UT	4430	41.83	-111.88	2003-2007	-1.9	-1.8	-1.6	2.0	2.5	2.9	4.4	3.8	1.7	0.0	-0.4	-1.3	0.9
Parowan, UT	Utah Agmet	UT	5754	37.86	-112.88	2004-2007	-3.3	-1.0	1.4	3.2	3.9	6.0	4.9	3.7	4.3	1.7	1.1	-1.9	2.0
Cedar City, UT	Utah Agmet	UT	5515	37.67	-113.14	2005-2007	-2.6	-0.3	1.2	3.4	4.7	8.1	6.5	4.7	4.8	2.2	2.9	-1.4	2.9
Flowell, UT	Utah Agmet	UT	4715	38.96	-112.42	2006-2007	-0.8	1.1	2.2	3.3	4.4	5.4	4.3	3.3	2.4	1.9	1.5	-3.7	2.1
Mason Valley, NV	USGS Bowen	NV	4322	39.11	-119.15	2005-2007	-0.4	0.7	2.3	2.2	1.6	2.3	3.6	2.4	1.4	0.6	-0.6	-0.7	1.3
Carson Valley, NV	USGS Bowen Ratio	NV	4686	39.01	-119.78	2003-2004	-0.1	2.0	2.3	3.0	1.9	2.4	2.4	1.8	2.5	1.9	0.2	-0.3	1.7
Eureka, NV	BOR Agrimet	NV	5897	39.69	-115.98	1989-2007	-3.6	-2.6	0.3	1.1	1.8	4.1	4.8	4.4	2.8	1.7	-0.9	-2.9	0.9
Fallon, NV	BOR Agrimet	NV	3965	39.46	-118.78	2001-2007	-1.0	1.0	4.6	5.6	6.7	9.6	8.3	5.9	4.9	3.2	0.3	-0.1	4.1
Lakeview, OR	BOR Agrimet	OR	4808	42.12	-120.52	1988-2007	-1.6	-1.4	-0.3	0.4	1.1	1.8	3.1	3.2	2.1	0.3	-1.5	-1.9	0.4
Lorella, OR	BOR Agrimet	OR	4130	42.08	-121.22	2001-2007	-1.7	-1.2	-1.0	-1.0	-0.2	0.1	0.7	0.3	-1.2	-2.4	-2.2	-1.6	-1.0
Mohave, AZ	AZMET	AZ	1581	34.97	-114.61	2003-2007	2.7	3.5	4.4	6.4	8.0	9.1	8.1	6.8	7.7	5.3	3.1	3.3	5.7

Appendix 3b. Interpolated or assigned basin average mean monthly dew point depression K_o (^oC) used for assignment to respective weather stations. Symbol * next to the basin name indicates the basins that were assigned the measured mean monthly dew point depression.

BASIN NUMBER	BASIN NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN ANNUAL
142	Alkali Spring Valley	-0.2	0.9	2.9	3.8	3.8	4.8	4.6	3.8	3.1	2.1	0.9	0.1	2.5
111B	Alkali Valley	-0.2	1.1	3.0	3.5	3.3	4.2	4.3	3.4	2.7	1.8	0.4	0.1	2.3
230	Amargosa Desert	-0.5	0.8	2.7	3.9	4.3	5.7	5.1	4.1	3.8	2.4	1.2	0.0	2.8
57	Antelope Valley	-1.6	-0.3	2.0	2.7	3.0	4.7	4.9	4.0	2.9	1.7	-0.4	-1.2	1.9
106	Antelope Valley	-0.4	1.3	2.5	2.9	2.3	3.1	3.4	2.5	2.4	1.5	-0.1	-0.4	1.7
186B	Antelope Valley	-2.3	-1.4	0.4	1.9	2.4	3.6	3.8	3.4	2.4	1.3	-0.3	-2.3	1.1
137A	Big Smoky Valley	-0.6	0.7	2.8	3.6	3.6	4.9	4.7	3.8	3.0	2.0	0.6	-0.2	2.4
137B	Big Smoky Valley	-1.8	-0.5	1.9	2.7	3.0	4.8	4.9	4.0	3.0	1.8	-0.1	-1.4	1.9
215	Black Moutains Area	-0.6	0.8	2.4	4.1	5.0	6.9	5.9	4.7	4.9	2.8	1.7	0.0	3.2
28	Black Rock Desert	-1.3	-0.3	1.3	2.0	2.2	3.4	3.9	3.4	2.3	1.0	-0.9	-1.3	1.3
61	Boulder Flat	-2.1	-1.3	0.9	1.8	2.2	3.4	4.0	3.6	2.4	1.3	-0.8	-1.9	1.1
38	Bruneau River Area	-1.8	-1.4	0.3	1.6	2.0	2.5	3.2	3.1	1.9	0.9	-0.9	-1.9	0.8
129	Buena Vista Valley	-1.2	0.0	2.2	2.9	3.2	4.8	4.9	3.9	2.9	1.6	-0.5	-1.0	2.0
131	Buffalo Valley	-1.7	-0.6	1.5	2.3	2.6	4.0	4.4	3.7	2.6	1.4	-0.7	-1.4	1.5
101	Carson Desert*	-1.0	1.0	4.6	5.6	6.7	9.6	8.3	5.9	4.9	3.2	0.3	-0.4	4.1
105	Carson Valley*	-0.1	2.0	2.3	3.0	1.4	2.2	2.4	1.6	3.0	3.0	0.2	-0.3	1.7
102	Churchill Valley	-0.6	0.9	2.9	3.2	2.9	4.2	4.7	3.3	2.5	1.5	-0.3	-0.5	2.1
143	Clayton Valley	0.3	1.3	3.4	4.1	4.0	4.7	4.4	3.7	3.0	2.2	1.2	0.7	2.7
177	Clover Valley	-2.2	-1.5	0.4	1.8	2.2	3.2	3.6	3.3	2.2	1.2	-0.6	-2.1	1.0
204	Clover Valley	-2.7	-0.9	1.0	2.8	3.6	6.1	4.9	3.5	3.6	1.6	0.9	-1.8	1.9
64	Clovers Area	-1.9	-1.0	1.0	1.8	2.2	3.4	4.0	3.5	2.3	1.2	-0.9	-1.7	1.2
213	Colorado Valley	1.8	2.7	3.8	5.7	7.2	8.5	7.5	6.2	6.9	4.6	2.7	2.4	5.0
118	Columbus Salt Marsh Valley	0.1	1.2	3.2	3.9	3.8	4.6	4.4	3.7	2.9	2.1	0.9	0.4	2.6
126	Cowkick Valley	-1.0	0.6	3.1	3.8	4.1	6.0	5.8	4.3	3.4	2.1	-0.1	-0.5	2.6
54	Crescent Valley	-2.4	-1.4	1.0	1.8	2.3	4.0	4.4	3.9	2.7	1.5	-0.7	-2.0	1.3
103	Dayton Valley	-0.4	1.3	2.5	2.9	2.3	3.2	3.6	2.6	2.4	1.5	-0.2	-0.5	1.8
31	Desert Valley	-1.4	-0.5	1.3	2.0	2.2	3.4	3.9	3.4	2.3	1.0	-0.9	-1.4	1.3
153	Diamond Valley*	-3.6	-2.6	0.3	1.1	1.8	4.1	4.8	4.4	2.8	1.7	-0.9	-2.9	0.9
48	Dixie Creek-Tenmile Creek Area	-2.4	-1.6	0.6	1.7	2.2	3.6	4.0	3.7	2.4	1.3	-0.7	-2.2	1.0
128	Dixie Valley	-1.1	0.3	2.8	3.5	3.9	5.7	5.6	4.2	3.3	2.0	-0.2	-0.7	2.4
82	Dodge Flat	-0.8	0.8	2.9	3.5	3.6	5.2	5.2	3.9	3.1	1.9	-0.3	-0.5	2.4
104	Eagle Valley	-0.2	1.8	2.3	2.9	2.0	2.6	2.7	2.0	2.5	1.8	0.1	-0.3	1.7
200	Eagle Valley	-2.7	-1.0	0.9	2.8	3.6	6.1	4.8	3.4	3.5	1.5	0.8	-1.9	1.8

Appendix 3b cont. Interpolated or assigned basin average mean monthly dew point depression K_o (^oC).

BASIN NUMBER	BASIN NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN ANNUAL
127	Eastgate Valley Area	-1.0	0.5	2.9	3.6	3.9	5.7	5.6	4.2	3.3	2.0	-0.1	-0.6	2.5
167	Eldorado Valley	0.9	2.0	3.3	5.1	6.3	7.8	6.8	5.6	6.1	3.9	2.3	1.5	4.3
49	Elko Segment	-2.2	-1.5	0.6	1.7	2.2	3.4	3.8	3.5	2.3	1.3	-0.7	-2.1	1.0
76	Fernley Area	-0.8	0.9	3.4	4.0	4.2	6.1	5.8	4.2	3.4	2.1	-0.1	-0.4	2.7
117	Fish Lake Valley	0.7	1.5	3.7	4.4	4.1	4.5	4.2	3.7	2.9	2.3	1.4	1.1	2.9
227A	Fortymile Canyon	-0.7	0.6	2.5	3.7	4.1	5.6	5.0	4.1	3.7	2.3	1.1	-0.2	2.7
122	Gabbs Valley	-0.8	0.7	2.9	3.5	3.6	5.1	5.1	3.8	3.0	1.9	0.0	-0.5	2.4
172	Garden Valley	-1.9	-0.3	1.7	3.0	3.6	5.6	4.9	3.9	3.5	1.9	0.7	-1.4	2.1
187	Goshute Valley	-2.2	-1.4	0.3	1.7	2.2	3.2	3.5	3.3	2.2	1.2	-0.4	-2.1	1.0
71	Grass Valley	-1.5	-0.4	1.6	2.3	2.6	3.9	4.3	3.6	2.5	1.3	-0.7	-1.3	1.5
138	Grass Valley	-2.6	-1.5	1.1	1.9	2.4	4.4	4.7	4.1	2.8	1.7	-0.6	-2.1	1.4
192	Great Salt Lake Desert	-2.1	-1.3	0.3	1.8	2.4	3.4	3.5	3.3	2.3	1.2	-0.3	-2.1	1.0
6	Guano Valley	-1.6	-1.0	0.2	0.8	1.2	2.0	3.0	2.8	1.6	0.1	-1.4	-1.7	0.5
156	Hot Creek	-1.7	-0.3	1.9	2.9	3.3	5.1	4.9	4.0	3.2	1.9	0.4	-1.2	2.0
24	Hualapai Flat	-1.3	-0.3	1.1	1.7	1.9	3.0	3.7	3.3	2.2	0.8	-1.1	-1.3	1.1
47	Huntington Valley	-2.9	-1.9	0.6	1.5	2.1	4.0	4.5	4.0	2.7	1.5	-0.7	-2.5	1.1
72	Imlay Area	-1.3	-0.1	1.8	2.5	2.8	4.1	4.4	3.6	2.6	1.4	-0.6	-1.1	1.7
36	Independence Valley	-1.9	-1.4	0.4	1.6	2.0	2.8	3.5	3.3	2.0	1.0	-1.0	-1.9	0.9
161	Indian Springs Valley	-1.0	0.5	2.2	3.7	4.3	6.1	5.3	4.2	4.1	2.4	1.3	-0.4	2.7
135	Ione Valley	-0.9	0.5	2.7	3.4	3.5	5.0	4.9	3.8	3.0	1.9	0.1	-0.6	2.3
164A	Ivanpah Valley	0.7	1.8	3.1	4.9	6.0	7.5	6.6	5.3	5.7	3.7	2.1	1.2	4.0
174	Jakes Valley	-2.8	-1.5	0.9	1.9	2.5	4.5	4.7	4.0	2.9	1.7	-0.2	-2.3	1.4
39	Jarbidge River Area	-1.7	-1.3	0.3	1.6	2.0	2.4	3.0	3.0	1.8	1.0	-0.9	-1.8	0.8
30A	Kings River Valley	-1.6	-0.9	0.7	1.4	1.8	2.7	3.5	3.1	1.9	0.6	-1.1	-1.6	0.9
90	Lake Tahoe Basin	-0.3	1.7	2.3	2.9	2.1	2.7	2.7	2.1	2.5	1.8	0.1	-0.3	1.7
183	Lake Valley	-2.3	-0.7	1.2	2.8	3.6	5.8	4.9	3.7	3.5	1.7	0.9	-1.8	2.0
45	Lamoille Valley	-2.2	-1.5	0.5	1.7	2.2	3.3	3.8	3.5	2.2	1.2	-0.7	-2.1	1.0
212	Las Vegas Valley	-0.4	0.9	2.5	4.2	5.0	6.8	5.9	4.7	4.8	2.9	1.6	0.2	3.3
92A	Lemmon Valley	-0.8	0.6	2.1	2.6	2.4	3.5	3.9	3.3	2.6	1.4	-0.6	-0.8	1.7
92B	Lemmon Valley	-0.8	0.7	2.2	2.7	2.5	3.6	4.0	3.2	2.6	1.5	-0.5	-0.7	1.8
155A	Little Smoky Valley	-2.9	-1.7	0.9	1.8	2.3	4.4	4.8	4.2	2.9	1.7	-0.5	-2.3	1.3
73	Lovelock Valley	-1.0	0.4	2.7	3.4	3.7	5.4	5.3	4.1	3.1	1.8	-0.4	-0.7	2.3
205	Lower Meadow Valley Wash	-2.2	-0.4	1.4	3.1	3.9	6.2	5.1	3.8	3.8	1.9	1.1	-1.4	2.2
220	Lower Moapa Valley	-1.6	0.0	1.8	3.5	4.4	6.5	5.5	4.1	4.2	2.3	1.4	-0.9	2.6
59	Lower Reese River Valley	-1.9	-0.9	1.3	2.1	2.5	3.9	4.4	3.8	2.6	1.5	-0.7	-1.6	1.4
52	Marys Creek Area	-2.3	-1.4	0.8	1.8	2.2	3.6	4.0	3.7	2.4	1.4	-0.8	-2.1	1.1
42	Marys River Area	-1.9	-1.4	0.4	1.7	2.1	2.7	3.2	3.1	2.0	1.1	-0.8	-1.9	0.9

Appendix 3b cont. Interpolated or assigned basin average mean monthly dew point depression K_o (^oC).

BASIN NUMBER	BASIN NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN ANNUAL
108	Mason Valley*	-0.4	0.7	2.3	2.2	1.6	2.3	3.6	2.4	1.4	0.6	-0.6	-0.7	1.3
225	Mercury Valley	-0.7	0.6	2.4	3.8	4.3	5.9	5.3	4.2	4.0	2.4	1.3	-0.2	2.8
58	Middle Reese River Valley	-1.9	-0.7	1.6	2.3	2.7	4.3	4.6	3.9	2.8	1.6	-0.5	-1.5	1.6
26	Mud Meadow	-1.4	-0.5	1.0	1.6	1.9	2.9	3.6	3.2	2.1	0.7	-1.1	-1.4	1.0
44	North Fork Area	-1.9	-1.4	0.5	1.7	2.1	2.9	3.4	3.2	2.0	1.1	-0.8	-2.0	0.9
228	Oasis Valley	-0.6	0.7	2.6	3.7	4.0	5.3	4.8	3.9	3.5	2.2	1.1	-0.1	2.6
37	Owyhee River Area	-1.8	-1.4	0.3	1.5	2.0	2.6	3.3	3.1	1.9	0.9	-1.0	-1.9	0.8
209	Pahranagat Valley	-1.9	-0.3	1.6	3.2	3.9	6.0	5.1	3.9	3.7	1.9	1.0	-1.3	2.2
162	Pahrump Valley	-0.3	1.0	2.6	4.1	4.8	6.4	5.7	4.5	4.5	2.8	1.5	0.2	3.2
203	Panaca Valley	-2.6	-0.8	1.0	2.8	3.6	6.1	4.9	3.5	3.6	1.6	0.9	-1.8	1.9
69	Paradise Valley	-1.7	-0.9	0.9	1.7	2.1	3.1	3.8	3.3	2.1	0.9	-1.0	-1.6	1.1
202	Patterson Valley	-2.5	-0.8	1.1	2.9	3.6	6.0	4.9	3.6	3.6	1.7	0.9	-1.8	1.9
170	Penoyer Valley	-1.5	-0.1	1.9	3.2	3.7	5.6	5.0	3.9	3.5	2.0	0.8	-1.0	2.2
191	Pilot Creek Valley	-1.9	-1.4	0.2	1.7	2.1	2.8	3.2	3.1	2.0	1.1	-0.5	-2.0	0.9
29	Pine Forest Valley	-1.6	-0.8	0.7	1.5	1.8	2.8	3.5	3.1	1.9	0.6	-1.1	-1.6	0.9
53	Pine Valley	-2.9	-1.9	0.7	1.6	2.1	4.0	4.5	4.1	2.7	1.6	-0.7	-2.4	1.1
214	Piute Valley	2.0	2.9	3.9	5.9	7.3	8.6	7.6	6.3	7.1	4.7	2.8	2.6	5.1
88	Pleasant Valley	-0.4	1.3	2.4	2.9	2.3	3.1	3.3	2.6	2.5	1.6	-0.1	-0.5	1.8
130	Pleasant Valley	-1.4	-0.2	1.9	2.6	2.9	4.4	4.7	3.8	2.7	1.5	-0.5	-1.2	1.8
1	Pueblo Valley	-1.6	-0.9	0.6	1.3	1.7	2.6	3.3	3.0	1.8	0.5	-1.2	-1.6	0.8
65	Pumpernickel Valley	-1.7	-0.7	1.3	2.0	2.4	3.7	4.1	3.5	2.4	1.2	-0.8	-1.5	1.3
81	Pyramid Lake Valley	-1.0	0.4	2.1	2.7	2.7	4.2	4.5	3.7	2.8	1.4	-0.7	-0.9	1.8
116	Queen Valley	0.6	1.4	3.5	4.2	3.9	4.4	4.2	3.6	2.8	2.2	1.2	1.0	2.7
33A	Quinn River Valley	-1.6	-0.9	0.8	1.6	1.9	2.9	3.6	3.2	2.0	0.8	-1.1	-1.6	1.0
33B	Quinn River Valley	-1.7	-1.0	0.6	1.5	1.9	2.8	3.5	3.1	1.9	0.7	-1.1	-1.7	0.9
173A	Railroad Valley	-1.4	0.0	2.0	3.2	3.6	5.4	4.9	3.9	3.4	2.0	0.7	-1.0	2.2
173B	Railroad Valley	-2.2	-0.8	1.4	2.5	3.1	5.1	4.8	4.0	3.2	1.8	0.2	-1.7	1.8
141	Ralston Valley	-0.9	0.4	2.5	3.4	3.6	5.0	4.8	3.9	3.1	2.0	0.6	-0.5	2.3
176	Ruby Valley	-2.7	-1.7	0.5	1.7	2.3	3.9	4.2	3.8	2.6	1.4	-0.6	-2.3	1.1
40	Salmon Falls Creek Area	-1.6	-1.2	0.4	1.6	2.0	2.4	2.9	2.9	1.9	1.1	-0.7	-1.7	0.8
22	San Emidio Desert	-1.2	0.0	1.6	2.1	2.3	3.5	4.0	3.6	2.5	1.1	-0.9	-1.1	1.5
146	Sarcobatus Flat	-0.2	0.9	2.9	3.9	4.0	5.1	4.7	3.9	3.3	2.2	1.1	0.2	2.6
107	Smith Valley	-0.4	1.1	2.5	2.8	2.3	3.1	3.7	2.7	2.2	1.3	-0.2	-0.5	1.7
21	Smoke Creek Desert	-1.3	-0.3	1.1	1.6	1.7	2.9	3.6	3.5	2.3	0.8	-1.2	-1.3	1.1
195	Snake Valley	-2.3	-0.7	1.1	2.6	3.4	5.3	4.6	3.7	3.1	1.6	0.6	-2.1	1.7
121A	Soda Spring Valley	-0.5	0.8	2.9	3.5	3.4	4.7	4.6	3.6	2.9	1.9	0.3	-0.2	2.3
46	South Fork Area	-2.5	-1.6	0.6	1.7	2.2	3.6	4.0	3.7	2.4	1.3	-0.7	-2.3	1.0

Appendix 3b cont. Interpolated or assigned basin average mean monthly dew point depression K_o (^oC).

BASIN NUMBER	BASIN NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN ANNUAL
35	South Fork Owyhee River Area	-1.9	-1.4	0.4	1.5	2.0	2.7	3.5	3.2	1.9	0.8	-1.1	-1.9	0.8
184	Spring Valley	-2.4	-0.9	1.1	2.5	3.2	5.1	4.6	3.7	3.1	1.6	0.4	-2.1	1.7
201	Spring Valley	-2.6	-0.8	1.0	2.8	3.6	6.1	4.9	3.5	3.6	1.6	0.9	-1.8	1.9
43	Starr Valley Area	-2.1	-1.4	0.5	1.7	2.2	3.1	3.5	3.3	2.1	1.2	-0.7	-2.0	0.9
179	Steptoe Valley	-2.5	-1.3	0.8	2.1	2.7	4.5	4.5	3.8	2.8	1.5	0.0	-2.2	1.4
149	Stone Cabin Valley	-1.2	0.2	2.3	3.2	3.5	5.1	4.8	3.9	3.2	2.0	0.5	-0.8	2.2
14	Surprise Valley	-1.5	-0.9	0.2	0.8	1.2	2.1	3.0	2.8	1.6	0.1	-1.4	-1.6	0.5
114	Teels Marsh Valley	0.1	1.2	3.2	3.8	3.6	4.4	4.3	3.6	2.8	2.0	0.8	0.4	2.5
189A	Thousand Springs Valley	-1.8	-1.3	0.3	1.7	2.0	2.6	3.0	3.0	2.0	1.1	-0.7	-1.9	0.8
189D	Thousand Springs Valley	-1.7	-1.3	0.2	1.6	2.0	2.5	2.9	2.9	1.9	1.0	-0.6	-1.8	0.8
83	Tracy Segment	-0.6	1.0	2.7	3.2	2.9	4.2	4.4	3.3	2.7	1.7	-0.2	-0.5	2.0
91	Truckee Canyon Segment	-0.6	1.1	2.3	2.8	2.3	3.2	3.5	2.8	2.5	1.6	-0.3	-0.6	1.7
87	Truckee Meadows	-0.6	1.1	2.4	2.9	2.4	3.4	3.7	2.9	2.5	1.6	-0.2	-0.6	1.8
56	Upper Reese River Valley	-1.6	-0.3	2.1	2.8	3.2	4.9	5.0	4.0	3.0	1.8	-0.2	-1.2	2.0
222	Virgin River Valley	-2.2	-0.4	1.4	3.2	4.0	6.4	5.2	3.8	3.9	1.9	1.2	-1.4	2.3
4	Virgin Valley	-1.5	-0.9	0.4	1.1	1.5	2.4	3.2	2.9	1.7	0.3	-1.3	-1.6	0.7
110A	Walker Lake Valley	-0.6	0.8	2.8	3.1	2.9	4.2	4.7	3.3	2.4	1.4	-0.3	-0.5	2.0
110C	Walker Lake Valley	-0.4	1.0	2.9	3.4	3.2	4.3	4.5	3.4	2.7	1.7	0.2	-0.2	2.2
89	Washoe Valley	-0.3	1.5	2.4	2.9	2.2	2.9	3.0	2.3	2.5	1.7	0.0	-0.4	1.7
207	White River Valley	-2.3	-0.8	1.3	2.6	3.2	5.2	4.8	3.9	3.3	1.8	0.4	-1.8	1.8
63	Willow Creek Valley	-1.9	-1.2	0.7	1.7	2.1	3.0	3.6	3.4	2.2	1.1	-0.9	-1.8	1.0
70	Winnemucca Segment	-1.6	-0.6	1.3	2.0	2.3	3.5	4.0	3.5	2.3	1.1	-0.8	-1.4	1.3
159	Yucca Flat	-1.0	0.4	2.3	3.5	4.0	5.7	5.0	4.0	3.7	2.2	1.1	-0.5	2.5

Appendix 4a. Mean monthly 2 meter equivalent wind speed (m/s) for stations used in spatial interpolation and assignment to weather NWS weather stations.

STATION NAME	LAT	LONG	ELEVATION (FT)	STATE	NETWORK	BASIN NUMBER	BASIN NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN ANNUAL
AMARGOSA VALLEY	36.57	-116.46	2425	NV	CEMP	230	Amargosa Desert	1.8	2.2	2.3	3.0	2.7	2.9	2.9	2.8	2.3	2.0	1.7	1.7	2.4
ANTELOPE LAKE	41.68	-116.76	5459	NV	RAWS	34	Little Owyhee River Area	2.8	2.8	3.1	3.0	3.0	2.8	2.7	2.8	2.6	2.7	2.9	2.9	2.8
B11 WALKER BOWEN	39.11	-119.15	4321	NV	USGS	108	Mason Valley	1.4	2.1	2.0	2.2	1.8	1.5	1.4	1.4	1.4	1.3	1.5	1.5	1.6
BAKER FLAT	39.00	-114.22	6841	NV	RAWS	195	Snake Valley	1.5	1.4	1.8	2.0	2.0	2.1	2.0	2.0	1.9	1.6	1.5	1.5	1.8
BEACON LIGHT	40.56	-116.76	4800	NV	RAWS	59	Lower Reese River Valley	1.3	1.7	2.0	2.1	2.2	2.2	2.1	2.0	1.9	1.5	1.4	1.4	1.8
BENTON	37.84	-118.48	5449	CA	RAWS	NA	NA	1.8	2.2	2.4	2.6	2.3	2.1	1.9	1.9	1.8	1.9	2.0	1.9	2.1
BIG SMOKEY VALLEY	39.05	-117.00	5840	NV	DRI	137B	Big Smoky Valley	2.0	2.4	2.9	3.3	3.0	3.2	2.9	2.7	2.5	2.4	2.4	2.3	2.7
BLUEWING MOUNTAIN	40.50	-119.12	4570	NV	RAWS	79	Kumiva Valley	1.7	2.0	2.3	2.6	2.7	2.5	2.4	2.3	2.2	2.0	1.9	1.8	2.2
BUFFALO CREEK	40.58	-119.79	2795	NV	RAWS	21	Smoke Creek Desert	1.5	2.0	2.5	2.9	2.9	2.9	2.8	2.6	2.4	2.2	1.8	1.6	2.3
CARSON VALLEY	39.00	-119.78	4685	NV	NVDOT	105	Carson Valley	1.7	1.8	2.6	2.6	2.4	2.2	1.9	1.7	1.8	1.6	1.7	1.8	2.0
CATNIP MOUNTAIN	41.92	-119.50	5741	NV	RAWS	6	Guano Valley	3.6	3.2	3.4	3.3	3.0	2.9	2.6	2.5	2.4	2.8	3.3	3.5	3.0
CATTLE CAMP	38.90	-114.81	7024	NV	RAWS	179	Steptoe Valley	2.1	2.1	2.2	2.4	2.4	2.5	2.3	2.4	2.2	2.2	2.1	2.1	2.3
CEDARVILLE	41.59	-120.17	4600	CA	AGRIMET	NA	NA	2.1	2.1	2.5	2.4	2.2	2.0	1.9	1.9	1.8	1.8	2.1	2.1	2.1
COYOTE WASH	38.28	-114.76	5771	NV	RAWS	181	Dry Lake Valley	1.7	1.9	2.1	2.3	2.4	2.4	2.2	2.1	2.1	2.0	1.8	1.8	2.1
CURRANT CREEK	38.76	-115.41	5751	NV	RAWS	173B	Railroad Valley	1.8	2.2	2.6	2.9	2.8	2.9	2.7	2.8	2.6	2.3	1.9	1.7	2.4
DESATOYA MOUNTAIN	39.30	-117.58	6201	NV	RAWS	134	Smith Creek	2.2	2.4	2.5	2.5	2.5	2.5	2.4	2.3	2.1	2.0	2.2	2.3	2.3
DOYLE	40.03	-120.11	4239	CA	RAWS	NA	NA	1.9	2.2	2.3	2.3	2.3	2.1	2.1	2.1	2.0	2.0	2.0	2.0	2.1
DUCKWATER	38.92	-115.70	5463	NV	DRI	173B	Railroad Valley	2.6	2.6	3.1	3.5	3.1	3.3	2.7	2.7	2.8	2.8	2.6	2.4	2.8

Appendix 4a cont. Mean monthly 2 meter equivalent wind speed (m/s) for stations used in spatial interpolation and assignment to weather stations used for computing ET and net irrigation water requirements.

STATION NAME	LAT	LONG	ELEVATIO N (FT)	STATE	NETWORK	BASIN NUMBER	BASIN NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN ANNUAL
DYER - WALLACE FARMS	37.61	-117.99	4882	NV	DRI	117	Fish Lake Valley	3.2	3.8	3.8	4.1	3.2	3.2	2.9	2.8	2.8	3.1	3.1	3.3	3.3
EDWARDS CREEK VALLEY	39.53	-117.75	5194	NV	DRI	133	Edwards Creek Valley	1.7	1.9	2.1	2.4	2.4	2.4	2.4	2.3	2.1	1.9	1.8	1.8	2.1
ELKO WB AIRPORT	40.83	-115.78	5050	NV	AIRPORT	49	Elko Segment	1.6	1.8	2.1	2.3	2.2	2.2	2.1	1.9	1.8	1.6	1.7	1.6	1.9
ELY WBO	39.30	-114.85	6262	NV	AIRPORT	179	Steptoe Valley	3.0	3.1	3.3	3.4	3.4	3.4	3.3	3.3	3.2	3.1	3.0	3.1	3.2
EUREKA	39.69	-115.98	5896	NV	AGRIMET	153	Diamond Valley	1.7	1.9	2.6	3.0	2.3	2.2	1.9	1.8	1.8	1.8	1.9	2.0	2.1
FAIRVIEW VALLEY	39.32	-118.22	4236	NV	DRI	124	Fairview Valley	1.7	2.1	2.3	2.7	2.8	2.6	2.6	2.3	2.1	1.9	1.9	1.7	2.2
FALLON	39.46	-118.78	3967	NV	AGRIMET	101	Carson Desert	1.3	1.7	2.0	2.2	1.8	1.8	1.4	1.3	1.3	1.1	1.3	1.5	1.6
GARDEN VALLEY	38.03	-115.44	5167	NV	CEMP	172	Garden Valley	1.1	1.3	1.6	1.9	1.8	1.8	1.7	1.6	1.5	1.2	1.1	1.1	1.5
GARDNERVILLE	38.89	-119.72	4797	NV	NVDOT	105	Carson Valley	1.5	1.5	2.2	2.4	2.2	1.9	1.7	1.8	1.6	1.5	1.5	1.7	1.8
GOLDFIELD	37.71	-117.24	5627	NV	CEMP	142	Alkali Spring Valley	2.8	3.1	3.3	3.5	3.1	3.1	2.8	2.8	2.7	2.6	2.7	2.7	2.9
IMMIGRATION WASH	37.92	-114.17	6230	NV	RAWS	198	Dry Valley	2.2	2.4	2.8	3.1	3.2	3.3	2.9	2.8	2.8	2.6	2.3	2.2	2.7
LAS VEGAS WSO AIRPORT	36.23	-115.03	1883	NV	AIRPORT	212	Las Vegas Valley	2.4	2.8	3.3	3.6	3.7	3.6	3.3	3.1	2.9	2.6	2.5	2.4	3.0
LOVELOCK FAA AIRPORT	40.07	-118.57	3902	NV	AIRPORT	73	Lovelock Valley	1.8	2.2	2.5	2.9	3.0	2.9	2.6	2.4	2.2	2.0	1.8	1.7	2.3
LOWER BIG SMOKEY VALLEY	38.37	-117.47	5036	NV	DRI	137A	Big Smoky Valley	3.2	3.5	3.9	4.3	4.1	4.2	3.5	3.4	3.5	3.6	3.4	3.0	3.6
MEDLINS RANCH	37.40	-115.54	4475	NV	CEMP	169A	Tikapoo Valley	2.5	2.5	2.8	3.2	3.1	3.0	2.7	2.6	2.7	2.5	2.3	2.3	2.7
MESQUITE	36.81	-114.05	1768	NV	CEMP	222	Virgin River Valley	1.4	1.4	1.5	1.7	1.7	1.6	1.7	1.5	1.6	1.3	1.2	1.2	1.5
MOHAVE	34.97	-114.61	479	AZ	AZMET	NA	NA	2.6	2.7	2.7	2.8	2.6	2.2	1.8	1.7	1.6	1.9	2.3	2.9	2.3
MOREY CREEK	41.45	-117.62	5499	NV	RAWS	69	Paradise	2.1	2.3	3.0	3.0	2.9	2.9	2.9	2.8	2.6	2.5	2.3	2.1	2.6
NYALA	38.25	-115.73	4826	NV	CEMP	173B	Railroad Valley	1.3	1.5	1.9	2.4	2.3	2.4	2.3	2.2	1.9	1.6	1.4	1.2	1.9
ORIENTAL WASH	37.24	-117.50	4101	NV	RAWS	232	Oriental W.	3.1	3.2	3.4	3.6	3.6	3.6	3.4	3.4	3.4	3.5	3.2	3.1	3.4

Appendix 4a cont. Mean monthly 2 meter equivalent wind speed (m/s) for stations used in spatial interpolation and assignment to weather stations used for computing ET and net irrigation water requirements.

STATION NAME	LAT	LONG	ELEVATION (FT)	STATE	NETWORK	BASIN NUMBER	BASIN NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN ANNUAL
OVERTON	36.55	-114.45	1260	NV	CEMP	220	Lower Moapa Valley	1.4	1.5	1.6	1.9	1.8	1.8	1.5	1.6	1.5	1.4	1.3	1.3	1.5
PANCAKE	38.30	-116.19	5200	NV	RAWS	156	Hot Creek	1.4	1.8	2.3	2.6	2.6	2.6	2.4	2.3	2.1	1.9	1.7	1.6	2.1
PYRAMID LAKE FISHERIES	39.94	-119.59	3809	NV	DRI	81	Pyramid Lake Valley	2.5	2.7	3.0	3.2	2.7	2.5	2.3	2.5	2.5	2.5	2.8	3.2	2.7
RACHEL	37.64	-115.74	4849	NV	CEMP	170	Penoyer Valley	1.9	2.3	2.5	3.1	2.9	3.0	2.9	2.8	2.4	2.1	1.9	1.8	2.5
RED BUTTE	39.98	-117.32	5049	NV	RAWS	57	Antelope Valley	1.6	2.0	2.2	2.5	2.6	2.5	2.2	2.1	2.0	1.8	1.7	1.7	2.1
RED ROCK	39.90	-119.94	4715	NV	WASHOE COUNTY	99	Red Rock Valley	1.2	1.3	1.8	2.1	2.0	1.8	1.7	1.7	1.5	1.3	1.5	1.5	1.6
RENO WSFO AIRPORT	39.48	-119.77	4410	NV	AIRPORT	87	Truckee Meadows	1.6	2.0	2.5	2.8	2.8	2.7	2.5	2.3	2.0	1.7	1.8	1.7	2.2
ROCK SPRING CREEK	41.64	-114.44	5400	NV	RAWS	189B	Thousand Springs Valley	2.0	2.2	2.5	2.7	2.7	2.8	2.6	2.5	2.3	2.3	2.1	2.2	2.4
RUBY LAKE	40.17	-115.49	5971	NV	RAWS	176	Ruby Valley	2.5	2.7	3.0	3.2	3.0	2.9	2.5	2.5	2.5	2.5	2.6	2.6	2.7
SARCOBATUS FLATS	37.28	-117.02	4016	NV	CEMP	146	Sarcobatus Flat	2.3	2.4	2.6	2.7	2.2	2.3	2.2	2.0	1.9	1.9	2.0	2.2	2.2
SHO-PAI	42.02	-116.21	5351	ID	RAWS	NA	NA	2.8	2.8	3.3	3.2	3.1	2.9	2.9	2.8	2.7	2.6	3.1	3.0	2.9
SIARD	40.39	-117.63	4600	NV	RAWS	130	Pleasant Valley	1.7	1.9	2.3	2.4	2.5	2.5	2.3	2.2	2.1	1.9	1.8	1.8	2.1
SPRUCE MOUNTAIN	40.44	-114.81	6099	NV	RAWS	187	Goshute Valley	2.5	2.4	2.8	3.1	3.0	3.0	2.8	2.7	2.5	2.4	2.4	2.4	2.7
STEAD GOLF	39.63	-119.89	5140	NV	DRI	92A	Lemmon Valley	1.6	2.2	2.4	2.9	2.7	2.7	2.6	2.5	2.2	1.9	1.9	2.3	2.3
TONOPAH AIRPORT	38.05	-117.08	5395	NV	AIRPORT	141	Ralston Valley	3.0	3.3	3.6	3.9	3.7	3.5	3.1	3.1	3.0	3.1	3.1	3.0	3.3
TRACY CLARK	39.57	-119.53	4501	NV	NVDOT	83	Tracy Segment	1.5	2.1	2.4	3.1	2.8	2.5	2.4	2.3	2.1	1.8	1.9	1.7	2.2
WALKER	38.57	-119.46	5440	CA	RAWS	NA	NA	1.9	2.1	2.6	2.9	2.8	2.7	2.5	2.4	2.4	1.9	2.0	2.3	2.4
WASHOE VALLEY	39.27	-119.82	5043	NV	NVDOT	89	Washoe Valley	2.3	2.1	3.1	3.4	2.9	2.3	2.3	2.1	2.1	1.9	2.4	3.0	2.5
WASHOEVALLEY_EAST	39.29	-119.79	5040	NV	WASHOE COUNTY	89	Washoe Valley	2.8	3.1	4.4	5.2	5.1	4.3	4.2	4.5	4.5	3.7	3.1	3.8	4.0
WINNEMUCCA WSO AIRPORT	40.90	-117.80	4296	NV	AIRPORT	70	Winnemucca Segment	2.5	2.8	2.8	2.9	2.9	2.9	2.8	2.6	2.5	2.4	2.5	2.5	2.7

Appendix 4b. Interpolated or assigned basin average mean monthly wind speed (m/s) used for assignment to respective NWS weather stations. Symbol * next to the basin name indicates that the basins was assigned the measured mean monthly wind speed.

BASIN NUMBER	BASIN NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN ANNUAL
142	Alkali Spring Valley*	2.8	3.1	3.3	3.5	3.1	3.1	2.8	2.8	2.7	2.6	2.7	2.7	2.9
111B	Alkali Valley	2.0	2.3	2.7	2.9	2.6	2.5	2.2	2.2	2.1	2.0	2.1	2.2	2.3
230	Amargosa Desert*	1.8	2.2	2.3	3.0	2.7	2.9	2.9	2.8	2.3	2.0	1.7	1.7	2.4
57	Antelope Valley*	1.6	2.0	2.2	2.5	2.6	2.5	2.2	2.1	2.0	1.8	1.7	1.7	2.1
106	Antelope Valley	1.9	2.1	2.6	2.9	2.8	2.7	2.5	2.4	2.4	1.9	2.0	2.3	2.4
186B	Antelope Valley	2.4	2.4	2.7	3.0	2.8	2.9	2.6	2.6	2.4	2.4	2.3	2.3	2.6
137A	Big Smoky Valley*	3.2	3.5	3.9	4.3	4.1	4.2	3.5	3.4	3.5	3.6	3.4	3.0	3.6
137B	Big Smoky Valley*	2.0	2.4	2.9	3.3	3.0	3.2	2.9	2.7	2.5	2.4	2.4	2.3	2.7
215	Black Moutains Area	1.8	2.0	2.3	2.6	2.5	2.5	2.2	2.2	2.1	1.9	1.8	1.7	2.1
28	Black Rock Desert	2.0	2.2	2.6	2.8	2.7	2.6	2.5	2.4	2.3	2.2	2.1	2.1	2.4
61	Boulder Flat	1.7	2.0	2.3	2.5	2.4	2.4	2.3	2.2	2.0	1.8	1.8	1.8	2.1
38	Bruneau River Area	2.4	2.5	2.9	2.9	2.8	2.8	2.7	2.6	2.4	2.4	2.6	2.5	2.6
129	Buena Vista Valley	1.8	2.1	2.4	2.6	2.6	2.6	2.4	2.3	2.1	2.0	1.9	1.9	2.2
131	Buffalo Valley	1.8	2.0	2.3	2.5	2.5	2.5	2.3	2.3	2.1	1.9	1.9	1.8	2.2
101	Carson Desert*	1.3	1.7	2.0	2.2	1.8	1.8	1.4	1.3	1.3	1.1	1.3	1.5	1.6
105	Carson Valley*	1.6	1.6	2.4	2.5	2.3	2.0	1.8	1.7	1.7	1.6	1.6	1.8	1.9
102	Churchill Valley	1.6	2.0	2.3	2.6	2.3	2.1	1.9	1.8	1.8	1.6	1.8	1.8	2.0
143	Clayton Valley	2.8	3.2	3.4	3.6	3.2	3.2	2.9	2.8	2.8	2.8	2.8	2.8	3.0
177	Clover Valley	2.3	2.3	2.7	2.9	2.8	2.8	2.6	2.5	2.3	2.3	2.3	2.3	2.5
204	Clover Valley	1.9	2.0	2.3	2.7	2.6	2.7	2.5	2.4	2.4	2.1	1.9	1.8	2.3
64	Clovers Area	1.9	2.1	2.5	2.6	2.6	2.5	2.4	2.3	2.2	2.0	2.0	1.9	2.2
213	Colorado Valley	2.6	2.7	2.7	2.8	2.6	2.2	1.8	1.7	1.6	1.9	2.3	2.9	2.3
118	Columbus Salt Marsh Valley	2.6	3.0	3.2	3.5	3.1	3.0	2.7	2.6	2.6	2.7	2.7	2.6	2.8
126	Cowkick Valley	1.8	2.1	2.3	2.6	2.6	2.5	2.5	2.3	2.1	1.9	1.9	1.9	2.2
54	Crescent Valley	1.6	1.9	2.3	2.4	2.4	2.4	2.2	2.1	2.0	1.8	1.7	1.7	2.1
103	Dayton Valley	1.8	2.0	2.6	2.9	2.6	2.3	2.2	2.0	2.0	1.8	2.0	2.1	2.2
31	Desert Valley	2.2	2.4	2.7	2.8	2.8	2.8	2.6	2.5	2.4	2.3	2.3	2.2	2.5
153	Diamond Valley*	1.7	1.9	2.6	3.0	2.3	2.2	1.9	1.8	1.8	1.8	1.9	2.0	2.1
48	Dixie Creek-Tenmile Creek Area	1.8	2.0	2.3	2.5	2.4	2.4	2.2	2.1	2.0	1.9	1.9	1.9	2.1
128	Dixie Valley	1.7	2.0	2.3	2.6	2.6	2.5	2.4	2.2	2.1	1.9	1.9	1.8	2.1

Appendix 4b cont. Interpolated or assigned basin average mean monthly wind speed (m/s) used for assignment to respective weather stations. Symbol * next to the basin name indicates that the basins was assigned the measured mean monthly wind speed.

BASIN NUMBER	BASIN NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN ANNUAL
82	Dodge Flat	1.7	2.1	2.5	2.9	2.7	2.4	2.3	2.2	2.1	1.8	2.0	2.1	2.2
104	Eagle Valley	2.0	2.0	2.7	3.0	2.7	2.3	2.2	2.0	2.0	1.8	2.1	2.4	2.3
200	Eagle Valley	2.1	2.4	2.7	3.1	3.1	3.3	2.9	2.8	2.8	2.5	2.3	2.2	2.7
127	Eastgate Valley Area	1.9	2.2	2.3	2.6	2.6	2.5	2.4	2.3	2.1	1.9	2.0	2.0	2.2
167	Eldorado Valley	2.2	2.5	2.8	3.1	3.1	3.0	2.7	2.6	2.4	2.3	2.2	2.2	2.6
49	Elko Segment	1.6	1.8	2.1	2.3	2.2	2.2	2.1	1.9	1.8	1.6	1.7	1.6	1.9
76	Fernley Area	1.7	2.1	2.4	2.8	2.6	2.3	2.2	2.1	1.9	1.7	1.9	2.0	2.1
117	Fish Lake Valley*	3.2	3.8	3.8	4.1	3.2	3.2	2.9	2.8	2.8	3.1	3.1	3.3	3.3
227A	Fortymile Canyon	2.0	2.3	2.5	3.1	2.8	2.9	2.8	2.7	2.3	2.2	1.9	1.9	2.4
122	Gabbs Valley	2.0	2.4	2.6	2.9	2.8	2.7	2.5	2.3	2.2	2.1	2.2	2.1	2.4
172	Garden Valley*	1.1	1.3	1.6	1.9	1.8	1.8	1.7	1.6	1.5	1.2	1.1	1.1	1.5
187	Goshute Valley*	2.5	2.4	2.8	3.1	3.0	3.0	2.8	2.7	2.5	2.4	2.4	2.4	2.7
71	Grass Valley	2.1	2.3	2.6	2.7	2.7	2.7	2.6	2.5	2.3	2.2	2.2	2.1	2.4
138	Grass Valley	1.8	2.1	2.4	2.7	2.6	2.5	2.3	2.2	2.1	2.0	1.9	1.9	2.2
192	Great Salt Lake Desert	2.3	2.3	2.7	2.9	2.8	2.8	2.6	2.5	2.4	2.3	2.3	2.3	2.5
6	Guano Valley	3.6	3.2	3.4	3.3	3.0	2.9	2.6	2.5	2.4	2.8	3.3	3.5	3.0
156	Hot Creek*	1.4	1.8	2.3	2.6	2.6	2.6	2.4	2.3	2.1	1.9	1.7	1.6	2.1
156	Hot Creek	1.4	1.8	2.3	2.6	2.6	2.6	2.4	2.3	2.1	1.9	1.7	1.6	2.1
24	Hualapai Flat	1.9	2.1	2.5	2.8	2.7	2.6	2.5	2.4	2.2	2.1	2.0	2.0	2.3
47	Huntington Valley	2.2	2.4	2.7	3.0	2.8	2.7	2.4	2.4	2.3	2.3	2.3	2.3	2.5
72	Imlay Area	2.0	2.3	2.5	2.7	2.7	2.7	2.5	2.4	2.3	2.1	2.1	2.0	2.4
72	Imlay Area	2.0	2.3	2.5	2.7	2.7	2.7	2.5	2.4	2.3	2.1	2.1	2.0	2.4
36	Independence Valley	2.2	2.3	2.7	2.8	2.7	2.6	2.5	2.4	2.3	2.2	2.3	2.3	2.4
161	Indian Springs Valley	2.0	2.2	2.5	2.9	2.8	2.8	2.7	2.5	2.3	2.1	2.0	1.9	2.4
135	Ione Valley	2.4	2.7	2.9	3.2	3.1	3.1	2.8	2.6	2.6	2.5	2.5	2.4	2.7
164A	Ivanpah Valley	2.2	2.5	2.9	3.2	3.2	3.1	2.8	2.7	2.5	2.3	2.3	2.2	2.7
174	Jakes Valley	2.3	2.5	2.8	3.0	2.9	2.9	2.7	2.7	2.6	2.5	2.4	2.4	2.6
39	Jarbidge River Area	2.3	2.4	2.8	2.9	2.8	2.8	2.6	2.5	2.4	2.3	2.5	2.4	2.6
30A	Kings River Valley	2.3	2.4	2.9	2.9	2.8	2.8	2.7	2.6	2.4	2.4	2.4	2.3	2.6
90	Lake Tahoe Basin	1.9	2.0	2.7	2.9	2.6	2.3	2.1	2.0	2.0	1.8	2.0	2.3	2.2
183	Lake Valley	1.9	2.0	2.3	2.5	2.5	2.6	2.4	2.3	2.2	2.1	1.9	1.9	2.2
45	Lamoille Valley	1.9	2.0	2.4	2.6	2.5	2.4	2.3	2.2	2.1	1.9	2.0	1.9	2.2
212	Las Vegas Valley	2.4	2.8	3.3	3.6	3.7	3.6	3.3	3.1	2.9	2.6	2.5	2.4	3.0
92A	Lemmon Valley*	1.6	2.2	2.4	2.9	2.7	2.7	2.6	2.5	2.2	1.9	1.9	2.3	2.3
92B	Lemmon	1.6	2.2	2.4	2.9	2.7	2.7	2.6	2.5	2.2	1.9	1.9	2.3	2.3

Appendix 4b cont. Interpolated or assigned basin average mean monthly wind speed (m/s) used for assignment to respective weather stations. Symbol * next to the basin name indicates that the basins was assigned the measured mean monthly wind speed.

BASIN NUMBER	BASIN NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN ANNUAL
	Valley													
155A	Little Smoky Valley	2.1	2.3	2.7	3.1	2.8	2.8	2.5	2.5	2.4	2.3	2.2	2.1	2.5
73	Lovelock Valley*	1.8	2.2	2.5	2.9	3.0	2.9	2.6	2.4	2.2	2.0	1.8	1.7	2.3
205	Lower Meadow V. W	1.7	1.8	2.1	2.4	2.3	2.3	2.2	2.1	2.0	1.8	1.7	1.6	2.0
220	Lower Moapa Valley*	1.4	1.5	1.6	1.9	1.8	1.8	1.5	1.6	1.5	1.4	1.3	1.3	1.5
59	Lower Reese River Valley*	1.3	1.7	2.0	2.1	2.2	2.2	2.1	2.0	1.9	1.5	1.4	1.4	1.8
52	Marys Creek Area	1.8	2.0	2.3	2.5	2.4	2.4	2.3	2.2	2.0	1.9	1.9	1.8	2.1
42	Marys River Area	2.1	2.3	2.6	2.8	2.7	2.7	2.5	2.4	2.3	2.2	2.2	2.2	2.4
108	Mason Valley*	1.4	2.1	2.0	2.2	1.8	1.5	1.4	1.4	1.4	1.3	1.5	1.5	1.6
225	Mercury Valley	2.0	2.2	2.5	3.0	2.8	2.9	2.8	2.6	2.3	2.1	1.9	1.9	2.4
58	Middle Reese River Valley	1.7	2.0	2.3	2.5	2.5	2.5	2.3	2.1	2.0	1.9	1.8	1.8	2.1
26	Mud Meadow	2.2	2.3	2.7	2.8	2.7	2.6	2.5	2.4	2.2	2.2	2.3	2.3	2.4
44	North Fork Area	2.0	2.2	2.5	2.7	2.6	2.5	2.4	2.3	2.2	2.1	2.1	2.1	2.3
228	Oasis Valley	2.3	2.5	2.7	3.1	2.7	2.8	2.7	2.5	2.3	2.3	2.2	2.2	2.5
37	Owyhee River Area	2.5	2.6	3.0	3.0	2.9	2.8	2.7	2.7	2.5	2.4	2.8	2.7	2.7
209	Pahranagat Valley	2.0	2.1	2.4	2.8	2.7	2.7	2.5	2.4	2.3	2.1	1.9	1.9	2.3
162	Pahrump Valley	2.1	2.4	2.7	3.1	2.9	3.0	2.8	2.6	2.4	2.2	2.1	2.0	2.5
203	Panaca Valley	1.9	2.1	2.5	2.8	2.8	2.9	2.6	2.5	2.5	2.2	2.0	1.9	2.4
69	Paradise Valley*	2.1	2.3	3.0	3.0	2.9	2.9	2.9	2.8	2.6	2.5	2.3	2.1	2.6
202	Patterson Valley	1.9	2.1	2.4	2.7	2.7	2.8	2.5	2.5	2.4	2.2	2.0	1.9	2.4
170	Penoyer Valley*	1.9	2.3	2.5	3.1	2.9	3.0	2.9	2.8	2.4	2.1	1.9	1.8	2.5
191	Pilot Creek Valley	2.2	2.3	2.6	2.8	2.7	2.8	2.6	2.5	2.4	2.3	2.3	2.3	2.5
29	Pine Forest Valley	2.3	2.5	2.8	2.9	2.8	2.8	2.6	2.5	2.4	2.3	2.4	2.4	2.6
53	Pine Valley	1.9	2.1	2.5	2.7	2.5	2.5	2.3	2.2	2.1	2.0	2.0	2.0	2.2
214	Piute Valley	2.6	2.7	2.7	2.8	2.6	2.2	1.8	1.7	1.6	1.9	2.3	2.9	2.3
88	Pleasant Valley	2.1	2.3	2.8	3.1	2.9	2.6	2.4	2.3	2.2	2.0	2.3	2.6	2.5
130	Pleasant Valley*	1.7	1.9	2.3	2.4	2.5	2.5	2.3	2.2	2.1	1.9	1.8	1.8	2.1
1	Pueblo Valley	2.5	2.5	2.9	2.9	2.8	2.8	2.6	2.5	2.4	2.4	2.5	2.5	2.6
65	Pumpernickel Valley	2.0	2.2	2.5	2.7	2.7	2.7	2.5	2.4	2.3	2.1	2.1	2.0	2.3
81	Pyramid Lake Valley*	2.5	2.7	3.0	3.2	2.7	2.5	2.3	2.5	2.5	2.5	2.8	3.2	2.7
116	Queen Valley	2.0	2.3	2.6	2.8	2.4	2.3	2.1	2.0	2.0	2.0	2.1	2.1	2.2
33A	Quinn River Valley	2.2	2.3	2.9	2.9	2.9	2.9	2.8	2.7	2.5	2.4	2.4	2.2	2.6
33B	Quinn River	2.3	2.4	2.9	2.9	2.9	2.8	2.7	2.6	2.5	2.4	2.4	2.3	2.6

Appendix 4b cont. Interpolated or assigned basin average mean monthly wind speed (m/s) used for assignment to respective weather stations. Symbol * next to the basin name indicates that the basins was assigned the measured mean monthly wind speed.

BASIN NUMBER	BASIN NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN ANNUAL
	Valley													
173A	Railroad Valley	1.8	2.1	2.4	2.8	2.7	2.7	2.5	2.4	2.2	2.0	1.9	1.8	2.3
173B	Railroad Valley*	1.9	2.1	2.5	2.9	2.7	2.8	2.6	2.6	2.4	2.2	2.0	1.8	2.4
141	Ralston Valley*	3.0	3.3	3.6	3.9	3.7	3.5	3.1	3.1	3.0	3.1	3.1	3.0	3.3
176	Ruby Valley*	2.5	2.7	3.0	3.2	3.0	2.9	2.5	2.5	2.5	2.5	2.6	2.6	2.7
40	Salmon Falls Creek Area	2.1	2.3	2.6	2.8	2.7	2.8	2.6	2.5	2.3	2.3	2.2	2.2	2.5
22	San Emidio Desert	1.7	2.0	2.4	2.7	2.7	2.6	2.4	2.3	2.2	2.0	1.9	1.9	2.2
146	Sarcobatus Flat*	2.3	2.4	2.6	2.7	2.2	2.3	2.2	2.0	1.9	1.9	2.0	2.2	2.2
107	Smith Valley	1.5	1.7	2.1	2.4	2.2	2.0	1.9	1.8	1.8	1.5	1.6	1.7	1.8
21	Smoke Creek Desert*	1.5	2.0	2.5	2.9	2.9	2.9	2.8	2.6	2.4	2.2	1.8	1.6	2.3
195	Snake Valley*	1.5	1.4	1.8	2.0	2.0	2.1	2.0	2.0	1.9	1.6	1.5	1.5	1.8
121A	Soda Spring Valley	2.4	2.8	3.0	3.3	3.0	3.0	2.7	2.6	2.5	2.5	2.5	2.4	2.7
46	South Fork Area	2.1	2.2	2.5	2.8	2.6	2.6	2.4	2.3	2.2	2.1	2.2	2.1	2.3
35	South Fork Owyhee River Area	2.6	2.7	3.0	3.0	3.0	2.8	2.7	2.7	2.5	2.5	2.8	2.7	2.7
184	Spring Valley	2.1	2.2	2.5	2.7	2.6	2.7	2.5	2.5	2.4	2.2	2.1	2.1	2.4
201	Spring Valley	2.0	2.2	2.5	2.8	2.8	2.9	2.7	2.6	2.5	2.3	2.1	2.0	2.5
43	Starr Valley Area	2.0	2.2	2.5	2.7	2.6	2.6	2.4	2.3	2.2	2.1	2.1	2.1	2.3
179	Steptoe Valley	2.6	2.6	2.8	2.9	2.9	2.9	2.8	2.8	2.7	2.6	2.5	2.6	2.7
149	Stone Cabin Valley	2.3	2.6	2.9	3.2	3.1	3.1	2.8	2.7	2.5	2.4	2.4	2.3	2.7
14	Surprise Valley	2.3	2.3	2.6	2.6	2.4	2.3	2.1	2.1	2.0	2.0	2.2	2.3	2.3
114	Teels Marsh Valley	2.2	2.6	2.8	3.1	2.7	2.6	2.3	2.3	2.2	2.3	2.3	2.3	2.5
189A	Thousand Springs Valley	2.1	2.3	2.6	2.8	2.7	2.8	2.6	2.5	2.3	2.3	2.2	2.2	2.4
189D	Thousand Springs Valley	2.1	2.2	2.6	2.8	2.7	2.8	2.6	2.5	2.3	2.3	2.2	2.2	2.4
83	Tracy Segment*	1.5	2.1	2.4	3.1	2.8	2.5	2.4	2.3	2.1	1.8	1.9	1.7	2.2
91	Truckee Canyon Segment	1.9	2.2	2.6	3.0	2.8	2.6	2.4	2.3	2.2	1.9	2.1	2.3	2.3
87	Truckee Meadows*	1.6	2.0	2.5	2.8	2.8	2.7	2.5	2.3	2.0	1.7	1.8	1.7	2.2
56	Upper Reese River Valley	2.0	2.3	2.6	2.8	2.7	2.7	2.5	2.4	2.3	2.1	2.1	2.1	2.4
222	Virgin River Valley	1.4	1.4	1.5	1.7	1.7	1.6	1.7	1.5	1.6	1.3	1.2	1.2	1.5
4	Virgin Valley	3.0	2.8	3.1	3.1	2.9	2.7	2.5	2.5	2.4	2.5	2.9	3.0	2.8
110A	Walker Lake Valley	1.6	2.0	2.3	2.5	2.3	2.0	1.9	1.8	1.8	1.6	1.7	1.8	1.9
110C	Walker Lake Valley	2.0	2.4	2.7	2.9	2.6	2.5	2.3	2.2	2.1	2.0	2.1	2.2	2.3

Appendix 4b cont. Interpolated or assigned basin average mean monthly wind speed (m/s) used for assignment to respective weather stations. Symbol * next to the basin name indicates that the basins was assigned the measured mean monthly wind speed.

BASIN NUMBER	BASIN NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN ANNUAL
89	Washoe Valley*	2.6	2.6	3.7	4.3	4.0	3.3	3.2	3.3	3.3	2.8	2.8	3.4	3.3
207	White River Valley	1.9	2.1	2.4	2.7	2.6	2.7	2.5	2.5	2.4	2.2	2.0	1.9	2.3
63	Willow Creek Valley	2.2	2.4	2.7	2.8	2.7	2.7	2.5	2.5	2.3	2.3	2.3	2.3	2.5
70	Winnemucca Segment*	2.5	2.8	2.8	2.9	2.9	2.9	2.8	2.6	2.5	2.4	2.5	2.5	2.7
159	Yucca Flat	2.1	2.3	2.6	3.0	2.8	2.9	2.7	2.6	2.4	2.2	2.1	2.0	2.5

Appendix 5. Crop parameter table listing all parameters used in estimating crop ET, planting or greenup, harvest, killing frost, and runoff.

Parameter	Explanation	Alfalfa Hay	Grass Hay	Beans Fresh	Beans Dry	Field Corn	Silage Corn	Sweet Corn - early	Sweet Corn - late	Spring Grain	Winter Grain
Days after planting or greenup for earliest irrigation		0	0	0	0	0	0	0	0	20	155
Winter surface class	1=bare, 2=mulch, 3=turf	2	3	1	1	1	1	1	1	2	2
MAD during initial and development stage	Maximum Allowable Depletion of soil moisture in percent	60	50	60	60	60	60	60	60	60	60
MAD during midseason and late season	Maximum Allowable Depletion of soil moisture in percent	60	50	50	50	50	50	50	50	50	50
Initial effective rooting depth, m	On alfalfa, 2nd cycle, start at max.	0.7	0.3	0.12	0.12	0.12	0.12	0.12	0.12	0.25	0.25
Maximum effective rooting depth, m		1.8	1.1	1.2	1.2	1.5	1.5	1	1	1.8	1.8
End of root growth, as a fraction of time from planting or greenup to EFC		0.5	0.4	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Starting crop height, m		0.1	0.1	0.05	0.05	0.1	0.1	0.1	0.1	0.05	0.05
Maximum Crop height, m		0.6	0.6	0.35	0.35	3	3.5	1.5	1.5	1	1
Crop Kcb curve number		13	19	12	11	9	9	10	10	1	2
Crop curve type	1=NCGDD, 2=%PL-EC, 3=%PL-EC,daysafter	1	1	1	1	1	1	1	1	1	1
Flag for means to estimate Greenup	1=CGDD, 2=T30, 3=date, 4 is on all the time	1	2	2	2	2	2	2	2	2	3
T30 for Greenup or CGDD for Greenup	30 day moving average, Degree C	300	7	11	11	9	9	9	12	5	
Date of Greenup (can be blank)	A negative values is an offset to the prior row, pos is months (fraction)										10
For NCGDD based curves: Tbase:	Mean Temp Base Degree C	0	0	5	5	-10	-10	-10	-10	0	0
CGDD for EFC	Cumulative Degree C days from Jan 1	880	1200	670	670	540	540	540	540	840	1080
CGDD for termination		740	3600	1150	1350	1400	1300	1000	1000	1600	1800
time for harvest (neg to extend until frost)	Use as max length for CGDD crops									180	
Killing frost temperature	Degrees C	-7	-5	-2	-2	-5	-4	-4	-5	-100	-100
Invoke Stress	1 yes, 0 no, 2 yes and will recover after severe stress (Ks<0.05)	2	2	1	1	1	1	1	1	2	2
NRCS runoff curve number - coarse soil		60	60	67	67	67	67	67	67	63	65
NRCS runoff curve number - medium soil		68	68	75	75	75	75	75	75	75	75
NRCS runoff curve number - fine soil		77	77	85	85	85	85	85	85	85	85

Appendix 5 cont. Crop parameter table listing all parameters used in estimating crop ET, planting or greenup, harvest, killing frost, and runoff.

Parameter	Explanation	Grass Pasture - high management	Grass Pasture - low management	Grass - Turf	Orchards - Apples and Cherries w/ground cover	Orchards - Apples and Cherries no ground cover	Garden Vegetables - general
Days after planting or greenup for earliest irrigation		0	0	0	0	0	0
Winter surface class	1=bare, 2=mulch, 3=turf	3	3	3	2	1	1
MAD during initial and development stage	Maximum Allowable Depletion of soil moisture in percent	60	60	60	50	50	50
MAD during midseason and late season	Maximum Allowable Depletion of soil moisture in percent	50	50	50	50	50	40
Initial rooting depth, m	On alfalfa, 2nd cycle, start at max.	0.3	0.3	0.3	1.5	1.5	0.12
Maximum rooting depth, m		1	1	0.6	1.5	1.5	0.6
End of root growth, as a fraction of time from planting or greenup to EFC		0.4	0.4	0.4	0.5	0.5	1.2
Starting crop height, m		0.1	0.1	0.05	4	4	0.1
Maximum Crop height, m		0.25	0.15	0.1	4	4	0.4
Crop Kcb curve number		30	31	29	24	25	20
Crop curve type	1=NCGDD, 2=%PL-EC, 3=%PL-EC,daysafter	3	3	2	2	2	2
Flag for means to estimate Greenup	1=CGDD, 2=T30, 3=date, 4 is on all the time	2	2	2	2	2	2
T30 for Greenup or CGDD for Greenup	30 day moving average, Degree C	5	5	5	6	6	10
Time for EFC	Days after planting or greenup	40	50	70	55	55	80
time for harvest (neg to extend until frost)	Use as max length for CGDD crops	-220	-220	-270	-260	-260	200
Killing frost temperature	Degrees C	-5	-5	-5	-5	-5	-2
Invoke Stress	1 yes, 0 no, 2 yes and will recover after severe stress (Ks<0.05)	2	2	2	1	1	1
NRCS runoff curve number - coarse soil		40	40	40	60	65	72
NRCS runoff curve number - medium soil		70	70	70	68	72	80
NRCS runoff curve number - fine soil		82	82	82	70	82	88

Appendix 5 cont. Crop parameter table listing all parameters used in estimating crop ET, planting or greenup, harvest, killing frost, and runoff.

Parameter	Explanation	Onions	Melons	Wine Grapes	Alfalfa Seed	Peas-fresh	Peas-seed	Potatoes-processing (early harvest)	Potatoes-cold pack (late harvest)
Days after planting or greenup for earliest irrigation		0	0	20	0	0	0	0	0
Winter surface class	1=bare, 2=mulch, 3=turf	1	1	1	2	1	1	1	1
MAD during initial and development stage	Maximum Allowable Depletion of soil moisture in percent	50	50	70	70	60	60	50	50
MAD during midseason and late season	Maximum Allowable Depletion of soil moisture in percent	40	50	70	70	50	50	40	40
Initial rooting depth, m	On alfalfa, 2nd cycle, start at max.	0.2	0.2	1	0.7	0.2	0.2	0.3	0.3
Maximum rooting depth, m		0.8	1.2	2	1.5	1	1	0.8	0.8
End of root growth, as a fraction of time from planting or greenup to EFC		1.2	1.2	1	0.5	1	1	1	1
Starting crop height, m		0.1	0.05	1.5	0.1	0.05	0.05	0.05	0.05
Maximum Crop height, m		0.4	0.3	1.5	0.6	0.3	0.3	0.4	0.4
Crop Kcb curve number		20	22	21	33	4	3	7	6
Crop curve type	1=NCGDD, 2=%PL-EC, 3=%PL-EC,daysafter	2	2	2	3	1	1	1	1
Flag for means to estimate Greenup	1=CGDD, 2=T30, 3=date, 4 is on all the time	2	2	2	1	2	2	2	2
T30 for Greenup or CGDD for Greenup	30 day moving average, Degree C	7.5	10	8	240	5	5	5	5
For NCGDD based curves: Tbase:	Temp Min. Degree C				0	0	0	5	5
CGDD for EFC	Cumulative Degree C days from Jan 1					640	640	700	740
CGDD for termination						1000	1620	1350	1900
Time for EFC	Days after planting or greenup	70	70	80	80				
time for harvest (neg to extend until frost)	Use as max length for CGDD crops	220	145	-270	100				
Killing frost temperature	Degrees C	-2	-2	-3	-7	-4	-4	-5	-5
Invoke Stress for rainfed agriculture	1 yes, 0 no, 2 yes and will recover after severe stress (Ks<0.05)	1	1	1	1	1	1	1	1
NRCS runoff curve number - coarse soil		72	72	65	60	63	63	70	70
NRCS runoff curve number - medium soil		80	80	72	68	70	70	76	76
NRCS runoff curve number - fine soil		88	88	82	77	82	82	88	88

Appendix 5 cont. Crop parameter table listing all parameters used in estimating crop ET, planting or greenup, harvest, killing frost, and runoff.

Parameter	Explanation	Sugar beets	Hops	Sunflower	Safflower	Canola
Days after planting or greenup for earliest irrigation		0	0	0	0	0
Winter surface class	1=bare, 2=mulch, 3=turf	1	1	1	2	2
MAD during initial and development stage	Maximum Allowable Depletion of soil moisture in percent	50	50	60	60	60
MAD during midseason and late season	Maximum Allowable Depletion of soil moisture in percent	50	50	60	60	60
Initial rooting depth, m	On alfalfa, 2nd cycle, start at max.	0.15	1	0.2	0.2	0.2
Maximum rooting depth, m		1.3	1.5	2.5	2.5	1.6
End of root growth, as a fraction of time from planting or greenup to EFC		1.2	1	1.2	1.2	1.2
Starting crop height, m		0.05	1	0.1	0.1	0.1
Maximum Crop height, m		0.35	6	2	1	1
Crop Kcb curve number		5	23	28	28	27
Crop curve type	1=NCGDD, 2=%PL-EC, 3=%PL-EC,daysafter	1	2	2	2	2
Flag for means to estimate Greenup	1=CGDD, 2=T30, 3=date, 4 is on all the time	2	1	2	2	2
T30 for Greenup or CGDD for Greenup	30 day moving average, Degree C	8	600	10	8	8
For NCGDD based curves: Tbase:	Temp Min. Degree C	0	0			
CGDD for EFC	Cumulative Degree C days from Jan 1	970				
CGDD for termination		2600				
Time for EFC	Days after planting or greenup		100	70	70	55
time for harvest (neg to extend until frost)	Use as max length for CGDD crops		170	170	170	170
Killing frost temperature	Degrees C	-4	-2	-4	-4	-4
Invoke Stress	1 yes, 0 no, 2 yes and will recover after severe stress (Ks<0.05)	1	1	1	1	1
NRCS runoff curve number - coarse soil		67	65	58	58	58
NRCS runoff curve number - medium soil		74	72	72	72	72
NRCS runoff curve number - fine soil		86	82	83	83	83

Appendix 5 cont. Crop parameter table listing all parameters used in estimating crop ET, planting or greenup, harvest, killing frost, and runoff.

Parameter	Explanation	Garlic	Bare soil	Mulched soil - including wheat stubble	Dormant Turf (winter time)	Open water - shallow systems
Days after planting or greenup for earliest irrigation		0	NA	NA	NA	NA
Winter surface class	1=bare, 2=mulch, 3=turf	1	1	2	3	NA
MAD during initial and development stage	Maximum Allowable Depletion of soil moisture in percent	50	60	60	60	NA
MAD during midseason and late season	Maximum Allowable Depletion of soil moisture in percent	40	60	60	60	NA
Initial rooting depth, m	On alfalfa, 2nd cycle, start at max.	0.2	0.08	0.08	0.08	NA
Maximum rooting depth, m		0.8	0.08	0.08	0.08	NA
End of root growth, as a fraction of time from planting or greenup to EFC		1.2	1	1	1	NA
Starting crop height, m		0.1	0.05	0.05	0.05	NA
Maximum Crop height, m		0.4	0.05	0.05	0.05	NA
Crop Kcb curve number		20	0	0	0	NA
Crop curve type	1=NCGDD, 2=%PL-EC, 3=%PL-EC,daysafter	2	NA	NA	NA	NA
Flag for means to estimate Greenup	1=CGDD, 2=T30, 3=date, 4 is on all the time	2	4	4	4	NA
T30 for Greenup or CGDD for Greenup	30 day moving average, Degree C	7.5				
Time for EFC	Days after planting or greenup	70				
time for harvest (neg to extend until frost)	Use as max length for CGDD crops	200				
Killing frost temperature	Degrees C	-2	-50	-50	-50	NA
Invoke Stress	1 yes, 0 no, 2 yes and will recover after severe stress (Ks<0.05)	1	2	2	2	NA
NRCS runoff curve number - coarse soil		72	58	58	40	NA
NRCS runoff curve number - medium soil		80	72	72	70	NA
NRCS runoff curve number - fine soil		88	83	83	82	NA

Appendix 6. Basal crop coefficient (K_{cb}) curve values for crop types simulated.

Type of K_{cb} Curve	1	1	1	1	1	1	1
X axis = NCGDD*100 (type 1)	**Spring Wheat**	**Winter Wheat**	**Peas, seed**	**Peas, fresh**	**Sugar Beets**	**Potatoes--cold pack (late harvest)**	**Potatoes--processing (early harvest)**
0	0.18	0.14	0.14	0.14	0.18	0.18	0.18
10	0.18	0.14	0.17	0.17	0.18	0.18	0.18
20	0.24	0.18	0.18	0.18	0.19	0.18	0.18
30	0.34	0.24	0.19	0.19	0.2	0.2	0.2
40	0.48	0.32	0.24	0.24	0.22	0.28	0.28
50	0.6	0.48	0.38	0.38	0.25	0.42	0.42
60	0.71	0.86	0.55	0.55	0.48	0.58	0.58
70	0.98	1.12	0.76	0.76	0.68	0.74	0.74
80	1.14	1.19	0.92	0.92	0.88	0.83	0.83
90	1.19	1.24	1.02	1.02	1.06	0.89	0.89
100	1.24	1.24	1.1	1.1	1.24	0.92	0.92
110	1.24	1.24	1.1	1.1	1.24	0.92	0.92
120	1.24	1.24	1.1	1.1	1.24	0.92	0.91
130	1.24	1.24	1.09	1.09	1.24	0.9	0.86
140	1.24	1.22	1.01	1.01	1.22	0.86	0.84
150	1.24	1.2	0.94	0.94	1.21	0.84	0.82
160	1.24	0.86	0.85	0.85	1.19	0.82	0.78
170	1.21	0.52	0.78	0.78	1.16	0.79	0.76
180	1.16	0.3	0.7		1.14	0.77	0.71
190	1.06	0.18	0.62		1.09	0.73	0.65
200	0.77	0.12	0.54		1.04	0.7	0.48
210	0.49	0.06	0.46		0.98	0.65	0.12
220	0.34		0.37		0.92	0.58	
230	0.19		0.32		0.88	0.19	
240	0.12		0.26		0.83	0.12	
250	0.06		0.22		0.76		
260			0.17		0.68		
270			0.12		0.12		

Appendix 6 cont. Basal crop coefficient (K_{cb}) curve values for crop types simulated.

Type of K_{cb} Curve	1	1	1	1	1	1	1	1
X axis = NCGDD*100 (type 1)	Field Corn	Sileage Corn	Sweet Corn	Snap Beans-dry	Snap Beans-fresh	Alfalfa 1st cycle	Alfalfa Int cycle	Alfalfa Last cycle
0	0.18	0.18	0.18	0.18	0.18	0.3	0.3	0.3
10	0.18	0.18	0.18	0.19	0.19	0.61	0.4	0.35
20	0.18	0.18	0.18	0.23	0.23	0.88	0.54	0.46
30	0.2	0.2	0.2	0.28	0.28	1.01	0.96	0.67
40	0.23	0.23	0.23	0.46	0.46	1.08	1.12	0.95
50	0.34	0.34	0.34	0.59	0.59	1.18	1.19	1.09
60	0.5	0.5	0.5	0.72	0.72	1.2	1.2	1.15
70	0.65	0.65	0.65	0.89	0.89	1.2	1.19	1.2
80	0.88	0.88	0.88	1.03	1.03	1.19	1.16	1.19
90	1.03	1.03	1.03	1.13	1.13	1.16	1.15	1.15
100	1.15	1.15	1.15	1.14	1.14	1.15	1.13	1.13
110	1.15	1.15	1.15	1.14	1.14			
120	1.15	1.15	1.14	1.14	1.14			
130	1.15	1.15	1.13	1.12	1.12			
140	1.15	1.15	1.12	1.08	1.08			
150	1.13	1.13	1.08	1.02	1.02			
160	1.08	1.08	1.03	0.9	0.9			
170	1.03	1.03	0.98	0.77				
180	0.98	0.98		0.59				
190	0.94	0.94		0.41				
200	0.88	0.88		0.23				
210	0.78	0.78		0.1				
220	0.53	0.24						
230	0.26	0.12						
240	0.16	0.12						

Appendix 6 cont. Basal crop coefficient (K_{cb}) curve values for crop types simulated.

Type of K_{cb} Curve	1	1	1	2	2	2	2	2	2	2
X axis = NCGDD*100 or % Time to EFC (type 1 and 2)	**Lentils**	**Mint**	**Grass Hay**	**Onions**	**Garlic**	**Wine grapes**	**Melons**	**Hops**	**Orchard w/GC**	**Orchard w/no GC**
0	0.18	0.42	0.24	0.18	0.18	0.19	0.18	0.12	0.18	0.18
10	0.18	0.61	0.55	0.18	0.18	0.22	0.18	0.12	0.24	0.18
20	0.22	0.88	0.82	0.18	0.18	0.26	0.2	0.12	0.29	0.22
30	0.3	1.01	0.95	0.29	0.29	0.31	0.24	0.14	0.4	0.3
40	0.43	1.08	1.02	0.4	0.4	0.44	0.29	0.16	0.53	0.42
50	0.54	1.18	1.12	0.49	0.49	0.67	0.37	0.38	0.66	0.53
60	0.64	1.2	1.14	0.62	0.62	0.78	0.53	0.66	0.79	0.68
70	0.89	1.2	1.14	0.74	0.74	0.78	0.67	0.83	0.92	0.79
80	1.03	1.19	1.13	0.85	0.85	0.78	0.78	0.95	1.01	0.86
90	1.07	1.16	1.1	0.9	0.9	0.78	0.78	1.04	1.04	0.9
100	1.12	1.15	1.09	0.9	0.9	0.78	0.78	1.15	1.08	0.9
110	1.12	0.3	0.6	0.9	0.9	0.78	0.78	1.2	1.08	0.9
120	1.12	0.4	0.66	0.9	0.9	0.78	0.78	1.2	1.08	0.9
130	1.12	0.54	0.84	0.9	0.9	0.78	0.78	1.2	1.08	0.9
140	1.12	0.9	0.9	0.9	0.9	0.78	0.78	1.16	1.08	0.9
150	1.12	0.9	0.9	0.9	0.78	0.78	0.78	1.07	1.08	0.9
160	1.12	0.9	0.9	0.9	0.67	0.78	0.78	0.85	1.08	0.9
170	1.09	0.9	0.9	0.78	0.56	0.78	0.78	0.62	1.08	0.9
180	1.04	0.9	0.9	0.67	0.46	0.78	0.78	0.36	1.08	0.9
190	0.95	0.9	0.84	0.56		0.72	0.78	0.31	1.08	0.9
200	0.7	0.9	0.84	0.46		0.72	0.78	0.26	1.08	0.9
210	0.44	0.9	0.84			0.72	0.78		1.08	0.9
220	0.3	0.9	0.78			0.72	0.78		0.88	0.84
230	0.19	0.9	0.78			0.72	0.78		0.66	0.66
240	0.12	0.9	0.78			0.72	0.78		0.66	0.66
250		0.9	0.72			0.72	0.78		0.66	0.66
260		0.9	0.66			0.72	0.78		0.66	0.66
270		0.9	0.6			0.72	0.78		0.66	0.66
280			0.54							
290			0.54							
300			0.54							

Appendix 6 cont. Basal crop coefficient (K_{cb}) curve values for crop types simulated.

Type of K_{cb} Curve		2	2	2	3	3	3
X axis = % Time to EFC (type 2)	**X axis = % Time to EFC then days after (type 3)**	**Canola**	**Sunflower/ Safflower**	**Turf**	**Grass Pasture - high management**	**Grass Pasture - low management**	**Alfalfa Seed**
0	0	0.18	0.18	0.18	0.35	0.26	0.42
10	10	0.18	0.18	0.3	0.42	0.31	0.6
20	20	0.18	0.18	0.46	0.5	0.38	0.72
30	30	0.23	0.23	0.58	0.6	0.46	0.8
40	40	0.35	0.35	0.71	0.71	0.53	0.88
50	50	0.79	0.67	0.78	0.84	0.64	0.95
60	60	1.02	0.9	0.84	0.89	0.66	0.98
70	70	1.14	1.02	0.84	0.92	0.7	1
80	80	1.16	1.04	0.84	0.96	0.72	1.01
90	90	1.16	1.04	0.84	0.96	0.72	1.01
100	100	1.16	1.04	0.84	0.96	0.72	1.02
110	0	1.16	1.04	0.84	0.96	0.72	1.02
120	10	1.16	1.04	0.84	0.96	0.72	1.02
130	20	1.16	1.04	0.84	0.96	0.72	1.02
140	30	1.15	1.03	0.84	0.96	0.72	1.02
150	40	0.97	0.85	0.84	0.96	0.72	1
160	50	0.7	0.58	0.84	0.96	0.72	0.97
170	60	0.43	0.37	0.84	0.96	0.72	0.95
180	70	0.3	0.24	0.84	0.96	0.72	0.84
190	80	0.12	0.12	0.84	0.96	0.71	0.68
200	90			0.84	0.95	0.7	0.54
210	100			0.84	0.92	0.68	0.48
220	110			0.84	0.9	0.67	0.48
230	120			0.84	0.84	0.65	
240	130			0.84	0.78	0.62	
250	140			0.84	0.72	0.6	
260	150			0.84	0.66	0.48	
270	160			0.84	0.6	0.36	
	170				0.48	0.36	
	180				0.48	0.36	
	190				0.48	0.36	
	200				0.48	0.36	
	210				0.48	0.36	
	220				0.48	0.36	
	230				0.48	0.36	

Appendix 7. Description of greenup and harvest information used in calibrating the cumulative growing degree day and T30 parameters controlling simulated greenup and harvest dates.

The calibration of parameters T_{30}, CGDD, controlling the greenup or planting dates and harvest dates was accomplished by comparing simulated mean annual dates to documented and typical dates of greenup or planting, and cutting and harvest dates for major crops grown in valleys discussed in the paragraphs below. Table 4 in the main body outlines the calibration information used for multiple crops.

Alfalfa grown in Carson Valley, Douglas County, typically greens up in early April and the typical beef hay alfalfa farmer gets a first cutting in the second week of June, second cutting in the first week of August, and last cutting in mid September. After the third cutting the crop is left for grazing and it is not irrigated, usually due to a shortage of water. Typical beef hay yields range between 4 and 4.5 tons per acre (Andy Aldax, verbal communication, 2008). The dairy hay farmer that irrigates with center pivots usually sees greenup occur in early April and the alfalfa usually reaches full cover by the mid May, and as a rule of thumb makes the first cutting at the end of May with 28-35 days between cuttings. The fourth and last cutting usually takes more time and occurs in mid September. Typical yields for dairy hay average about 5.5 tons per acre (Jim Usher, Bently Farms, verbal communication, 2008).

In the Boulder Flat hydrographic area, located in Eureka County, dairy and beef alfalfa hay is the primary crop and is largely irrigated from water derived from dewatering activities at surrounding mine sites. The greenup and harvest times of are very similar to Carson Valley where greenup occurs around the first of April and is first cut around the end of May to the beginning of June, with approximately 30-35 days in between cuttings. Some years however a fourth cutting is not attainable due to weather conditions of the season (Dan Gralian, TS Ranch, written communication, 2008).

In the Mason and Smith Valley hydrographic areas, located in Lyon County, beef and dairy hay are the primary crops grown, however the valleys are famous for producing some of the best quality onions in the country. Alfalfa greenup dates in Mason and SmithValley typically occur in mid to late March to early April and cutting dates usually occurs every 35 to 45 days beginning in the end of May to early June (John Snyder, verbal communication, 2009). Onion crops in Mason Valley are typically planted in mid March and greenup occurs 3 to 4 weeks after planting. Harvest of onions usually takes place in late August and continues throughout September depending on the variety. After harvest the fields are fallow until the next seasons planting (Peri and Sons, verbal communication, 2008, John Snyder, verbal communication, 2009). Garlic is commonly grown in Mason Valley and is typically harvested 2-3 weeks before onions. Irrigation is usually ceased by early to mid August to allow drying of the garlic (John Snyder, verbal communication, 2009).

Fallon, located in the Carson Desert hydrographic area, Churchill County, is well known for producing beef and dairy hay alfalfa and melons. Melons are a 90 day crop and are typically planted in early May, greenup occurs 10-12 days after planting, and harvest occurs in the middle of August (Workman Farms & Latin Farms, verbal communication, 2008). Fresh beans are typically planted in the middle of May and are harvested in the middle of August. Sweet corn being a 70-90 day crop is planted around the first of May and is harvested by the middle August to early September, and silage corn is planted at the same time as sweet corn but is grown longer and harvested around the middle to late September (Latin Farms, verbal communication, 2008). Alfalfa greenup usually occurs at the end of March with cuttings beginning in early to mid June, with 30 – 40 days between cuttings, and ending in late September to mid October with 3 to 4 cuttings.

Paradise Valley, located in Humboldt County, is a large agricultural area that is well known for its potatoes, but also produces wheat and dairy and beef alfalfa hay. Potatoes are grown for the processing and fresh market industry and are typically planted around early April to mid May. Processing potatoes are harvested beginning in mid August through mid September while fresh potatoes are harvested beginning in September through mid October (Verbal Communication, Shane Cheyne, Winnemucca Farms, 2008). Winter wheat is typically planted during the mid part of September through October and is harvested in mid to late July. Spring wheat is typically planted in late March, greens up in mid April, and is harvested in mid July to mid August.

Lake Valley, located in Lincoln County and White Pine counties, is home to Atlanta Farms, which produces large quantities of dairy and beef alfalfa hay and fresh potatoes. Greenup of alfalfa usually occurs in mid April, with the first cutting in mid June, and subsequent cuttings every 35-45 days after, with 3-4 cuttings. Potatoes are planted in mid April to mid May and harvest usually occurs in mid September through early October (Verbal Communication, Joseph Harker, Atlanta Farms, 2009).

Antelope Valley, located in Lander County, primarily produces dairy hay alfalfa. Typical greenup occurs between April 1 – 15, with effective full cover occurring around the mid to end of May, the first cutting occurring between June 15, the second cutting occurring near the beginning of August, and the last and third cutting occurring near Sept 15. Spring wheat is grown as a rotation crop is planted in mid April and is harvested in middle to late July (verbal communication, Allen Farr, Farr Farms, 2008).

In Moapa Valley, located in Clark County, dairy hay alfalfa is the primary crop grown and typically greens up near mid February, where the first cutting is generally within the first week of April and a 30 day period between cuttings with typically 7 cutting per year. The last cutting usually occurs in the mid part of November (verbal communication, Glenn Hardy, 2007). Typical annual alfalfa yields were stated to be about 8 tons per acre. After 3 to 4 years of alfalfa production Sudan grass and winter wheat are the typical rotation crops.

Appendix 8. Weather station aridity ratings following Allen and Brockway (1983), estimated from station photos, and high resolution image analysis (0= irrigated area, 100=completely arid).

Station Name	NOAA #	Station Aridity	Area Aridity	Regional Aridity	Cumulative Aridity
ADAVEN	260046	30	70	100	57
ALAMO	260099	30	60	80	50
AMARGOSA FARMS-GAREY	260150	90	90	100	91
ANTELOPE VALLEY FARR	260282	50	60	80	58
ARTHUR 4 NW	260438	50	60	70	57
AUSTIN #2	260507	90	80	80	84
BASALT	260668	100	100	100	100
BATTLE MTN	260688	80	70	70	74
BATTLE MTN AP	260691	100	80	70	87
BEATTY	260715	100	80	90	89
BEATTY 8 N	260718	90	90	100	91
BEOWAWE	260795	90	60	70	73
BEOWAWE U OF N RCH	260800	20	40	80	36
BLUE EAGLE RCH HANKS	260955	30	50	90	46
BLUE JAY HWY STN	260961	100	100	100	100
BOULDER CITY	261071	100	90	90	94
BRINKERHOFF RCH	261160	100	90	100	95
BUFFALO RCH	261311	90	90	90	90
BUNKERVILLE	261327	70	70	90	72
CALIENTE	261358	60	70	90	68
CALLVILLE BAY	261371	100	70	90	84
CARLIN NEWMONT MINE	261415	100	100	90	99
CARSON CITY	261485	100	80	70	87
CATHEDRAL GORGE SP	261590	90	90	90	90
CENTRAL NEVADA FLD LAB	261630	70	60	90	67
CHARLESTON	261660	70	60	80	66
CLOVER VALLEY	261740	20	30	90	32
COALDALE JUNCTION	261755	100	100	100	100
CONTACT	261905	100	80	90	89
CORTEZ GOLD MINE	261975	100	100	100	100
CURRANT	262078	50	30	90	44
CURRANT HWY STN	262091	100	100	100	100
CURRIE HWY STN	262096	80	70	90	76

Appendix 8 cont. Weather station aridity ratings following Allen and Brockway (1983), estimated from station photos, and high resolution image analysis (0= irrigated area, 100=completely arid).

Station Name	NOAA #	Station Aridity	Area Aridity	Regional Aridity	Cumulative Aridity
DAGGET PASS	262119	70	60	60	64
DENIO	262229	70	60	80	66
DESERT NWR	262243	80	90	100	87
DIABLO	262276	100	100	100	100
DIAMOND VALLEY USDA	262296	70	20	40	42
DUCKWATER	262390	60	60	80	62
DUFURRENA	262394	80	60	90	71
DYER	262431	90	90	90	90
EASTGATE	262477	90	90	100	91
ECHO BAY	262497	100	80	70	87
ELGIN	262557	60	90	90	78
ELGIN 3 SE	262562	60	90	90	78
ELKO	262570	70	70	90	72
ELKO RGNL AP	262573	100	70	80	83
ELY 6 NE	262626	90	90	90	90
ELY YELLAND FLD AP	262631	100	100	90	99
EMIGRANT PASS HWY STN	262656	90	90	100	91
EMPIRE	262662	70	90	100	83
EUREKA	262708	90	90	100	91
FALLON EXP STN	262780	50	70	50	60
FERGUSON SPRINGS HMS	262820	90	90	90	90
FERNLEY	262840	100	100	100	100
FISH CREEK RCH	262860	20	40	80	36
GERLACH	263090	100	90	100	95
GEYSER RCH	263101	60	70	90	68
GIBBS RCH	263114	50	50	70	52
GLENBROOK	263205	50	70	70	62
GOLCONDA	263245	100	100	100	100
GOLDFIELD	263285	100	100	100	100
GOODSPRINGS	263316	80	100	100	92
GREAT BASIN NP	263340	70	80	100	78
HAWTHORNE	263512	90	100	100	96
HAWTHORNE AP	263515	80	90	100	87
HIKO	263671	50	50	70	52
HUMBOLDT FLD	263853	90	100	100	96
I-L RCH	263940	80	80	90	81
IMLAY	263957	90	90	100	91
INDIAN SPRINGS	263980	100	100	100	100
JACKPOT	264016	70	90	100	83

Appendix 8 cont. Weather station aridity ratings following Allen and Brockway (1983), estimated from station photos, and high resolution image analysis (0= irrigated area, 100=completely arid).

Station Name	NOAA #	Station Aridity	Area Aridity	Regional Aridity	Cumulative Aridity
JARBRIDGE 4 N	264038	100	100	100	100
JARBIDGE 7 N	264039	40	70	100	61
JIGGS 8 SSE ZAGA	264095	70	90	100	83
JUNGO MEYER RCH	264108	80	90	100	87
KIMBERLY	264199	100	100	100	100
KNOLL CREEK FLD	264268	60	60	100	64
KYLE CANYON RS	264314	80	80	100	82
LAGES	264341	90	100	100	96
LAHONTAN DAM	264349	100	90	100	95
LAKE VALLEY STEWARD	264384	80	90	100	87
LAMOILLE YOST	264394	80	100	90	91
LAMOILLE PH	264395	80	90	90	86
LAS VEGAS	264429	100	100	100	100
LAS VEGAS WB AP	264436	100	100	100	100
LAS VEGAS NWFO	264439	100	100	100	100
LATHROP WELLS	264457	90	100	100	96
LAUGHLIN	264480	100	100	100	100
LEHMAN CAVES NM	264514	80	100	100	92
LEONARD CREEK RCH	264527	60	80	100	74
LEWERS RCH	264542	20	30	40	27
LITTLE RED ROCK	264600	100	100	100	100
LOGANDALE	264651	60	60	60	60
LOVELOCK DERBY FLD	264700	100	100	100	100
LUND	264745	60	60	80	62
MALA VISTA RCH	264824	60	50	80	57
MARLETTE LAKE	264858	80	80	80	80
MCDERMITT	264935	80	80	100	82
MCGILL	264950	80	90	100	87
MESQUITE	265085	70	70	80	71
METROPOLIS	265092	60	70	90	68
MIDAS 4 SE	265105	60	70	90	68
MIDDLEGATE-LOWERY	265132	100	100	100	100
MINA	265168	100	100	100	100
MINDEN	265191	10	30	30	22
MONTELLO 2 SE	265352	60	70	80	67
MONTGOMERY MNTC STN	265362	100	100	100	100
MOORMAN RCH	265371	100	100	100	100
MTN CITY RS	265392	70	80	90	77
MT CHARLESTON	265400	70	80	90	77

Appendix 8 cont. Weather station aridity ratings following Allen and Brockway (1983), estimated from station photos, and high resolution image analysis (0= irrigated area, 100=completely arid).

Station Name	NOAA #	Station Aridity	Area Aridity	Regional Aridity	Cumulative Aridity
FS					
MT ROSE BOWL	265440	70	80	90	77
NIXON	265605	90	80	100	86
NORTH LAS VEGAS	265705	100	100	100	100
OASIS	265722	70	70	90	72
OLD RUTH	265760	100	100	100	100
OROVADA 3 W	265818	30	60	60	48
OVERTON	265846	70	70	80	71
OWYHEE	265869	60	30	60	45
PAHRANAGAT WR	265880	60	60	60	60
PAHRUMP	265890	100	100	100	100
PAHUTE MEADOWS RCH	265907	40	60	90	55
PALMETTO	265931	100	100	100	100
PARADISE VALLEY 1 NW	266005	70	70	80	71
PARIS RCH	266055	60	70	90	68
PENOYER VALLEY	266130	60	20	70	41
PEQUOP	266148	100	100	100	100
PILOT VALLEY-LEE	266228	70	90	100	83
PINE VALLEY BAILEY RCH	266242	60	50	80	57
PIOCHE	266252	100	100	100	100
QUINN RVR CROSSING	266504	50	50	70	52
RAND RCH PALISADE	266574	60	40	80	52
RATTLESNAKE	266630	100	100	100	100
RED ROCK CANYON SP	266691	50	80	100	70
REESE RIVER	266746	60	80	90	73
REESE VALLEY CARPER	266748	60	50	60	55
RENO TAHOE INTL AP	266779	100	90	80	93
RENO WFO	266791	100	100	100	100
RUBY LAKE	267123	60	60	70	61
RUTH	267175	70	70	100	73
RYNDON	267188	60	50	70	56
RYE PATCH DAM	267192	70	60	90	67
SAND PASS	267261	70	80	100	78
SAN JACINTO	267284	70	50	60	59
SARCOBATUS	267319	50	60	90	59
SAVAL RCH	267324	90	90	100	91
SCHURZ	267358	60	70	70	66
SEARCHLIGHT	267369	100	100	100	100

Appendix 8 cont. Weather station aridity ratings following Allen and Brockway (1983), estimated from station photos, and high resolution image analysis (0= irrigated area, 100=completely arid).

Station Name	NOAA #	Station Aridity	Area Aridity	Regional Aridity	Cumulative Aridity
SEVENTY ONE RCH	267397	20	40	60	34
SHELDON	267443	50	50	80	53
SHOSHONE 5 N	267450	50	90	90	74
SILVERPEAK	267463	60	60	90	63
SMITH 1 N	267609	60	40	40	48
SMITH 6 N	267612	100	70	60	81
SMOKE CREEK ESPIL	267618	80	80	90	81
SMOKEY VALLEY	267620	70	80	90	77
SNOWBALL RCH	267640	100	100	100	100
SOUTH FORK SP	267690	90	90	90	90
SPRING VALLEY SP	267750	20	40	70	35
STATELINE-HARRAH'S	267806	20	30	30	26
STEAD	267820	100	90	100	95
SULPHUR	267873	100	100	100	100
SUNNYSIDE	267908	100	100	100	100
SUTCLIFFE	267953	70	80	90	77
TEMPIUTE 4 NW	267983	100	100	100	100
THORNE	268034	100	100	100	100
TONOPAH	268170	100	100	100	100
TOPAZ LAKE 3N	268186	70	90	100	83
TOPAZ LAKE 4 N	268202	70	90	100	83
TUSCARORA	268346	100	100	100	100
TWIN SPRING FALLINI	268443	100	100	100	100
UNIV OF NEVADA EXP FM	268500	50	70	80	63
URSINE	268538	40	60	80	54
VALLEY OF FIRE SP	268588	100	100	100	100
VIRGINIA CITY	268761	70	80	100	78
VYA	268810	100	100	100	100
WABUSKA 6 SE	268822	100	70	80	83
WADSWORTH	268834	100	70	90	84
WADSWORTH 4 N	268838	100	70	90	84
WELLINGTON RS	268977	60	70	70	66
WELLS	268988	70	80	100	78
WILDHORSE RSVR	269072	100	100	100	100
WILKINS	269122	70	70	90	72
WILLOW SPRINGS	269137	100	100	100	100
WINNEMUCCA #2	269168	70	90	90	82
WINNEMUCCA MUNI AP	269171	100	100	100	100
YERINGTON	269229	50	60	50	55

Appendix 8 cont. Weather station aridity ratings following Allen and Brockway (1983), estimated from station photos, and high resolution image analysis (0= irrigated area, 100=completely arid).

Station Name	NOAA #	Station Aridity	Area Aridity	Regional Aridity	Cumulative Aridity
LAS VEGAS	23112	100	100	100	100
RED ROCK WC	29999	90	30	40	55
WASHOE VALLEY WC	39999	60	30	30	42

Appendix 9. Descriptions of daily, monthly, annual, and statistical summaries of ET, net irrigation water requirement, and effective precipitation.

Daily Time Series

The daily ET_c time series files are assembled as one file per station and contain daily information for entire periods of record. The daily ET_c time series file has ET_c information for up to 34 crops or land use conditions. Any missing data in the daily ET_c files are denoted as –99. Generally, missing data occurred due to missing air temperature data for a day that precluded the calculation of ET_{os}. Often, entire months were missing from NWS files obtained from the NOAA-NCDC system. The daily ET_c files can be large, exceeding 50mb for some stations having long periods of record and many crop types. The total crop types that are included for each station are listed in Appendix 10.

The names of the ET_c files for the National Weather Service (NWS) stations contain the NCDC station ID number, for example, 262780 for the Fallon Exp station. The extension to these files is '*.dat*.' For example, the name Fallon Exp station is 262780ETca.dat. The daily ET_c files are 'flat' text (i.e., ASCII) files with all columns of data separated by one or more blank spaces. The daily ETc files contain daily ETc data for the full period of record for the particular station, with some files dating to the late 1800's. All NWS files conclude at 12/31/2007 or earlier, as the end of 2007 was the last period for which data were obtained for most stations. The full list of weather station names along with assigned file numbers are provided in Appendix 1a and 1b.

The daily files contain reference ET and reported precipitation in units of mm/day, along with the computed 30-day average daily mean air temperature (T30), and crop ET for different crop types. The value for T30 is for the 30-day period ending on the particular date. T30 was used to estimate starts of growth periods for many types of crops. The file header is comprised of five lines that describe the date of computation, the station ID number and internal station 'ET number' as well as the station latitude, longitude and elevation (in decimal degrees and feet). The fourth line of the header lists the total number of crop or land cover types in the specific file as well as a listing of each crop type. Each crop or land cover type is listed beginning with its specific number (1 through 34) followed by a short character description of the crop or land use. The last line in the header describes each data column. The first seven columns, headed by "*Year DoY Mo Dy PMETo Pr.mm T30*" represent the year, day of year (1-366), month, day of month, grass reference ET computed by the ASCE Penman-Monteith ETos method, gross precipitation, and 30-day mean air temperature. Following these seven columns, seven columns appear for each crop or land cover: "*ETact ETpot ETbas Irrn Seasn Runof DPerc*" These columns are defined as follows:

ETact (*actual daily* ET_c) - ET_{act} represents the total estimated flux of ET given any reduction in actual ET caused by soil water shortage or soil surface dryness. ET_{act} is computed as $ET_{act} = K_s\, ET_{bas} + K_e\, ET_{os}$, where ET_{os} is grass reference ET, K_s is a stress factor (0 – 1 where 1 means no stress) and K_e is the evaporation coefficient. ET_{bas} is defined below. ET_{act} is occasionally less than ET_{pot} for irrigated crops prior to the growing season when a low-level, basal crop coefficient for the non-growing season cover cannot be sustained by precipitation, or early in the growing season prior to initiation of irrigation. <u>ET_{act} includes evaporation from the soil surface from both precipitation and any simulated irrigation.</u>

ETpot (p*otential daily* ET_c) - ET_{pot} represents the total estimated flux of ET that would occur if there were no moisture stress imposed by soil water shortage in the root zone. ET_{pot} includes evaporation from the soil surface from both precipitation and any simulated irrigation. ET_{pot} is computed as $ET_{pot} = ET_{bas} + K_e ET_{os}$, where ET_{os} is the grass reference ET.

ETbas (*basal daily* ET_c) - ET_{bas} represents the ET that would occur under no water stress and with no surface wetting by precipitation or irrigation. In other words, ET_{bas} represents potential ET_c (ET_{pot}) for a dry soil surface. ET_{bas} should not be used to estimate irrigation water requirements, and is included to provide an indication of the amount of *ET* that is primarily 'transpiration', as opposed to any amount that is from evaporation of water from the soil surface layer. ET_{bas} is calculated as K_{cb} ET_{os} where K_{cb} is the basal crop coefficient and ET_{os} is the grass reference ET.

Irrn (*irrigations)* - Irrigation timing and amount is simulated using a daily soil water balance. Irrigations are simulated when the root zone dries to the specified threshold point (i.e. the maximum allowable depletion) where stress will begin to occur (listed in appendix 5). The simulated irrigation frequency and depth per irrigation is a function of the crop type and available water holding capacity.

Seasn (*growing or non-growing season*) - The *Seasn* column contains a 'flag' that is 1 when the date is inside the estimated growing season and 0 when outside the growing season. The growing season is defined as the time from first green-up or planting of the crop type until the time of harvest, senescence, or killing frost. The season start and end varies from year to year for crops where the season start is estimated using T30, cumulative growing degree days, and/or where season length is estimated using cumulative growing degree days, or is terminated by frost specified by a killing frost temperature. In the case of the four land cover types (bare soil, mulch, dormant turf, and small open water bodies), the season flag is always on.

Runof (*surface runoff from precipitation)* - Surface runoff is estimated during precipitation events using the NRCS curve number as described in the main body of text.

DPerc (*deep percolation below the root zone) - DPerc* represents water, in mm/day, percolating below the maximum root zone depth for the crop or land cover type. This water is considered to be unrecoverable for fulfilling any ET requirements. There are no estimates for upward capillary fluxes into the root zone from below the root zone. The *DPerc* during irrigation events may contain 10% of the irrigation depth (the amount of water required to refill the root zone). This 10% was included to provide recharge to depths in the soil profile that are above the maximum rooting depth, and below the current rooting depth of the crop. This was necessary to simulate buildup of soil water during irrigation events that is used later in the season as roots may deepen. This phenomenon is typical in practice.

Monthly Time Series

Files for monthly ET_c time series have names that follow the same convention for daily ET_c files. The latter portion of the name carries the label '*ETc_monthly.dat*', for example, the Fallon Exp station is "*262780ETc_monthly.dat.*" The monthly files are assembled as one file per station. Each file has ETc information for up to 34 crops or land use conditions. The monthly ET_c time series files have 10 lines of header information that contain similar information as for the daily time series files. The header notes the time and date of computation of the original daily ET_c information as well as the time and date of computation of the monthly summaries (series). The first three columns of data contain the year, the month number (1-12) and the number of 'valid' days in the month (*V.Dys*). *V.Dys* represents valid days (that do not have a –999 flag in the daily ET_c file caused by lack of weather data). The next two columns are average reference ET (ET_{os}) and average daily precipitation (*Prec*). Any missing data in the monthly ET_c time series files are denoted as –999. Generally, a monthly period in a time series was marked as missing if air temperature data were missing for all days in that month. Entire months were frequently missing from NWS files obtained as from the NOAA-NCDC system. All units are mm/day averaged over the month.

There are six columns of data presented for each crop or land cover that are defined as follow:

ETact (*actual monthly* ET_c) - ET_{act} represents the total estimated flux of ET given any reduction in actual ET caused by soil water shortage or soil surface dryness. ET_{act} is computed as $ET_{act} = K_s\ ET_{bas} + K_e\ ET_{os}$, where ET_{os} is grass reference ET, K_s is a stress factor (0 – 1 where 1 means no stress) and K_e is the evaporation coefficient. ET_{bas} is defined below. ET_{act} is occasionally less than ET_{pot} for irrigated crops prior to the growing season when a low-level, basal crop coefficient for the non-growing season cover cannot be sustained by precipitation, or early in the growing season prior to initiation of irrigation. ET_{act} includes evaporation from the soil surface from both precipitation and any simulated irrigation.

ETpot (p*otential monthly* ET_c*)* - ET_{pot} represents the total estimated flux of ET that would occur if there were no moisture stress imposed by soil water shortage in the root zone. ET_{pot} includes evaporation from the soil surface from both precipitation and any simulated irrigation. ET_{pot} is computed as $ET_{pot} = ET_{bas} + K_e ET_{os}$, where ET_{os} is the grass reference ET.

NIWR (*Net Irrigation Water Requirement AKA precipitation deficit)* - The NIWR is the difference between the actual ET (ET_{act}) and the amount of precipitation that resides in the root zone (*P_rz*) and is available for ET. *NIWR* is calculated as ET_{act} – *P_rz*. *NIWR* represents the amount of additional water that the crop would consume (evapotranspire) beyond *P_rz* if that water were made available at the right time during the growing or non-growing season. The ET_{act} estimate includes soil evaporation from precipitation and simulated irrigation events. The *NIWR*, if summed only during the growing season, does not include the impact of the *NIWR* during the non-growing season in providing stored soil moisture that may offset irrigation requirements during the growing season. Conversely, if summed on an annual time step, the *NIWR* does include stored soil moisture from non-growing season precipitation, and represents what has historically been called the ***net consumptive use***, and is being termed the ***net irrigation water requirement*** in this report. All available precipitation in the root zone is considered when computing the *NIWR* because ET_{act} is used, where ET_{act} is the actual ET that is calculated from a daily soil water balance, and includes evaporation from precipitation. Because ET_{act} includes evaporation of precipitation *P_rz* must be subtracted from ET_{act}.

P_rz (*precipitation residing in the root zone)* - *P_rz* is the amount of gross reported precipitation less any surface runoff or deep percolation that resides in the soil and is available for consumption by evaporation or transpiration. *P_rz* is computed as *P – Runoff – DPerc* where *P* is gross reported precipitation, *Runoff* is estimated surface runoff and *DPerc* is deep percolation of any precipitation below the maximum root zone for the crop or land cover type. The difference between *P_rz* and ET_{act} during the non-growing season represents the amount of 'recharge' or 'build-up' of moisture to the root zone during the non-growing season (i.e., increase in soil water storage) that would be available at the start of the growing season to later partially fulfill plant water requirements. The ratio of ($P\_rz – ET_{act}$)/*P* computed during the non-growing period represents the 'efficiency' or effectiveness of gross precipitation in building soil water for use during the growing season.

P_efT (*precipitation residing in the root zone that is available for transpiration)* - *P_efT* is the amount of gross reported precipitation less any surface runoff or deep percolation that resides in the soil and is available for consumption by transpiration. *P_efT* does not include the amount of infiltrated precipitation that evaporates from the surface evaporation layer (upper 100 mm of soil). The *P_efT* parameter is useful in estimating the amount of precipitation during the non-growing season that is stored and made available for transpiration requirements during the growing season. *P_efT* is always less than *P_rz*. When analyzed during the growing season, *P_efT* is useful for estimating how 'efficient' precipitation is in fulfilling transpiration requirements of crops, as opposed to simply 'burning off' as evaporation from the soil surface. *P_efT* was calculated as *P_efT* = *P_rz - surface evaporation losses* = *P – Runoff – DPerc - surface evaporation losses*, where *P_rz* is precipitation infiltrating and residing in the maximum root zone for the crop, *P* is gross reported precipitation, *Runoff* is estimated surface runoff, and *DPerc* is deep percolation of any precipitation below the maximum root zone for the crop or land cover type.

SeDys (number of *growing season days* within the particular month) - *SeDys is* computed by summing the *Seasn* flag contained in the daily ETc files.

Annual Time Series

The annual ET_c time series files contain the same information as the monthly ET_c time series files. The annual files have names that follow the same convention for daily ET_c files previously described. The latter portion of the name carries the label '*ETc_annual.dat*', for example, for Fallon Exp, the name for the annual file is "*262780ETc_annual.dat*". Each file has ET_c information for up to 34 crops and land cover conditions. All units are in mm/year.

The annual ET_c time series files have 10 lines of header information that contain similar information as for the monthly and daily time series files. The header notes the time and date of computation of the original daily ET_c information as well as the time and date of computation of the annual summaries. The first four columns of data contain the year and the number of 'valid' days in the year (*V.Days*). *V.Days* represents those days that do not have a –999 flag in the daily ET_c file caused by lack of weather data. The next two columns are total reference ET (ET_{os}) and total precipitation (*Prec.*) for the calendar year, both expressed as mm over the year. It is important to note that both ET_{os} and *Prec.* represent the entire calendar year (365 or 366 days), including winter periods. Any years that had less than 350 days of valid data or more than 5 days of missing data during the growing season (defined as the growing period for grass hay) were reported as –999. Years having one to fifteen missing days during the year (and fewer than 6 missing days during the growing season) had annual values for ET and precipitation deficit adjusted by multiplying by 365 or 366 divided by the number of valid days. Any years that had more than 5 days of missing data during the growing season for a crop were reported as –999 for the seasonal ET totals.

There are six columns of annual data presented for each crop that are defined as follow:

ETac (*actual ETc) -* ET_{act} summed over the year. ET_{act} represents the total estimated flux of ET given any reduction in actual ET caused by soil water shortage or soil surface dryness. ET_{act} is computed as $ET_{act} = K_s\ ET_{bas} + K_e\ ET_{os}$, where ET_{os} is grass reference ET, K_s is a stress factor (0 – 1 where 1 means no stress) and K_e is the evaporation coefficient. ET_{bas} is defined below. ET_{act} is occasionally less than ET_{pot} for irrigated crops prior to the growing season when a low-level, basal crop coefficient for the non-growing season cover cannot be sustained by precipitation, or early in the growing season prior to initiation of irrigation. ET_{act} includes evaporation from the soil surface from both precipitation and any simulated irrigation.

ETpt (*potential* ET_c*) -* ET_{pot} summed over the year. ET_{pot} represents the total estimated flux of ET that would occur if there were no moisture stress imposed by soil water shortage in the root zone. ET_{pot} includes evaporation from the soil surface from both precipitation and any simulated irrigation. ET_{pot} is computed as $ET_{pot} = ET_{bas} + K_eET_{os}$, where ET_{os} is the grass reference ET.

NIWR (*Net Irrigation Water Requirement AKA precipitation deficit)* – NIWR summed over the year. The NIWR is the difference between the actual ET (ET_{act}) and the amount of precipitation that resides in the root zone and is available for ET. *NIWR* is calculated as ET_{act} – *P_rz*. *NIWR* represents the amount of additional water that the crop would consume (evapotranspire) beyond *P_rz* if that water were made available at the right time during the growing or non-growing season. The ET_{act} estimate includes soil evaporation for precipitation and simulated irrigation events. Summed on an annual time step, *NIWR* <u>does</u> include stored soil moisture from non-growing season precipitation, and represents what has historically been called the ***net consumptive use***, and is being termed the ***net irrigation water requirement*** in this report. Although P_rz includes precipitation that is later evaporated and not "consumed" by the crop, it is important to note that because ET_{act} includes water that is consumed by evaporation of precipitation, that ET_{act} – P_rz, represents the net irrigation water requirement, and not ET_{act} minus root zone water that is effective toward transpiration only.

P_rz (p*recipitation residing in the root zone)* - *P_rz* is the amount of gross reported precipitation less any surface runoff or deep percolation that resides in the soil and is available for consumption by evaporation or transpiration. *P_rz* is computed as *P – Runoff – DPerc* where *P* is gross reported precipitation, *Runoff* is estimated surface runoff and *DPerc* is deep percolation of any precipitation below the maximum root zone for the crop or land cover type.

P_efT (*precipitation residing in the root zone that is available for transpiration) - P_efT* is the amount of gross reported precipitation less any surface runoff or deep percolation that resides in the soil and is available for consumption by transpiration. *P_efT* does not include the amount of infiltrated precipitation that evaporates from the surface evaporation layer (upper 100 mm of soil). The *P_efT* parameter is useful in estimating the amount of precipitation that is stored and made available for transpiration requirements. *P_efT* is always less than *P_rz. P_efT* is useful for estimating how 'efficient' precipitation is in fulfilling transpiration requirements of crops, as opposed to simply 'burning off' as evaporation from the soil surface. *P_efT* was calculated as *P_efT* = *P_rz - surface evaporation losses = P – Runoff – DPerc - surface evaporation losses*, where *P_rz* is precipitation infiltrating and residing in the maximum root zone for the crop, *P* is gross reported precipitation, *Runoff* is estimated surface runoff, and *DPerc* is deep percolation of any precipitation below the maximum root zone for the crop or land cover type.

DSn – The *number of growing season days* within the calendar year. *DSn* was computed by summing the *Seasn* flag contained in the daily ETc files over the calendar year.

Statistics Files

Perhaps the most useful results from this study are the statistics describing long-term mean values for ET_c on monthly, growing season, and annual bases, as well as standard deviations and 20% and 80% exceedence values that describe the expected variation of the populations of ET_c. These statistics have been computed for the following lengths of time periods within each month; 3, 7, 15, and 30 days. These period lengths were selected to include expected lengths of irrigation intervals or drying periods that are of interest in irrigation system design and operation. For example, a potato crop may be irrigated each 3 days during the peak month of July, so that users may be interested in reviewing the statistics describing the 3 day periods within the month of July for irrigation systems design. Or, for example, if a crop of alfalfa having a deeper effective root zone is irrigated on average each two weeks during August, then users may be interested in reviewing the statistics describing 15 day periods within the month of August for irrigation systems design.

There are four 'statistics' files per weather station. These files contain statistical summaries for 1) *actual ET*; 2) *potential ET*; 3) *basal ET*; and 4) *precipitation deficit* (i.e., *net irrigation water requirement*). The files have names beginning with the station coop number and ending with '*ETcact_stats.dat*', '*ETcpot_stats.dat*', '*ETcbas_stats.dat*' or '*NIWR_stats.dat*'. For example, in the case of the Fallon Exp station, the four files are named *262780ETcact_stats.dat*, *262780ETcpot_stats.dat*, *262780ETcbas_stats.dat* and *262780NIWR_stats.dat*. The *ETcact* represents actual ET, *ETcpot* represents potential ET, *Etcbas* represents basal ET, and *NIWR* represents the Net Irrigation Water Requirement (i.e. precipitation deficit, *P_def*). All of these terms have been defined under the daily, monthly, annual time series sections above. The *NIWR* is summarized for both growing season and annual time periods. The four files all contain headers comprised of 12 lines containing similar information including the time and date of the original calculation of daily ET and the time and date of the calculation of the statistical summaries. The headers also contain the station latitude and longitude in decimal degrees and station elevation in feet. Each crop or land cover type that was processed for a station is contained in the statistics files, following a single entry for reference ET (in the '*ETcact_stats*' file), for gross precipitation (in the '*ETcpot_stats*' file), or for 30 day average daily mean air temperature (in the '*ETcbas_stats*' file).

The statistics were computed over the most recent 30 years of valid (non-missing) data or over shorter periods if less than 30 years of valid data were available (minimum of 4 years). The span of the 30 year 'normals' are listed for each crop, but may not necessarily contain 30 years depending on the station period of record or number of missing days. The span of the normal periods can change with crop type, depending on the timing of any missing data (inside or outside growing periods). The span of the normal period can also exceed 30 years if some intervening years were omitted due to missing data.

The 30 year normal or shorter periods available were used to generate means and other statistics describing the behavior of the ET data rather than the entire periods of record (i.e. greater than 30 years) for two reasons. One, lengths of station records vary widely from station to station, ranging from as few as 4 years from 2005-2008, to 112 years from 1893-2004. Secondly, trends in air temperature and growing season lengths are apparent, and consequently ET trends exist. Some of these trends are caused by changes in relative dryness of the local or regional environment due to irrigation development or land-use change, by specific station location, or perhaps by change in overall climate. The last 30 years of usable record are considered to be more representative of expected future conditions than prior periods. The full record for each station is preserved in the daily, monthly and annual time series files. Therefore, statistics for the full periods of record can be computed as needed from these series.

For each crop, the following data columns are reported for each month, for the calendar year ('Ann.' row) and for the growing season ('Sea.' row):

Mean (*mean value) - Mean value* for the month and over the 'normal' period of record for the location. *Mean* represents either *ETcact, ETcpot, ETcbas* or *NIWR*, depending on the file. Units are in mm/day for monthly periods and mm/year annual and seasonal periods. The '*nyr*' column represents the number of years that had 'valid' entries for the month and that were included in the mean. Generally, if a full normal period was available, *nyr* = 30. The actual period of record for the station may have been much longer and is preserved in the time series files. Values for means are reported for the monthly, 15, 7, and 3 day averaging periods within each month. In general, these four means are nearly the same, and are reported only for documentation. Means for the 15, 7 and 3 day periods can deviate from those for the entire month because some information near the beginning and end of the month may not have the same weight. This was caused by the requirement that each 3, 7 or 15 day period considered for a month must have all of its member days residing within the month evaluated. For example, for the 15 day statistics, generally 13 to 16 separate 15 day averages were computed and considered for a specific month and year. The member days for the 15-day averages were days 1-15, days 2-16, days 3-17, ……, days 14-28, days 15-29, days 16-30, and days 17-31. Therefore, days nearer to the beginning and end of a period appeared fewer times in the computed means for the month. Thus, some differences in monthly means occurred between the 3, 7, 15 and monthly periods. Differences were generally small.

Stdev (*standard deviation) - Standard devieation* of the variable for the month over the normal period of record. The *Stdev* entry for a particular month was computed using one value (the observation mean) per year for the month. Units are in mm/day for monthly periods and mm for annual and seasonal periods.

Skew (*skew of the distribution of values)* - The *skew* is shown for the variable for each month for the monthly means (only) over the period of record. The skew for a particular month was computed using one value (the observation mean) per year for the month. A value for skew near zero indicates that the underlying distribution approximates a normal (Gaussian) and symmetrical distribution. A skew near 1.0 indicates that the underlying distribution approximates a lognormal distribution. The values for skew, standard deviation and mean can be used to parameterize a variety of probability density functions such as the normal, lognormal, Pearson, and Gamma distributions.

Kurt. (*Kurtosis) - Kurtosis* is a measurement of the 'slenderness' of the underlying distribution; in other words, the 'height to width ratio' of the probability density function. A normal (Gaussian) distribution has a kurtosis of 3. The higher the number, the taller and more slender the distribution is. A high kurtosis indicates that many of the observations in the distribution have very similar values. Kurtosis was calculated for monthly averages only over the normal period.

20%Ex *(20% exceedence)* **-** The *20%Ex* value represents the value for the parameter (actual, potential or basal ET or the precipitation deficit) *that has a 20% chance of being exceeded* that month during any particular year. Conversely, there is an 80% chance that the value of the parameter (for the particular length of averaging period) will be less than the *20%Ex* value. The *20%Ex* value is commonly used in design of capacity for irrigation and water supply systems. Units for *20%Ex* are in mm/day for monthly periods and mm for annual and seasonal periods. The *20%Ex* values were computed assuming a 'distribution free' probability density function. The values were selected by ranking the highest 3-, 7-, 15- or 30-day value within the month for *ETact, ETpot, ETbas* or *NIWR* for each year of the 30 year normal period and selecting the value that was positioned 20% of the way down from the highest value. There were '*nyrs*' values that were ranked (one for each year). In this way, the *20%Ex* value represents that value for the parameter (*ETact, ETpot, ETbas* or *NIWR*) that, when averaged over any 3-, 7-, 15- or 30- day period within the month, would have only a 20% chance of being exceeded at any time during that month for the given year. Thus, if an irrigation system were designed with capacity to provide the *20%Ex* amount of *NIWR* over a 7-day period, for example, the system's 'net' output (less any incidental leakage, spray drift or uniformity 'losses') would exceed the actual precipitation deficit (i.e., the ET less any Prz) 8 years out of 10. During two years out of any 10 year period, the ET less any Prz would exceed the net system capacity during at least one 7 day period during the particular month by some amount. The amount of the exceedence might range from only a millimeter to perhaps 15 to 20 mm over the period.

AveHi *(average hi)* - The *AveHi* parameter complements the *20%Ex* parameter, where *AveHi* represents the average (over the normal period) of the highest value for the parameter within the 3, 7, or 15 day period for each month. Therefore, each month of each year was assigned one 'highest' value for the parameter for the 3, 7 or 15 day averaging length. Then, for each month of the year, the values over the normal period were averaged to obtain *AveHi*. The value for *AveHi* for 3, 7 and 15 day periods is always greater than the average for the month itself (i.e., the mean), since the *AveHi* is the mean of the highest value for the 3, 7, or 15 day period within the month. The value for *AveHi* increases as the length of the averaging period (3, 7 or 15 days) decreases. The same values used to calculate *AveHi* were used in calculating the *20%Ex* value.

80%Ex *(20% exceedence)* **-** The *80%Ex* value represents the *value* for the parameter (actual, potential, basal ET, or the precipitation deficit) *that has an 80% chance of being exceeded* that month during any particular year. Conversely, there is a 20% chance that the value of the parameter (for the particular length of averaging period) will be less than the *80%Ex* value. The *80%Ex* value is commonly used in design of land application systems where water application may need to be limited to amounts that have at least 80% chance of being consumed. Units for *80%Ex* are in mm/day for monthly periods and mm for annual and seasonal periods. The *80%Ex* values were computed assuming a 'distribution free' probability density function. The values were selected by ranking the lowest 3-, 7-, 15- or 30-day value during the month for *ETact, ETpot, ETbas* or *NIWR* for each year and selecting the value that was positioned 80% of the way down from the highest value. There were 'nyrs' values that were ranked (one for each year). In this way, the 80%Ex value represents that value for the parameter (*ETact, ETpot, ETbas* or *NIWR*) that, when averaged over any 3-, 7-, 15- or 30- day period within the month, would have an 80% chance of being exceeded at all times during that month for the given year. Thus, if a land application system were designed with capacity to provide the *80%Ex* amount of *NIWR* over a 7-day period, for example, then the systems 'net' output (less any incidental leakage, spray drift or uniformity 'losses') would exceed the actual precipitation deficit (i.e., the ET less any Prz) during 2 years out of a 10 year period. During eight years out of any 10 year period, the ET less any Prz would exceed the application amount during all 7 day periods during the particular month by some amount. The amount of the exceedence might range from only a millimeter to perhaps 15 to 20 mm.

AveLo *(average low)* **-** The *AveLo* parameter complements the *80%Ex* parameter, where *AveLo* represents the average (over the normal period) of the lowest value for the parameter within the 3, 7, or 15 day period for each month. Therefore, each month of each year was assigned one 'lowest' value for the parameter for the 3, 7 or 15 day averaging length. Then, for each month of the year, the values over the normal period were averaged to obtain *AveLo*. The value for *AveLo* for 3, 7 and 15 day periods is always less than the average for the month itself (i.e., the 'mean'), since the *AveLo* is the mean of the lowest value for the 3, 7, or 15 day period within the month. The value for *AveLo* decreases as the length of the averaging period (3, 7 or 15 days) decreases. The same values used to calculate *AveLo* were used in calculating the *80%Ex* value. On an annual or growing season basis, the mean, *20%Ex* and *80%Ex* values are computed only for annual or growing season totals and represent the distribution of annual or growing season values (rather than for specific months).

Appendix 10. Crop or land cover class simulated for each station (1 = yes, 0 = no).

Station Name	Station Number	Alfalfa Hay	Grass Hay	Snap and Dry Beans - fresh	Snap and Dry Beans - seed	Field Corn	Silage Corn	Sweet Corn-- early	Sweet Corn-- late	Spring Grain - irrigated	Winter Grain - irrigated
ADAVEN	260046	1	1								
ALAMO	260099	1	1			1	1	1	1	1	1
AMARGOSA FARMS-GAREY	260150	1	1			1	1	1	1	1	1
ANTELOPE VALLEY FARR	260282	1	1								
ARTHUR 4 NW	260438	1	1			1	1	1	1	1	1
AUSTIN #2	260507	1	1								
BASALT	260668	1	1								
BATTLE MTN	260688	1	1			1	1	1	1	1	1
BATTLE MTN AP	260691	1	1			1	1	1	1	1	1
BEATTY	260715	1	1			1	1	1	1	1	1
BEATTY 8 N	260718	1	1			1	1	1	1	1	1
BEOWAWE	260795	1	1								
BEOWAWE U OF N RCH	260800	1	1								
BLUE EAGLE RCH HANKS	260955	1	1								
BLUE JAY HWY STN	260961	1	1								
BOULDER CITY	261071	1	1			1	1	1	1	1	1
BRINKERHOFF RCH	261160	1	1								
BUFFALO RCH	261311	1	1								
BUNKERVILLE	261327	1	1			1	1	1	1	1	1
CALIENTE	261358	1	1			1	1	1	1	1	1
CALLVILLE BAY	261371	1	1								
CARLIN NEWMONT MINE	261415	1	1								
CARSON CITY	261485	1	1								
CATHEDRAL GORGE SP	261590	1	1			1	1	1	1	1	1
CENTRAL NEVADA FLD LAB	261630	1	1			1	1	1	1	1	1
CHARLESTON	261660	1	1								
CLOVER VALLEY	261740	1	1			1	1	1	1	1	1
COALDALE JUNCTION	261755	1	1								
CONTACT	261905	1	1								
CORTEZ GOLD MINE	261975	1	1								
CURRANT	262078	1	1			1	1	1	1	1	1
CURRANT HWY STN	262091	1	1								
CURRIE HWY STN	262096	1	1								
DAGGET PASS	262119	1	1								
DENIO	262229	1	1			1	1	1	1	1	1
DESERT NWR	262243	1	1								
DIABLO	262276	1	1								
DIAMOND VALLEY USDA	262296	1	1			1	1	1	1	1	1
DUCKWATER	262390	1	1			1	1	1	1	1	1
DUFURRENA	262394	1	1								
DYER	262431	1	1			1	1	1	1	1	1
EASTGATE	262477	1	1								
ECHO BAY	262497	1	1								
ELGIN	262557	1	1			1	1	1	1	1	1
ELGIN 3 SE	262562	1	1			1	1	1	1	1	1

Appendix 10 cont. Crop or land cover class simulated for each station (1 = yes, 0 = no).

Station Name	Station Number	Alfalfa Hay	Grass Hay	Snap and Dry Beans - fresh	Snap and Dry Beans - seed	Field Corn	Silage Corn	Sweet Corn-- early	Sweet Corn-- late	Spring Grain - irrigated	Winter Grain - irrigated
ELKO	262570	1	1			1	1	1	1	1	1
ELKO RGNL AP	262573	1	1			1	1	1	1	1	1
ELY 6 NE	262626	1	1			1	1	1	1	1	1
ELY YELLAND FLD AP	262631	1	1			1	1	1	1	1	1
EMIGRANT PASS HWY STN	262656	1	1								
EMPIRE	262662	1	1			1	1	1	1	1	1
EUREKA	262708	1	1								
FALLON EXP STN	262780	1	1	1	1	1	1	1	1	1	1
FERGUSON SPRINGS HMS	262820	1	1								
FERNLEY	262840	1	1	1	1	1	1	1	1	1	1
FISH CREEK RCH	262860	1	1			1	1	1	1	1	1
GERLACH	263090	1	1			1	1	1	1	1	1
GEYSER RCH	263101	1	1			1	1	1	1	1	1
GIBBS RCH	263114	1	1								
GLENBROOK	263205	1	1								
GOLCONDA	263245	1	1								
GOLDFIELD	263285	1	1								
GOODSPRINGS	263316	1	1								
GREAT BASIN NP	263340	1	1								
HAWTHORNE	263512	1	1								
HAWTHORNE AP	263515	1	1								
HIKO	263671	1	1			1	1	1	1	1	1
HUMBOLDT FLD	263853	1	1								
I-L RCH	263940	1	1								
IMLAY	263957	1	1								
INDIAN SPRINGS	263980	1	1								
JACKPOT	264016	1	1								
JARBRIDGE 4 N	264038	1	1								
JARBIDGE 7 N	264039	1	1								
JIGGS 8 SSE ZAGA	264095	1	1								
JUNGO MEYER RCH	264108	1	1								
KIMBERLY	264199	1	1								
KNOLL CREEK FLD STN	264268	1	1								
KYLE CANYON RS	264314	1	1								
LAGES	264341	1	1								
LAHONTAN DAM	264349	1	1								
LAKE VALLEY STEWARD	264384	1	1								
LAMOILLE YOST	264394	1	1			1	1	1	1	1	1
LAMOILLE PH	264395	1	1			1	1	1	1	1	1
LAS VEGAS	264429	1	1			1	1	1	1	1	1
LAS VEGAS WB AP	264436	1	1			1	1	1	1	1	1
LAS VEGAS NWFO	264439	1	1			1	1	1	1	1	1
LATHROP WELLS	264457	1	1			1	1	1	1	1	1
LAUGHLIN	264480	1	1			1	1	1	1	1	1
LEHMAN CAVES NM	264514	1	1			1	1	1	1	1	1
LEONARD CREEK RCH	264527	1	1			1	1	1	1	1	1
LEWERS RCH	264542	1	1								
LITTLE RED ROCK	264600	1	1								

Appendix 10 cont. Crop or land cover class simulated for each station (1 = yes, 0 = no).

Station Name	Station Number	Alfalfa Hay	Grass Hay	Snap and Dry Beans - fresh	Snap and Dry Beans - seed	Field Corn	Silage Corn	Sweet Corn-- early	Sweet Corn-- late	Spring Grain - irrigated	Winter Grain - irrigated
LOGANDALE	264651	1	1	1	1	1	1	1	1	1	1
LOVELOCK DERBY FLD	264700	1	1	1	1	1	1	1	1	1	1
LUND	264745	1	1			1	1	1	1	1	1
MALA VISTA RCH	264824	1	1			1	1	1	1	1	1
MARLETTE LAKE	264858	1	1								
MCDERMITT	264935	1	1			1	1	1	1	1	1
MCGILL	264950	1	1			1	1	1	1	1	1
MESQUITE	265085	1	1			1	1	1	1	1	1
METROPOLIS	265092	1	1			1	1	1	1	1	1
MIDAS 4 SE	265105	1	1								
MIDDLEGATE-LOWERY	265132	1	1								
MINA	265168	1	1								
MINDEN	265191	1	1			1	1	1	1	1	1
MONTELLO 2 SE	265352	1	1			1	1	1	1	1	1
MONTGOMERY MNTC STN	265362	1	1								
MOORMAN RCH	265371	1	1								
MTN CITY RS	265392	1	1								
MT CHARLESTON FS	265400	1	1								
MT ROSE BOWL	265440	1	1								
NIXON	265605	1	1			1	1	1	1	1	1
NORTH LAS VEGAS	265705	1	1			1	1	1	1	1	1
OASIS	265722	1	1								
OLD RUTH	265760	1	1								
OROVADA 3 W	265818	1	1	1	1	1	1	1	1	1	1
OVERTON	265846	1	1	1	1	1	1	1	1	1	1
OWYHEE	265869	1	1			1	1	1	1	1	1
PAHRANAGAT WR	265880	1	1			1	1	1	1	1	1
PAHRUMP	265890	1	1			1	1	1	1	1	1
PAHUTE MEADOWS RCH	265907	1	1								
PALMETTO	265931	1	1								
PARADISE VALLEY 1 NW	266005	1	1			1	1	1	1	1	1
PARIS RCH	266055	1	1								
PENOYER VALLEY	266130	1	1								
PEQUOP	266148	1	1								
PILOT VALLEY-LEE	266228	1	1								
PINE VALLEY BAILEY RCH	266242	1	1			1	1	1	1	1	1
PIOCHE	266252	1	1			1	1	1	1	1	1
QUINN RVR CROSSING	266504	1	1			1	1	1	1	1	1
RAND RCH PALISADE	266574	1	1			1	1	1	1	1	1
RATTLESNAKE	266630	1	1								
RED ROCK CANYON SP	266691	1	1								
REESE RIVER	266746	1	1			1	1	1	1	1	1
REESE VALLEY CARPER	266748	1	1								
RENO TAHOE INTL AP	266779	1	1			1	1	1	1	1	1
RENO WFO	266791	1	1			1	1	1	1	1	1
RUBY LAKE	267123	1	1			1	1	1	1	1	1
RUTH	267175	1	1								
RYNDON	267188	1	1			1	1	1	1	1	1

Appendix 10 cont. Crop or land cover class simulated for each station (1 = yes, 0 = no).

Station Name	Station Number	Alfalfa Hay	Grass Hay	Snap and Dry Beans - fresh	Snap and Dry Beans - seed	Field Corn	Silage Corn	Sweet Corn--early	Sweet Corn--late	Spring Grain - irrigated	Winter Grain - irrigated
RYE PATCH DAM	267192	1	1								
SAND PASS	267261	1	1								
SAN JACINTO	267284	1	1								
SARCOBATUS	267319	1	1								
SAVAL RCH	267324	1	1								
SCHURZ	267358	1	1								
SEARCHLIGHT	267369	1	1								
SEVENTY ONE RCH	267397	1	1			1	1	1	1	1	1
SHELDON	267443	1	1								
SHOSHONE 5 N	267450	1	1								
SILVERPEAK	267463	1	1								
SMITH 1 N	267609	1	1			1	1	1	1	1	1
SMITH 6 N	267612	1	1			1	1	1	1	1	1
SMOKE CREEK ESPIL	267618	1	1								
SMOKEY VALLEY	267620	1	1			1	1	1	1	1	1
SNOWBALL RCH	267640	1	1								
SOUTH FORK SP	267690	1	1			1	1	1	1	1	1
SPRING VALLEY SP	267750	1	1								
STATELINE-HARRAH'S	267806	1	1								
STEAD	267820	1	1			1	1	1	1	1	1
SULPHUR	267873	1	1								
SUNNYSIDE	267908	1	1								
SUTCLIFFE	267953	1	1								
TEMPIUTE 4 NW	267983	1	1								
THORNE	268034	1	1								
TONOPAH	268170	1	1			1	1	1	1	1	1
TOPAZ LAKE 3N	268186	1	1			1	1	1	1	1	1
TOPAZ LAKE 4 N	268202	1	1			1	1	1	1	1	1
TUSCARORA	268346	1	1								
TWIN SPRING FALLINI	268443	1	1								
UNIV OF NEVADA EXP FM	268500	1	1			1	1	1	1	1	1
URSINE	268538	1	1								
VALLEY OF FIRE SP	268588	1	1								
VIRGINIA CITY	268761	1	1			1	1	1	1	1	1
VYA	268810	1	1								
WABUSKA 6 SE	268822	1	1			1	1	1	1	1	1
WADSWORTH	268834	1	1			1	1	1	1	1	1
WADSWORTH 4 N	268838	1	1								
WELLINGTON RS	268977	1	1			1	1	1	1	1	1
WELLS	268988	1	1			1	1	1	1	1	1
WILDHORSE RSVR	269072	1	1								
WILKINS	269122	1	1								
WILLOW SPRINGS	269137	1	1								
WINNEMUCCA #2	269168	1	1			1	1	1	1	1	1
WINNEMUCCA MUNI AP	269171	1	1			1	1	1	1	1	1
YERINGTON	269229	1	1			1	1	1	1	1	1
LAS VEGAS	23112	1	1			1	1	1	1	1	1
RED ROCK WC	29999	1	1			1	1	1	1	1	1
WASHOE VALLEY WC	39999	1	1			1	1	1	1	1	1

Appendix 10 cont. Crop or land cover class simulated for each station (1 = yes, 0 = no).

Station Name	Station Number	Grass Pasture - high management	Grass Pasture - low management	Grass - Turf	Orchards - Apples and Cherries w/ground cover	Orchards - Apples and Cherries w/no ground cover	Garden Vegetables - general	Onions	Melons
ADAVEN	260046	1	1	1					
ALAMO	260099	1	1	1	1	1	1	1	
AMARGOSA FARMS-GAREY	260150	1	1	1	1	1	1	1	
ANTELOPE VALLEY FARR	260282	1	1	1					
ARTHUR 4 NW	260438	1	1	1	1	1			
AUSTIN #2	260507	1	1	1					
BASALT	260668	1	1	1					
BATTLE MTN	260688	1	1	1	1	1	1	1	
BATTLE MTN AP	260691	1	1	1	1	1	1	1	
BEATTY	260715	1	1	1	1	1	1	1	
BEATTY 8 N	260718	1	1	1	1	1	1	1	
BEOWAWE	260795	1	1	1					
BEOWAWE U OF N RCH	260800	1	1	1					
BLUE EAGLE RCH HANKS	260955	1	1	1					
BLUE JAY HWY STN	260961	1	1	1					
BOULDER CITY	261071	1	1	1	1	1	1		
BRINKERHOFF RCH	261160	1	1	1					
BUFFALO RCH	261311	1	1	1					
BUNKERVILLE	261327	1	1	1	1	1	1	1	
CALIENTE	261358	1	1	1	1	1	1	1	
CALLVILLE BAY	261371	1	1	1					
CARLIN NEWMONT MINE	261415	1	1	1					
CARSON CITY	261485	1	1	1					
CATHEDRAL GORGE SP	261590	1	1	1	1	1	1	1	
CENTRAL NEVADA FLD LAB	261630	1	1	1	1	1	1		
CHARLESTON	261660	1	1	1					
CLOVER VALLEY	261740	1	1	1	1	1	1		
COALDALE JUNCTION	261755	1	1	1					
CONTACT	261905	1	1	1					
CORTEZ GOLD MINE	261975	1	1	1					
CURRANT	262078	1	1	1	1	1	1	1	
CURRANT HWY STN	262091	1	1	1					
CURRIE HWY STN	262096	1	1	1					
DAGGET PASS	262119	1	1	1					
DENIO	262229	1	1	1	1	1	1	1	
DESERT NWR	262243	1	1	1					
DIABLO	262276	1	1	1					
DIAMOND VALLEY USDA	262296	1	1	1	1	1	1		
DUCKWATER	262390	1	1	1	1	1	1	1	
DUFURRENA	262394	1	1	1					
DYER	262431	1	1	1	1	1	1	1	
EASTGATE	262477	1	1	1					
ECHO BAY	262497	1	1	1					
ELGIN	262557	1	1	1	1	1	1	1	
ELGIN 3 SE	262562	1	1	1	1	1	1	1	
ELKO	262570	1	1	1	1	1	1		

Appendix 10 cont. Crop or land cover class simulated for each station (1 = yes, 0 = no).

Station Name	Station Number	Grass Pasture - high management	Grass Pasture - low management	Grass - Turf	Orchards - Apples and Cherries w/ground cover	Orchards - Apples and Cherries w/no ground cover	Garden Vegetables - general	Onions	Melons
ELKO RGNL AP	262573	1	1	1	1	1	1		
ELY 6 NE	262626	1	1	1	1	1	1		
ELY YELLAND FLD AP	262631	1	1	1	1	1	1		
EMIGRANT PASS HWY STN	262656	1	1	1					
EMPIRE	262662	1	1	1	1	1	1	1	
EUREKA	262708	1	1	1					
FALLON EXP STN	262780	1	1	1	1	1	1	1	1
FERGUSON SPRINGS HMS	262820	1	1	1					
FERNLEY	262840	1	1	1	1	1	1	1	1
FISH CREEK RCH	262860	1	1	1	1	1	1		
GERLACH	263090	1	1	1	1	1	1	1	
GEYSER RCH	263101	1	1	1	1	1	1	1	
GIBBS RCH	263114	1	1	1					
GLENBROOK	263205	1	1	1					
GOLCONDA	263245	1	1	1					
GOLDFIELD	263285	1	1	1					
GOODSPRINGS	263316	1	1	1					
GREAT BASIN NP	263340	1	1	1					
HAWTHORNE	263512	1	1	1					
HAWTHORNE AP	263515	1	1	1					
HIKO	263671	1	1	1	1	1	1	1	
HUMBOLDT FLD	263853	1	1	1					
I-L RCH	263940	1	1	1					
IMLAY	263957	1	1	1					
INDIAN SPRINGS	263980	1	1	1					
JACKPOT	264016	1	1	1					
JARBRIDGE 4 N	264038	1	1	1					
JARBIDGE 7 N	264039	1	1	1					
JIGGS 8 SSE ZAGA	264095	1	1	1					
JUNGO MEYER RCH	264108	1	1	1					
KIMBERLY	264199	1	1	1					
KNOLL CREEK FLD STN	264268	1	1	1					
KYLE CANYON RS	264314	1	1	1					
LAGES	264341	1	1	1					
LAHONTAN DAM	264349	1	1	1					
LAKE VALLEY STEWARD	264384	1	1	1					
LAMOILLE YOST	264394	1	1	1	1	1			
LAMOILLE PH	264395	1	1	1	1	1			
LAS VEGAS	264429	1	1	1	1	1	1		
LAS VEGAS WB AP	264436	1	1	1	1	1	1		
LAS VEGAS NWFO	264439	1	1	1	1	1	1		
LATHROP WELLS	264457	1	1	1	1	1	1	1	
LAUGHLIN	264480	1	1	1	1	1	1		
LEHMAN CAVES NM	264514	1	1	1	1	1	1		
LEONARD CREEK RCH	264527	1	1	1	1	1	1	1	
LEWERS RCH	264542	1	1	1					
LITTLE RED ROCK	264600	1	1	1					
LOGANDALE	264651	1	1	1	1	1	1	1	

Appendix 10 cont. Crop or land cover class simulated for each station (1 = yes, 0 = no).

Station Name	Station Number	Grass Pasture - high management	Grass Pasture - low management	Grass - Turf	Orchards - Apples and Cherries w/ground cover	Orchards - Apples and Cherries w/no ground cover	Garden Vegetables - general	Onions	Melons
LOVELOCK DERBY FLD	264700	1	1	1	1	1	1	1	
LUND	264745	1	1	1	1	1	1	1	
MALA VISTA RCH	264824	1	1	1	1	1	1	1	
MARLETTE LAKE	264858	1	1	1					
MCDERMITT	264935	1	1	1	1	1	1	1	
MCGILL	264950	1	1	1	1	1	1	1	
MESQUITE	265085	1	1	1	1	1	1	1	
METROPOLIS	265092	1	1	1	1	1	1	1	
MIDAS 4 SE	265105	1	1	1					
MIDDLEGATE-LOWERY	265132	1	1	1					
MINA	265168	1	1	1					
MINDEN	265191	1	1	1	1	1	1	1	
MONTELLO 2 SE	265352	1	1	1	1	1	1	1	
MONTGOMERY MNTC STN	265362	1	1	1					
MOORMAN RCH	265371	1	1	1					
MTN CITY RS	265392	1	1	1					
MT CHARLESTON FS	265400	1	1	1					
MT ROSE BOWL	265440	1	1	1					
NIXON	265605	1	1	1	1	1	1	1	
NORTH LAS VEGAS	265705	1	1	1	1	1	1		
OASIS	265722	1	1	1					
OLD RUTH	265760	1	1	1					
OROVADA 3 W	265818	1	1	1	1	1	1	1	
OVERTON	265846	1	1	1	1	1	1	1	1
OWYHEE	265869	1	1	1	1	1	1		
PAHRANAGAT WR	265880	1	1	1	1	1	1	1	
PAHRUMP	265890	1	1	1	1	1	1	1	
PAHUTE MEADOWS RCH	265907	1	1	1					
PALMETTO	265931	1	1	1					
PARADISE VALLEY 1 NW	266005	1	1	1	1	1	1	1	
PARIS RCH	266055	1	1	1					
PENOYER VALLEY	266130	1	1	1					
PEQUOP	266148	1	1	1					
PILOT VALLEY-LEE	266228	1	1	1					
PINE VALLEY BAILEY RCH	266242	1	1	1	1	1	1		
PIOCHE	266252	1	1	1	1	1	1	1	
QUINN RVR CROSSING	266504	1	1	1	1	1	1	1	
RAND RCH PALISADE	266574	1	1	1	1	1	1	1	
RATTLESNAKE	266630	1	1	1					
RED ROCK CANYON SP	266691	1	1	1					
REESE RIVER	266746	1	1	1	1	1	1	1	
REESE VALLEY CARPER	266748	1	1	1					
RENO TAHOE INTL AP	266779	1	1	1	1	1	1	1	
RENO WFO	266791	1	1	1	1	1	1	1	
RUBY LAKE	267123	1	1	1	1	1	1		
RUTH	267175	1	1	1					
RYNDON	267188	1	1	1	1	1	1	1	
RYE PATCH DAM	267192	1	1	1					

Appendix 10 cont. Crop or land cover class simulated for each station (1 = yes, 0 = no).

Station Name	Station Number	Grass Pasture - high management	Grass Pasture - low management	Grass - Turf	Orchards - Apples and Cherries w/ground cover	Orchards - Apples and Cherries w/no ground cover	Garden Vegetables - general	Onions	Melons
SAND PASS	267261	1	1	1					
SAN JACINTO	267284	1	1	1					
SARCOBATUS	267319	1	1	1					
SAVAL RCH	267324	1	1	1					
SCHURZ	267358	1	1	1					
SEARCHLIGHT	267369	1	1	1					
SEVENTY ONE RCH	267397	1	1	1	1	1			
SHELDON	267443	1	1	1					
SHOSHONE 5 N	267450	1	1	1					
SILVERPEAK	267463	1	1	1					
SMITH 1 N	267609	1	1	1	1	1	1	1	
SMITH 6 N	267612	1	1	1	1	1	1	1	
SMOKE CREEK ESPIL	267618	1	1	1					
SMOKEY VALLEY	267620	1	1	1	1	1	1		
SNOWBALL RCH	267640	1	1	1					
SOUTH FORK SP	267690	1	1	1	1	1	1	1	
SPRING VALLEY SP	267750	1	1	1					
STATELINE-HARRAH'S	267806	1	1	1					
STEAD	267820	1	1	1	1	1	1		
SULPHUR	267873	1	1	1					
SUNNYSIDE	267908	1	1	1					
SUTCLIFFE	267953	1	1	1					
TEMPIUTE 4 NW	267983	1	1	1					
THORNE	268034	1	1	1					
TONOPAH	268170	1	1	1	1	1	1	1	
TOPAZ LAKE 3N	268186	1	1	1	1	1	1	1	
TOPAZ LAKE 4 N	268202	1	1	1	1	1	1	1	
TUSCARORA	268346	1	1	1					
TWIN SPRING FALLINI	268443	1	1	1					
UNIV OF NEVADA EXP FM	268500	1	1	1	1	1	1	1	
URSINE	268538	1	1	1					
VALLEY OF FIRE SP	268588	1	1	1					
VIRGINIA CITY	268761	1	1	1	1	1	1	1	
VYA	268810	1	1	1					
WABUSKA 6 SE	268822	1	1	1	1	1	1	1	
WADSWORTH	268834	1	1	1	1	1	1	1	
WADSWORTH 4 N	268838	1	1	1					
WELLINGTON RS	268977	1	1	1	1	1	1	1	
WELLS	268988	1	1	1	1	1			
WILDHORSE RSVR	269072	1	1	1					
WILKINS	269122	1	1	1					
WILLOW SPRINGS	269137	1	1	1					
WINNEMUCCA #2	269168	1	1	1	1	1	1		
WINNEMUCCA MUNI AP	269171	1	1	1	1	1	1		
YERINGTON	269229	1	1	1	1	1	1	1	
LAS VEGAS	23112	1	1	1	1	1	1		
RED ROCK WC	29999	1	1	1	1	1	1		
WASHOE VALLEY WC	39999	1	1	1	1	1	1		

Appendix 10 cont. Crop or land cover class simulated for each station (1 = yes, 0 = no).

Station Name	Station Number	Grapes--wine	Alfalfa Seed	Peas--fresh	Peas--seed	Potatoes--processing (early harvest)	Potatoes--cold pack (late harvest)	Sugar beets	Hops
ADAVEN	260046								
ALAMO	260099		1			1	1	1	
AMARGOSA FARMS-GAREY	260150		1			1	1	1	
ANTELOPE VALLEY FARR	260282								
ARTHUR 4 NW	260438		1						
AUSTIN #2	260507								
BASALT	260668								
BATTLE MTN	260688		1			1	1		
BATTLE MTN AP	260691		1			1	1		
BEATTY	260715		1			1	1	1	
BEATTY 8 N	260718		1			1	1	1	
BEOWAWE	260795								
BEOWAWE U OF N RCH	260800								
BLUE EAGLE RCH HANKS	260955								
BLUE JAY HWY STN	260961								
BOULDER CITY	261071		1						
BRINKERHOFF RCH	261160								
BUFFALO RCH	261311								
BUNKERVILLE	261327		1			1	1	1	
CALIENTE	261358		1			1	1	1	
CALLVILLE BAY	261371								
CARLIN NEWMONT MINE	261415								
CARSON CITY	261485								
CATHEDRAL GORGE SP	261590		1			1	1	1	
CENTRAL NEVADA FLD LAB	261630		1						
CHARLESTON	261660								
CLOVER VALLEY	261740		1						
COALDALE JUNCTION	261755								
CONTACT	261905								
CORTEZ GOLD MINE	261975								
CURRANT	262078		1			1	1	1	
CURRANT HWY STN	262091								
CURRIE HWY STN	262096								
DAGGET PASS	262119								
DENIO	262229		1			1	1	1	
DESERT NWR	262243								
DIABLO	262276								
DIAMOND VALLEY USDA	262296		1						
DUCKWATER	262390		1			1	1	1	
DUFURRENA	262394								
DYER	262431		1			1	1	1	
EASTGATE	262477								
ECHO BAY	262497								
ELGIN	262557		1			1	1	1	
ELGIN 3 SE	262562		1			1	1	1	

Appendix 10 cont. Crop or land cover class simulated for each station (1 = yes, 0 = no).

Station Name	Station Number	Grapes--wine	Alfalfa Seed	Peas--fresh	Peas--seed	Potatoes--processing (early harvest)	Potatoes--cold pack (late harvest)	Sugar beets	Hops
ELKO	262570		1						
ELKO RGNL AP	262573		1						
ELY 6 NE	262626		1						
ELY YELLAND FLD AP	262631		1						
EMIGRANT PASS HWY STN	262656								
EMPIRE	262662		1			1	1	1	
EUREKA	262708								
FALLON EXP STN	262780	1	1	1	1	1	1	1	
FERGUSON SPRINGS HMS	262820								
FERNLEY	262840	1	1	1	1	1	1	1	
FISH CREEK RCH	262860		1						
GERLACH	263090		1			1	1	1	
GEYSER RCH	263101		1			1	1	1	
GIBBS RCH	263114								
GLENBROOK	263205								
GOLCONDA	263245								
GOLDFIELD	263285								
GOODSPRINGS	263316								
GREAT BASIN NP	263340								
HAWTHORNE	263512								
HAWTHORNE AP	263515								
HIKO	263671		1			1	1	1	
HUMBOLDT FLD	263853								
I-L RCH	263940								
IMLAY	263957								
INDIAN SPRINGS	263980								
JACKPOT	264016								
JARBRIDGE 4 N	264038								
JARBIDGE 7 N	264039								
JIGGS 8 SSE ZAGA	264095								
JUNGO MEYER RCH	264108								
KIMBERLY	264199								
KNOLL CREEK FLD STN	264268								
KYLE CANYON RS	264314								
LAGES	264341								
LAHONTAN DAM	264349								
LAKE VALLEY STEWARD	264384								
LAMOILLE YOST	264394		1						
LAMOILLE PH	264395		1						
LAS VEGAS	264429		1						
LAS VEGAS WB AP	264436		1						
LAS VEGAS NWFO	264439		1						
LATHROP WELLS	264457		1						
LAUGHLIN	264480		1						
LEHMAN CAVES NM	264514		1			1	1		
LEONARD CREEK RCH	264527		1			1	1	1	
LEWERS RCH	264542								
LITTLE RED ROCK	264600								

Appendix 10 cont. Crop or land cover class simulated for each station (1 = yes, 0 = no).

Station Name	Station Number	Grapes--wine	Alfalfa Seed	Peas--fresh	Peas--seed	Potatoes--processing (early harvest)	Potatoes--cold pack (late harvest)	Sugar beets	Hops
LOGANDALE	264651	1	1	1	1	1	1	1	1
LOVELOCK DERBY FLD	264700	1	1	1	1	1	1	1	1
LUND	264745		1			1	1	1	1
MALA VISTA RCH	264824		1			1	1	1	
MARLETTE LAKE	264858								
MCDERMITT	264935		1			1	1	1	1
MCGILL	264950		1			1	1	1	1
MESQUITE	265085		1			1	1	1	
METROPOLIS	265092		1			1	1	1	
MIDAS 4 SE	265105								
MIDDLEGATE-LOWERY	265132								
MINA	265168								
MINDEN	265191		1			1	1	1	1
MONTELLO 2 SE	265352		1			1	1	1	1
MONTGOMERY MNTC STN	265362								
MOORMAN RCH	265371								
MTN CITY RS	265392								
MT CHARLESTON FS	265400								
MT ROSE BOWL	265440								
NIXON	265605		1			1	1	1	1
NORTH LAS VEGAS	265705		1						
OASIS	265722								
OLD RUTH	265760								
OROVADA 3 W	265818		1	1	1	1	1	1	1
OVERTON	265846	1	1	1	1	1	1	1	1
OWYHEE	265869		1						1
PAHRANAGAT WR	265880		1			1	1	1	
PAHRUMP	265890		1			1	1	1	1
PAHUTE MEADOWS RCH	265907								
PALMETTO	265931								
PARADISE VALLEY 1 NW	266005		1			1	1	1	1
PARIS RCH	266055								
PENOYER VALLEY	266130								
PEQUOP	266148								
PILOT VALLEY-LEE	266228								
PINE VALLEY BAILEY RCH	266242		1						
PIOCHE	266252		1			1	1	1	
QUINN RVR CROSSING	266504		1			1	1	1	
RAND RCH PALISADE	266574		1			1	1	1	
RATTLESNAKE	266630								
RED ROCK CANYON SP	266691								
REESE RIVER	266746		1			1	1	1	
REESE VALLEY CARPER	266748								
RENO TAHOE INTL AP	266779	1	1			1	1		
RENO WFO	266791	1	1			1	1		
RUBY LAKE	267123		1						
RUTH	267175								
RYNDON	267188		1			1	1	1	

Appendix 10 cont. Crop or land cover class simulated for each station (1 = yes, 0 = no).

Station Name	Station Number	Grapes--wine	Alfalfa Seed	Peas--fresh	Peas--seed	Potatoes--processing (early harvest)	Potatoes--cold pack (late harvest)	Sugar beets	Hops
RYE PATCH DAM	267192								
SAND PASS	267261								
SAN JACINTO	267284								
SARCOBATUS	267319								
SAVAL RCH	267324								
SCHURZ	267358								
SEARCHLIGHT	267369								
SEVENTY ONE RCH	267397		1						
SHELDON	267443								
SHOSHONE 5 N	267450								
SILVERPEAK	267463								
SMITH 1 N	267609	1	1			1	1		
SMITH 6 N	267612	1	1			1	1		
SMOKE CREEK ESPIL	267618								
SMOKEY VALLEY	267620		1						
SNOWBALL RCH	267640								
SOUTH FORK SP	267690		1			1	1	1	
SPRING VALLEY SP	267750								
STATELINE-HARRAH'S	267806								
STEAD	267820		1						
SULPHUR	267873								
SUNNYSIDE	267908								
SUTCLIFFE	267953								
TEMPIUTE 4 NW	267983								
THORNE	268034								
TONOPAH	268170		1			1	1		
TOPAZ LAKE 3N	268186		1			1	1		
TOPAZ LAKE 4 N	268202		1			1	1		
TUSCARORA	268346								
TWIN SPRING FALLINI	268443								
UNIV OF NEVADA EXP FM	268500		1			1	1		
URSINE	268538								
VALLEY OF FIRE SP	268588								
VIRGINIA CITY	268761		1			1	1		
VYA	268810								
WABUSKA 6 SE	268822		1			1	1		
WADSWORTH	268834		1			1	1		
WADSWORTH 4 N	268838								
WELLINGTON RS	268977		1			1	1		
WELLS	268988		1						
WILDHORSE RSVR	269072								
WILKINS	269122								
WILLOW SPRINGS	269137								
WINNEMUCCA #2	269168		1			1	1		
WINNEMUCCA MUNI AP	269171		1			1	1		
YERINGTON	269229		1			1	1		
LAS VEGAS	23112		1						
RED ROCK WC	29999		1			1	1		
WASHOE VALLEY WC	39999		1			1	1		

Appendix 10 cont. Crop or land cover class simulated for each station (1 = yes, 0 = no).

Station Name	Station Number	Sunflower -irrigated	Safflower -irrigated	Canola	Garlic	Bare soil	Mulched soil, including wheat stubble	Dormant turf (winter time)	Open water - shallow systems/ponds
ADAVEN	260046					1	1	1	1
ALAMO	260099	1	1	1	1	1	1	1	1
AMARGOSA FARMS-GAREY	260150	1	1	1		1	1	1	1
ANTELOPE VALLEY FARR	260282					1	1	1	1
ARTHUR 4 NW	260438					1	1	1	1
AUSTIN #2	260507					1	1	1	1
BASALT	260668					1	1	1	1
BATTLE MTN	260688					1	1	1	1
BATTLE MTN AP	260691					1	1	1	1
BEATTY	260715	1	1	1	1	1	1	1	1
BEATTY 8 N	260718	1	1	1	1	1	1	1	1
BEOWAWE	260795					1	1	1	1
BEOWAWE U OF N RCH	260800					1	1	1	1
BLUE EAGLE RCH HANKS	260955					1	1	1	1
BLUE JAY HWY STN	260961					1	1	1	1
BOULDER CITY	261071	1	1	1		1	1	1	1
BRINKERHOFF RCH	261160					1	1	1	1
BUFFALO RCH	261311					1	1	1	1
BUNKERVILLE	261327	1	1	1	1	1	1	1	1
CALIENTE	261358	1	1	1	1	1	1	1	1
CALLVILLE BAY	261371					1	1	1	1
CARLIN NEWMONT MINE	261415					1	1	1	1
CARSON CITY	261485					1	1	1	1
CATHEDRAL GORGE SP	261590	1	1	1		1	1	1	1
CENTRAL NEVADA FLD LAB	261630					1	1	1	1
CHARLESTON	261660					1	1	1	1
CLOVER VALLEY	261740					1	1	1	1
COALDALE JUNCTION	261755					1	1	1	1
CONTACT	261905					1	1	1	1
CORTEZ GOLD MINE	261975					1	1	1	1
CURRANT	262078	1	1	1		1	1	1	1
CURRANT HWY STN	262091					1	1	1	1
CURRIE HWY STN	262096					1	1	1	1
DAGGET PASS	262119					1	1	1	1
DENIO	262229	1	1	1	1	1	1	1	1
DESERT NWR	262243					1	1	1	1
DIABLO	262276					1	1	1	1
DIAMOND VALLEY USDA	262296					1	1	1	1
DUCKWATER	262390	1	1	1	1	1	1	1	1
DUFURRENA	262394					1	1	1	1
DYER	262431	1	1	1	1	1	1	1	1
EASTGATE	262477					1	1	1	1
ECHO BAY	262497					1	1	1	1
ELGIN	262557	1	1	1	1	1	1	1	1

Appendix 10 cont. Crop or land cover class simulated for each station (1 = yes, 0 = no).

Station Name	Station Number	Sunflower -irrigated	Safflower -irrigated	Canola	Garlic	Bare soil	Mulched soil, including wheat stubble	Dormant turf (winter time)	Open water - shallow systems/ponds
ELGIN 3 SE	262562	1	1	1	1	1	1	1	1
ELKO	262570					1	1	1	1
ELKO RGNL AP	262573					1	1	1	1
ELY 6 NE	262626					1	1	1	1
ELY YELLAND FLD AP	262631					1	1	1	1
EMIGRANT PASS HWY STN	262656					1	1	1	1
EMPIRE	262662	1	1	1	1	1	1	1	1
EUREKA	262708					1	1	1	1
FALLON EXP STN	262780	1	1	1	1	1	1	1	1
FERGUSON SPRINGS HMS	262820					1	1	1	1
FERNLEY	262840	1	1	1	1	1	1	1	1
FISH CREEK RCH	262860					1	1	1	1
GERLACH	263090	1	1	1	1	1	1	1	1
GEYSER RCH	263101	1	1	1	1	1	1	1	1
GIBBS RCH	263114					1	1	1	1
GLENBROOK	263205					1	1	1	1
GOLCONDA	263245					1	1	1	1
GOLDFIELD	263285					1	1	1	1
GOODSPRINGS	263316					1	1	1	1
GREAT BASIN NP	263340					1	1	1	1
HAWTHORNE	263512					1	1	1	1
HAWTHORNE AP	263515					1	1	1	1
HIKO	263671	1	1	1		1	1	1	1
HUMBOLDT FLD	263853					1	1	1	1
I-L RCH	263940					1	1	1	1
IMLAY	263957					1	1	1	1
INDIAN SPRINGS	263980					1	1	1	1
JACKPOT	264016					1	1	1	1
JARBRIDGE 4 N	264038					1	1	1	1
JARBIDGE 7 N	264039					1	1	1	1
JIGGS 8 SSE ZAGA	264095					1	1	1	1
JUNGO MEYER RCH	264108					1	1	1	1
KIMBERLY	264199					1	1	1	1
KNOLL CREEK FLD STN	264268					1	1	1	1
KYLE CANYON RS	264314					1	1	1	1
LAGES	264341					1	1	1	1
LAHONTAN DAM	264349					1	1	1	1
LAKE VALLEY STEWARD	264384					1	1	1	1
LAMOILLE YOST	264394					1	1	1	1
LAMOILLE PH	264395					1	1	1	1
LAS VEGAS	264429	1	1	1		1	1	1	1
LAS VEGAS WB AP	264436	1	1	1		1	1	1	1
LAS VEGAS NWFO	264439	1	1	1		1	1	1	1
LATHROP WELLS	264457	1	1	1		1	1	1	1
LAUGHLIN	264480	1	1	1		1	1	1	1
LEHMAN CAVES NM	264514					1	1	1	1
LEONARD CREEK RCH	264527	1	1	1		1	1	1	1
LEWERS RCH	264542					1	1	1	1

Appendix 10 cont. Crop or land cover class simulated for each station (1 = yes, 0 = no).

Station Name	Station Number	Sunflower -irrigated	Safflower -irrigated	Canola	Garlic	Bare soil	Mulched soil, including wheat stubble	Dormant turf (winter time)	Open water - shallow systems/ponds
LITTLE RED ROCK	264600					1	1	1	1
LOGANDALE	264651	1	1	1		1	1	1	1
LOVELOCK DERBY FLD	264700	1	1	1	1	1	1	1	1
LUND	264745				1	1	1	1	1
MALA VISTA RCH	264824	1	1	1		1	1	1	1
MARLETTE LAKE	264858					1	1	1	1
MCDERMITT	264935					1	1	1	1
MCGILL	264950					1	1	1	1
MESQUITE	265085	1	1	1		1	1	1	1
METROPOLIS	265092	1	1	1		1	1	1	1
MIDAS 4 SE	265105					1	1	1	1
MIDDLEGATE-LOWERY	265132					1	1	1	1
MINA	265168					1	1	1	1
MINDEN	265191				1	1	1	1	1
MONTELLO 2 SE	265352				1	1	1	1	1
MONTGOMERY MNTC STN	265362					1	1	1	1
MOORMAN RCH	265371					1	1	1	1
MTN CITY RS	265392					1	1	1	1
MT CHARLESTON FS	265400					1	1	1	1
MT ROSE BOWL	265440					1	1	1	1
NIXON	265605				1	1	1	1	1
NORTH LAS VEGAS	265705	1	1	1		1	1	1	1
OASIS	265722					1	1	1	1
OLD RUTH	265760					1	1	1	1
OROVADA 3 W	265818				1	1	1	1	1
OVERTON	265846	1	1	1	1	1	1	1	1
OWYHEE	265869					1	1	1	1
PAHRANAGAT WR	265880	1	1	1	1	1	1	1	1
PAHRUMP	265890	1	1	1	1	1	1	1	1
PAHUTE MEADOWS RCH	265907					1	1	1	1
PALMETTO	265931					1	1	1	1
PARADISE VALLEY 1 NW	266005	1	1	1	1	1	1	1	1
PARIS RCH	266055					1	1	1	1
PENOYER VALLEY	266130					1	1	1	1
PEQUOP	266148					1	1	1	1
PILOT VALLEY-LEE	266228					1	1	1	1
PINE VALLEY BAILEY RCH	266242					1	1	1	1
PIOCHE	266252	1	1	1	1	1	1	1	1
QUINN RVR CROSSING	266504	1	1	1		1	1	1	1
RAND RCH PALISADE	266574	1	1	1		1	1	1	1
RATTLESNAKE	266630					1	1	1	1
RED ROCK CANYON SP	266691					1	1	1	1
REESE RIVER	266746	1	1	1		1	1	1	1
REESE VALLEY CARPER	266748					1	1	1	1
RENO TAHOE INTL AP	266779				1	1	1	1	1
RENO WFO	266791				1	1	1	1	1
RUBY LAKE	267123					1	1	1	1
RUTH	267175					1	1	1	1

Appendix 10 cont. Crop or land cover class simulated for each station (1 = yes, 0 = no).

Station Name	Station Number	Sunflower -irrigated	Safflower -irrigated	Canola	Garlic	Bare soil	Mulched soil, including wheat stubble	Dormant turf (winter time)	Open water - shallow systems/ponds
RYNDON	267188	1	1	1		1	1	1	1
RYE PATCH DAM	267192					1	1	1	1
SAND PASS	267261					1	1	1	1
SAN JACINTO	267284					1	1	1	1
SARCOBATUS	267319					1	1	1	1
SAVAL RCH	267324					1	1	1	1
SCHURZ	267358					1	1	1	1
SEARCHLIGHT	267369					1	1	1	1
SEVENTY ONE RCH	267397					1	1	1	1
SHELDON	267443					1	1	1	1
SHOSHONE 5 N	267450					1	1	1	1
SILVERPEAK	267463					1	1	1	1
SMITH 1 N	267609	1	1	1	1	1	1	1	1
SMITH 6 N	267612	1	1	1	1	1	1	1	1
SMOKE CREEK ESPIL	267618					1	1	1	1
SMOKEY VALLEY	267620					1	1	1	1
SNOWBALL RCH	267640					1	1	1	1
SOUTH FORK SP	267690				1	1	1	1	1
SPRING VALLEY SP	267750					1	1	1	1
STATELINE-HARRAH'S	267806					1	1	1	1
STEAD	267820					1	1	1	1
SULPHUR	267873					1	1	1	1
SUNNYSIDE	267908					1	1	1	1
SUTCLIFFE	267953					1	1	1	1
TEMPIUTE 4 NW	267983					1	1	1	1
THORNE	268034					1	1	1	1
TONOPAH	268170				1	1	1	1	1
TOPAZ LAKE 3N	268186				1	1	1	1	1
TOPAZ LAKE 4 N	268202				1	1	1	1	1
TUSCARORA	268346					1	1	1	1
TWIN SPRING FALLINI	268443					1	1	1	1
UNIV OF NEVADA EXP FM	268500					1	1	1	1
URSINE	268538					1	1	1	1
VALLEY OF FIRE SP	268588					1	1	1	1
VIRGINIA CITY	268761					1	1	1	1
VYA	268810					1	1	1	1
WABUSKA 6 SE	268822					1	1	1	1
WADSWORTH	268834					1	1	1	1
WADSWORTH 4 N	268838					1	1	1	1
WELLINGTON RS	268977	1	1	1	1	1	1	1	1
WELLS	268988					1	1	1	1
WILDHORSE RSVR	269072					1	1	1	1
WILKINS	269122					1	1	1	1
WILLOW SPRINGS	269137					1	1	1	1
WINNEMUCCA #2	269168					1	1	1	1
WINNEMUCCA MUNI AP	269171					1	1	1	1
YERINGTON	269229	1	1	1	1	1	1	1	1
LAS VEGAS	23112					1	1	1	1

Appendix 10 cont. Crop or land cover class simulated for each station (1 = yes, 0 = no).

Station Name	Station Number	Sunflower -irrigated	Safflower -irrigated	Canola	Garlic	Bare soil	Mulched soil, including wheat stubble	Dormant turf (winter time)	Open water - shallow systems/ponds
RED ROCK WC	29999					1	1	1	1
WASHOE VALLEY WC	39999					1	1	1	1

Appendix 11a. Mean annual ET_{os} and ET_{act} for each NWS weather station, sorted by station name. * Station was used in averaging or assigning ET_{os} and ET_{act} to respective hydrographic areas. Number of years used for average and start and end years listed are for alfalfa and may vary slightly for other crop types due to possible missing data within crop specific growing seasons. See statistic data files for further details.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
260046	ADAVEN	Garden Valley	172	30	1947	1978	3.8	3.1	3.1	2.5	2.9	2.9	4.0
260099	ALAMO*	Pahranagat Valley	209	29	1923	1958	5.6	5.0	4.5	3.6	4.2	4.6	5.8
260150	AMARGOSA FARMS-GAREY*	Amargosa Desert	230	28	1966	2005	5.8	5.6	4.8	3.9	3.7	5.6	6.1
260282	ANTELOPE VALLEY FARR*	Antelope Valley	57	8	1985	1998	4.4	3.6	3.6	3.0	3.5	3.5	4.6
260438	ARTHUR 4 NW*	Ruby Valley	176	30	1972	2007	3.8	3.1	3.0	2.5	2.9	2.8	4.0
260507	AUSTIN #2*	Upper Reese River Valley	56	30	1972	2007	4.1	3.4	3.3	2.7	3.1	3.1	4.3
260668	BASALT	Teels Marsh Valley	114	10	1942	1957	4.4	3.4	3.4	2.7	3.3	3.2	4.7
260691	BATTLE MTN AP*	Lower Reese River Valley	59	30	1974	2006	4.3	3.8	3.7	3.1	3.5	3.6	4.5
260688	BATTLE MTN*	Clovers Area	64	25	1903	1944	4.6	4.0	3.9	3.2	3.7	3.8	4.8
260718	BEATTY 8 N*	Oasis Valley	228	28	1973	2004	5.3	4.9	4.3	3.5	4.1	4.8	5.6
260715	BEATTY*	Oasis Valley	228	30	1925	1972	5.6	5.2	4.6	3.7	4.2	5.1	5.9
260800	BEOWAWE U OF N RCH*	Grass Valley	138	28	1973	2007	4.2	3.5	3.4	2.8	3.3	3.3	4.4
260795	BEOWAWE*	Crescent Valley	54	30	1976	2006	4.3	3.6	3.6	3.0	3.5	3.5	4.5

Appendix 11a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
260955	BLUE EAGLE RCH HANKS*	Railroad Valley	173B	23	1979	2007	4.8	4.4	4.3	3.6	4.2	4.3	5.0
260961	BLUE JAY HWY STN*	Hot Creek	156	7	1964	1983	4.8	3.9	3.9	3.2	3.7	3.7	5.0
261071	BOULDER CITY*	Eldorado Valley	167	30	1969	2004	5.4	5.1	4.3	3.5	3.1	5.0	5.7
261160	BRINKERHOFF RCH*	Dixie Valley	128	7	1967	1979	4.7	4.2	4.1	3.4	4.0	4.1	4.9
261311	BUFFALO RCH*	Buffalo Valley	131	7	1967	1978	4.0	3.7	3.5	2.9	3.3	3.5	4.2
261327	BUNKERVILLE*	Virgin River Valley	222	6	1980	2007	5.1	4.8	4.0	3.3	3.1	4.7	5.4
261358	CALIENTE*	Clover Valley	204	22	1904	2006	4.9	4.5	4.2	3.5	3.9	4.1	5.2
261371	CALLVILLE BAY*	Black Moutains Area	215	8	1990	2006	5.7	5.3	4.5	3.6	2.9	5.3	5.9
261415	CARLIN NEWMONT MINE	Boulder Flat	61	24	1967	1999	3.3	2.7	2.6	2.2	2.5	2.5	3.4
261485	CARSON CITY*	Eagle Valley	104	30	1974	2007	4.3	3.8	3.6	3.0	3.5	3.6	4.6
261590	CATHEDRAL GORGE SP*	Panaca Valley	203	4	2003	2007	5.0	4.7	4.4	3.7	4.3	4.3	5.3
261630	CENTRAL NEVADA FLD LAB*	Upper Reese River Valley	56	13	1966	1985	4.5	3.3	3.1	2.6	3.0	2.9	4.7
261660	CHARLESTON*	Bruneau River Area	38	4	1962	2005	4.1	2.3	2.0	1.7	1.7	1.8	4.3
261740	CLOVER VALLEY*	Clover Valley	177	30	1926	2007	4.0	3.3	3.3	2.7	3.1	3.1	4.2
261755	COALDALE JUNCTION*	Columbus Salt Marsh Valley	118	6	1942	1958	5.5	4.7	4.4	3.6	4.3	4.3	5.8

Appendix 11a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
261905	CONTACT*	Salmon Falls Creek Area	40	30	1958	1998	4.2	3.4	3.2	2.7	3.0	3.0	4.4
261975	CORTEZ GOLD MINE*	Crescent Valley	54	10	1969	1979	4.1	3.6	3.5	2.9	3.4	3.3	4.3
262091	CURRANT HWY STN	Railroad Valley	173B	7	1964	1977	4.3	3.0	3.0	2.4	2.7	2.7	4.5
262078	CURRANT*	Railroad Valley	173B	4	1942	1946	4.4	3.8	3.8	3.1	3.7	3.6	4.6
262096	CURRIE HWY STN*	Steptoe Valley	179	10	1962	1989	4.7	3.2	3.1	2.5	2.9	2.8	4.9
262119	DAGGET PASS	Lake Tahoe Basin	90	5	1989	2005	3.3	2.3	2.2	1.7	2.0	2.0	3.4
262229	DENIO*	Pueblo Valley	1	30	1970	2005	4.3	3.7	3.6	3.0	3.5	3.5	4.5
262243	DESERT NWR*	Las Vegas Valley	212	30	1976	2007	6.2	5.9	5.1	4.1	4.2	5.7	6.5
262276	DIABLO*	Railroad Valley	173A	10	1960	1978	4.8	4.2	4.1	3.4	4.0	4.1	5.0
262296	DIAMOND VALLEY USDA*	Diamond Valley	153	19	1980	2006	4.1	3.2	3.1	2.5	3.0	2.9	4.3
262390	DUCKWATER*	Railroad Valley	173B	19	1967	1998	4.5	3.9	3.8	3.1	3.7	3.6	4.7
262394	DUFURRENA*	Virgin Valley	4	30	1967	2004	4.4	3.3	3.1	2.6	3.0	2.9	4.6
262431	DYER*	Fish Lake Valley	117	30	1974	2007	5.5	4.6	4.4	3.6	4.3	4.3	5.8
262477	EASTGATE*	Eastgate Valley Area	127	4	1957	1963	4.5	3.9	3.9	3.2	3.9	3.8	4.8
262497	ECHO BAY*	Black Moutains Area	215	10	1990	2003	5.3	5.0	4.2	3.4	2.8	4.9	5.6

Appendix 11a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
262562	ELGIN 3 SE*	Lower Meadow Valley Wash	205	15	1966	1985	4.9	4.6	3.9	3.2	3.5	4.5	5.1
262557	ELGIN*	Lower Meadow Valley Wash	205	20	1986	2006	4.9	4.6	4.1	3.3	3.8	4.5	5.2
262573	ELKO RGNL AP*	Elko Segment	49	30	1978	2007	4.0	3.3	3.2	2.7	3.1	3.0	4.2
262570	ELKO*	Elko Segment	49	6	2000	2007	3.9	3.3	3.3	2.7	3.2	3.1	4.1
262626	ELY 6 NE	Steptoe Valley	179	5	2000	2005	4.8	4.0	3.9	3.3	3.7	3.7	5.1
262631	ELY YELLAND FLD AP*	Steptoe Valley	179	30	1976	2005	4.5	3.5	3.3	2.7	3.2	3.0	4.7
262656	EMIGRANT PASS HWY STN	Boulder Flat	61	27	1964	1999	3.8	3.2	3.2	2.6	3.0	3.0	4.0
262662	EMPIRE*	San Emidio Desert	22	6	1951	1976	4.4	3.9	3.9	3.2	3.8	3.9	4.6
262708	EUREKA	Diamond Valley	153	30	1975	2007	3.6	2.9	2.8	2.2	2.6	2.5	3.8
262780	FALLON EXP STN*	Carson Desert	101	30	1973	2005	4.1	3.6	3.5	2.9	3.5	3.5	4.3
262820	FERGUSON SPRINGS HMS*	Great Salt Lake Desert	192	7	1973	1982	3.6	2.9	2.9	2.3	2.7	2.7	3.7
262840	FERNLEY*	Fernley Area	76	21	1908	1974	4.6	3.9	3.8	3.1	3.6	3.7	4.8
262860	FISH CREEK RCH*	Little Smoky Valley	155A	14	1944	1964	4.5	3.1	3.1	2.5	2.9	2.9	4.8
263090	GERLACH*	San Emidio Desert	22	27	1963	2006	4.2	3.8	3.7	3.0	3.6	3.7	4.4
263101	GEYSER RCH*	Lake Valley	183	19	1972	2002	4.5	3.6	3.4	2.8	3.3	3.2	4.7

Appendix 11a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
263114	GIBBS RCH*	Marys River Area	42	30	1973	2007	3.9	3.0	2.9	2.4	2.8	2.8	4.1
263205	GLENBROOK*	Lake Tahoe Basin	90	30	1969	2007	3.5	2.9	2.7	2.2	2.5	2.5	3.7
263245	GOLCONDA*	Winnemucca Segment	70	30	1970	2005	4.6	4.0	3.9	3.2	3.8	3.8	4.8
263285	GOLDFIELD	Alkali Spring Valley	142	30	1951	2004	4.5	3.8	3.7	3.0	3.6	3.6	4.7
263316	GOODSPRINGS*	Ivanpah Valley	164A	6	2000	2006	5.9	5.7	4.9	4.0	4.1	5.6	6.2
263340	GREAT BASIN NP	Snake Valley	195	16	1988	2007	3.7	3.1	3.0	2.5	2.9	2.9	3.8
263515	HAWTHORNE AP*	Walker Lake Valley	110C	30	1948	1990	4.7	4.2	3.9	3.2	3.8	4.0	5.0
263512	HAWTHORNE*	Walker Lake Valley	110C	13	1955	2007	4.8	4.3	4.0	3.2	3.7	3.9	5.0
263671	HIKO*	Pahranagat Valley	209	15	1990	2006	5.0	4.5	4.2	3.4	3.8	4.4	5.2
263853	HUMBOLDT FLD	Buena Vista Valley	129	7	1940	1947	4.4	3.8	3.7	3.0	3.6	3.5	4.6
263940	I-L RCH*	South Fork Owyhee River Area	35	3	1963	1967	4.2	3.0	2.9	2.4	2.8	2.7	4.4
263957	IMLAY*	Imlay Area	72	30	1964	2007	4.5	4.0	3.9	3.2	3.8	3.8	4.7
263980	INDIAN SPRINGS*	Indian Springs Valley	161	23	1914	1964	6.0	5.4	4.9	4.0	4.2	5.3	6.3
264016	JACKPOT*	Salmon Falls Creek Area	40	15	1987	2004	3.9	3.2	3.2	2.6	3.0	3.0	4.1
264039	JARBIDGE 7 N*	Jarbidge River Area	39	11	1996	2006	3.9	3.3	3.0	2.5	2.9	2.8	4.1

Appendix 11a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
264038	JARBRIDGE 4 N	Jarbidge River Area	39	22	1965	1995	3.8	3.1	2.6	2.2	2.3	2.4	4.0
264095	JIGGS 8 SSE ZAGA*	Huntington Valley	47	19	1979	2007	4.0	3.2	3.0	2.5	2.8	2.8	4.2
264108	JUNGO MEYER RCH*	Desert Valley	31	7	1969	1985	4.3	3.8	3.7	3.0	3.5	3.6	4.5
264199	KIMBERLY	White River Valley	207	28	1929	1958	3.9	3.0	2.9	2.4	2.8	2.7	4.1
264268	KNOLL CREEK FLD STN	Salmon Falls Creek Area	40	6	1972	1979	4.0	2.9	2.7	2.1	2.5	2.4	4.2
264314	KYLE CANYON RS	Las Vegas Valley	212	4	1940	1948	4.5	3.4	3.0	2.4	3.2	2.7	4.7
264341	LAGES*	Steptoe Valley	179	21	1984	2006	4.5	3.6	3.5	2.8	3.3	3.2	4.7
264349	LAHONTAN DAM*	Churchill Valley	102	30	1969	2007	4.2	3.8	3.6	3.0	3.5	3.7	4.4
264384	LAKE VALLEY STEWARD	Lake Valley	183	22	1971	1998	3.8	3.2	3.1	2.5	3.0	2.9	4.0
264395	LAMOILLE PH	Lamoille Valley	45	30	1934	1972	3.6	3.1	2.9	2.4	2.8	2.8	3.8
264394	LAMOILLE YOST*	Lamoille Valley	45	22	1976	2003	3.9	3.0	2.8	2.3	2.7	2.6	4.1
264439	LAS VEGAS NWFO*	Las Vegas Valley	212	9	1997	2007	5.8	5.5	4.6	3.7	3.3	5.3	6.1
264436	LAS VEGAS WB AP*	Las Vegas Valley	212	30	1976	2005	5.8	5.6	4.9	4.0	3.4	5.7	6.0
23112	LAS VEGAS*	Las Vegas Valley	212	22	1949	1970	6.0	5.8	5.1	4.1	3.7	5.9	6.3
264429	LAS VEGAS*	Las Vegas Valley	212	30	1921	1956	6.6	6.4	5.6	4.6	4.3	6.5	6.9
264457	LATHROP WELLS	Fortymile Canyon	227A	8	1943	1963	5.8	5.4	4.7	3.8	3.9	5.4	6.0

Appendix 11a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
264480	LAUGHLIN*	Colorado Valley	213	10	1989	2006	6.5	6.2	5.3	4.3	3.7	6.1	6.9
264514	LEHMAN CAVES NM	Snake Valley	195	30	1958	1987	3.6	2.9	2.8	2.3	2.7	2.6	3.8
264527	LEONARD CREEK RCH*	Black Rock Desert	28	30	1971	2004	4.2	3.9	3.8	3.2	3.7	3.8	4.4
264542	LEWERS RCH	Washoe Valley	89	15	1893	1913	4.5	3.9	3.6	2.9	3.5	3.4	4.7
264600	LITTLE RED ROCK	Las Vegas Valley	212	4	1966	1970	5.1	4.8	4.1	3.3	3.6	4.6	5.4
264651	LOGANDALE*	Lower Moapa Valley	220	20	1969	1991	5.0	4.7	4.1	3.4	3.2	4.9	5.2
264700	LOVELOCK DERBY FLD*	Lovelock Valley	73	30	1970	2005	4.7	4.1	4.1	3.4	4.0	4.0	4.9
264745	LUND*	White River Valley	207	30	1977	2007	4.5	3.9	3.8	3.2	3.7	3.7	4.8
264824	MALA VISTA RCH*	Marys River Area	42	16	1940	1965	4.1	3.1	2.9	2.4	2.8	2.7	4.3
264858	MARLETTE LAKE	Lake Tahoe Basin	90	19	1917	1952	2.9	1.8	1.7	1.3	1.6	1.5	3.0
264935	MCDERMITT*	Quinn River Valley	33B	29	1974	2007	4.3	3.4	3.2	2.7	2.9	3.0	4.5
264950	MCGILL*	Steptoe Valley	179	30	1977	2007	4.2	3.6	3.5	2.9	3.3	3.3	4.4
265085	MESQUITE*	Virgin River Valley	222	13	1942	2006	5.1	5.0	4.4	3.6	3.3	5.0	5.4
265092	METROPOLIS*	Marys River Area	42	18	1966	1994	3.7	3.2	3.1	2.6	3.0	3.0	3.9
265105	MIDAS 4 SE*	Willow Creek Valley	63	4	1962	1967	4.4	3.1	3.1	2.6	2.9	2.9	4.7
265132	MIDDLEGATE-LOWERY*	Cowkick Valley	126	15	1989	2007	4.8	3.8	3.5	2.9	3.4	3.3	5.0

Appendix 11a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
265168	MINA*	Soda Spring Valley	121A	30	1978	2007	4.9	4.3	4.1	3.3	3.9	4.1	5.1
265191	MINDEN*	Carson Valley	105	30	1975	2007	4.3	3.6	3.5	2.9	3.3	3.4	4.5
265352	MONTELLO 2 SE*	Thousand Springs Valley	189D	30	1971	2007	4.4	3.5	3.4	2.7	3.2	3.1	4.6
265362	MONTGOMERY MNTC STN	Queen Valley	116	10	1961	1978	4.1	2.8	2.7	2.1	2.4	2.5	4.3
265371	MOORMAN RCH*	Jakes Valley	174	4	2003	2007	4.3	3.2	3.1	2.5	2.9	2.8	4.5
265400	MT CHARLESTON FS	Las Vegas Valley	212	6	1949	2007	4.4	3.4	2.7	2.1	3.1	2.4	4.7
265440	MT ROSE BOWL	Pleasant Valley	88	8	1974	1984	3.3	2.0	2.0	1.6	1.9	1.8	3.5
265392	MTN CITY RS*	Owyhee River Area	37	30	1965	1998	4.2	2.8	2.5	2.1	2.4	2.3	4.4
265605	NIXON*	Pyramid Lake Valley	81	30	1931	1973	4.8	4.1	4.0	3.2	3.8	3.9	5.0
265705	NORTH LAS VEGAS*	Las Vegas Valley	212	20	1952	2006	6.5	6.2	5.5	4.5	4.1	6.4	6.8
265722	OASIS*	Goshute Valley	187	17	1988	2006	4.2	3.4	3.2	2.6	3.1	2.9	4.5
265760	OLD RUTH	Steptoe Valley	179	5	1979	1985	3.8	2.9	2.9	2.3	2.7	2.6	4.0
265818	OROVADA 3 W*	Quinn River Valley	33A	30	1973	2006	4.4	3.9	3.8	3.1	3.6	3.6	4.6
265846	OVERTON*	Lower Moapa Valley	220	30	1953	2007	5.2	4.9	4.3	3.6	3.2	5.1	5.5
265869	OWYHEE*	Owyhee River Area	37	30	1954	1984	3.8	3.2	3.1	2.6	3.0	2.9	4.0

Appendix 11a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
265880	PAHRANAGAT WR*	Pahranagat Valley	209	30	1970	2006	5.2	4.8	4.3	3.5	3.7	4.6	5.4
265890	PAHRUMP*	Pahrump Valley	162	30	1976	2007	5.7	5.4	4.8	4.0	4.1	5.5	6.0
265907	PAHUTE MEADOWS RCH*	Black Rock Desert	28	4	1964	1974	4.2	3.6	3.6	2.9	3.5	3.5	4.4
265931	PALMETTO	Fish Lake Valley	117	14	1891	1907	4.9	3.5	3.4	2.7	3.1	3.1	5.2
266005	PARADISE VALLEY 1 NW*	Paradise Valley	69	30	1973	2007	4.6	3.8	3.6	3.0	3.5	3.4	4.8
266055	PARIS RCH*	Pleasant Valley	130	22	1967	1990	4.6	4.2	4.1	3.4	3.9	4.0	4.9
266130	PENOYER VALLEY*	Penoyer Valley	170	5	1968	2004	5.1	4.3	4.3	3.5	4.2	4.2	5.4
266148	PEQUOP	Goshute Valley	187	23	1960	1985	4.1	3.1	3.0	2.4	2.8	2.7	4.3
266228	PILOT VALLEY-LEE*	Pilot Creek Valley	191	6	2000	2007	4.2	3.4	3.3	2.7	3.1	3.1	4.4
266242	PINE VALLEY BAILEY RCH*	Pine Valley	53	11	1983	2003	4.5	3.4	3.2	2.7	3.0	3.0	4.7
266252	PIOCHE	Patterson Valley	202	30	1968	2006	4.1	3.6	3.4	2.8	3.3	3.3	4.3
266504	QUINN RVR CROSSING	Pine Forest Valley	29	10	1902	1950	4.5	3.6	3.5	2.8	3.4	3.3	4.8
266574	RAND RCH PALISADE*	Pine Valley	53	19	1958	1981	4.3	3.0	3.0	2.5	2.8	2.8	4.6
266630	RATTLESNAKE	Hot Creek	156	13	1949	1961	4.3	3.6	3.6	2.9	3.5	3.4	4.5
266691	RED ROCK CANYON SP	Las Vegas Valley	212	20	1978	2006	5.4	5.2	4.6	3.8	3.9	5.2	5.7
29999	RED ROCK WC*	Red Rock Valley	99	4	2004	2007	4.0	3.1	2.9	2.4	2.9	2.7	4.2

Appendix 11a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
266746	REESE RIVER*	Upper Reese River Valley	56	26	1973	2006	4.3	3.0	2.8	2.2	2.6	2.5	4.5
266748	REESE VALLEY CARPER	Middle Reese River Valley	58	6	1977	1983	4.3	3.5	3.3	2.8	3.2	3.1	4.5
266779	RENO TAHOE INTL AP*	Truckee Meadows	87	30	1978	2007	4.4	4.0	3.8	3.2	3.8	3.9	4.7
266791	RENO WFO*	Truckee Meadows	87	10	1997	2007	4.2	3.9	3.7	3.0	3.6	3.8	4.4
267123	RUBY LAKE*	Ruby Valley	176	30	1976	2007	4.2	3.5	3.4	2.8	3.3	3.2	4.4
267175	RUTH	Steptoe Valley	179	30	1963	2007	4.3	3.0	2.7	2.3	2.6	2.5	4.5
267192	RYE PATCH DAM*	Imlay Area	72	30	1973	2007	4.8	4.2	4.1	3.4	4.0	4.0	5.0
267188	RYNDON*	North Fork Area	44	6	2000	2007	4.3	3.5	3.1	2.6	3.0	2.9	4.5
267284	SAN JACINTO*	Salmon Falls Creek Area	40	21	1905	1947	4.1	3.2	3.0	2.5	2.9	2.8	4.3
267261	SAND PASS*	Smoke Creek Desert	21	30	1931	1970	4.5	4.0	4.0	3.3	3.9	3.9	4.7
267319	SARCOBATUS*	Sarcobatus Flat	146	14	1942	1961	5.3	4.4	4.3	3.4	3.9	4.3	5.5
267324	SAVAL RCH*	North Fork Area	44	5	1961	1965	3.5	2.6	2.3	1.9	2.3	2.1	3.7
267358	SCHURZ*	Walker Lake Valley	110A	30	1921	1955	4.6	3.9	3.9	3.2	3.8	3.9	4.9
267369	SEARCHLIGHT	Piute Valley	214	30	1976	2006	5.0	4.7	4.1	3.3	3.3	4.7	5.2
267397	SEVENTY ONE RCH*	Starr Valley Area	43	4	1940	1951	4.1	3.3	2.9	2.4	2.8	2.7	4.3

Appendix 11a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
267443	SHELDON	Guano Valley	6	30	1942	1972	3.5	2.5	2.3	1.9	2.2	2.2	3.6
267450	SHOSHONE 5 N*	Spring Valley	184	17	1989	2007	4.5	3.7	3.6	3.0	3.5	3.5	4.7
267463	SILVERPEAK*	Clayton Valley	143	30	1975	2007	5.5	4.7	4.6	3.8	4.2	4.7	5.7
267609	SMITH 1 N*	Smith Valley	107	23	1938	1966	4.4	3.6	3.5	2.9	3.3	3.4	4.6
267612	SMITH 6 N*	Smith Valley	107	23	1974	2007	4.3	3.7	3.6	3.0	3.4	3.5	4.5
267618	SMOKE CREEK ESPIL*	Smoke Creek Desert	21	14	1988	2004	4.7	4.2	4.1	3.4	4.0	4.0	4.9
267620	SMOKEY VALLEY*	Big Smoky Valley	137B	30	1975	2007	4.8	4.1	4.0	3.2	3.9	3.7	5.1
267640	SNOWBALL RCH	Little Smoky Valley	155A	30	1972	2002	4.0	3.0	2.8	2.3	2.6	2.6	4.2
267690	SOUTH FORK SP*	Dixie Creek - Tenmile	48	8	1994	2007	4.3	3.4	3.3	2.7	3.0	3.1	4.5
267750	SPRING VALLEY SP*	Spring Valley	201	24	1975	2007	4.9	3.6	3.5	2.8	3.3	3.2	5.1
267806	STATELINE-HARRAH'S*	Lake Tahoe Basin	90	13	1985	1998	3.6	2.9	2.8	2.3	2.6	2.7	3.7
267820	STEAD*	Lemmon Valley	92B	14	1986	2006	4.2	3.7	3.6	3.0	3.5	3.6	4.4
267873	SULPHUR*	Black Rock Desert	28	21	1915	1953	4.5	3.8	3.8	3.1	3.7	3.6	4.7
267908	SUNNYSIDE*	White River Valley	207	30	1974	2007	4.7	4.0	3.8	3.1	3.6	3.6	4.9
267953	SUTCLIFFE	Pyramid Lake Valley	81	27	1968	2006	3.9	3.7	3.4	2.8	3.3	3.6	4.1
267983	TEMPIUTE 4 NW*	Penoyer Valley	170	12	1973	1984	5.1	4.4	4.4	3.6	4.3	4.3	5.4

Appendix 11a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
268034	THORNE*	Walker Lake Valley	110C	24	1915	1950	4.6	4.1	3.9	3.1	3.8	3.9	4.8
268170	TONOPAH*	Ralston Valley	141	30	1975	2005	5.1	4.4	4.3	3.6	4.3	4.3	5.3
268186	TOPAZ LAKE 3N*	Antelope Valley	106	19	1958	2005	4.7	3.9	3.7	3.1	3.5	3.6	5.0
268202	TOPAZ LAKE 4 N*	Antelope Valley	106	11	1987	1997	4.3	3.7	3.6	3.0	3.6	3.6	4.5
268346	TUSCARORA*	Independence Valley	36	30	1973	2006	3.7	3.0	2.8	2.3	2.6	2.6	3.9
268443	TWIN SPRING FALLINI*	Hot Creek	156	10	1986	2005	4.7	3.9	3.9	3.1	3.8	3.7	4.9
268500	UNIV OF NEVADA EXP FM*	Truckee Meadows	87	4	1949	1954	4.4	4.0	3.8	3.2	3.8	3.9	4.6
268538	URSINE	Eagle Valley	200	4	1965	1972	4.8	4.3	4.2	3.5	4.1	4.1	5.1
268588	VALLEY OF FIRE SP	Black Moutains Area	215	30	1977	2007	5.1	4.7	3.9	3.1	2.7	4.6	5.3
268761	VIRGINIA CITY	Dayton Valley	103	30	1975	2007	3.5	2.9	2.8	2.3	2.7	2.7	3.7
268810	VYA	Surprise Valley	14	14	1960	1975	3.6	2.7	2.5	2.1	2.4	2.3	3.8
268822	WABUSKA 6 SE*	Mason Valley	108	27	1973	2006	4.2	3.5	3.4	2.8	3.3	3.3	4.4
268838	WADSWORTH 4 N*	Dodge Flat	82	21	1975	2002	4.6	3.9	3.8	3.1	3.7	3.7	4.8
268834	WADSWORTH*	Tracy Segment	83	6	1902	1947	4.6	4.1	3.8	3.1	3.5	3.6	4.9
39999	WASHOE VALLEY WC*	Washoe Valley	89	5	2004	2008	5.2	4.4	4.2	3.4	4.0	3.9	5.5
268977	WELLINGTON RS*	Smith Valley	107	27	1943	1972	4.2	3.6	3.5	2.9	3.4	3.5	4.4

Appendix 11a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
268988	WELLS*	Marys River Area	42	30	1975	2004	4.0	3.1	2.9	2.4	2.8	2.7	4.2
269072	WILDHORSE RSVR*	Owyhee River Area	37	18	1983	2006	4.0	2.5	2.1	1.8	2.1	2.0	4.2
269122	WILKINS*	Thousand Springs Valley	189A	16	1949	1964	4.3	2.9	2.8	2.3	2.7	2.5	4.5
269137	WILLOW SPRINGS*	Big Smoky Valley	137A	4	1942	1948	4.8	3.9	3.8	3.0	3.8	3.5	5.0
269168	WINNEMUCCA #2*	Grass Valley	71	6	2000	2007	4.4	3.9	3.8	3.1	3.6	3.7	4.7
269171	WINNEMUCCA MUNI AP*	Winnemucca Segment	70	30	1978	2007	4.7	3.9	3.8	3.1	3.6	3.6	4.9
269229	YERINGTON*	Mason Valley	108	30	1970	2007	4.1	3.5	3.4	2.8	3.3	3.5	4.3

Appendix 11b. Mean annual ET_{os} and ET_{act} for each NWS weather station, sorted by basin name. * Station was used in averaging or assigning ET_{os} and ET_{act} to respective hydrographic areas. Number of years used for average and start and end years listed are for alfalfa and may vary slightly for other crop types due to possible missing data within crop specific growing seasons. See statistic data files for further details.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
263285	GOLDFIELD	Alkali Spring Valley	142	30	1951	2004	4.5	3.8	3.7	3.0	3.6	3.6	4.7
260150	AMARGOSA FARMS-GAREY*	Amargosa Desert	230	28	1966	2005	5.8	5.6	4.8	3.9	3.7	5.6	6.1
260282	ANTELOPE VALLEY FARR*	Antelope Valley	57	8	1985	1998	4.4	3.6	3.6	3.0	3.5	3.5	4.6
268186	TOPAZ LAKE 3N*	Antelope Valley	106	19	1958	2005	4.7	3.9	3.7	3.1	3.5	3.6	5.0
268202	TOPAZ LAKE 4 N*	Antelope Valley	106	11	1987	1997	4.3	3.7	3.6	3.0	3.6	3.6	4.5
267620	SMOKEY VALLEY*	Big Smoky Valley	137B	30	1975	2007	4.8	4.1	4.0	3.2	3.9	3.7	5.1
269137	WILLOW SPRINGS*	Big Smoky Valley	137A	4	1942	1948	4.8	3.9	3.8	3.0	3.8	3.5	5.0
261371	CALLVILLE BAY*	Black Moutains Area	215	8	1990	2006	5.7	5.3	4.5	3.6	2.9	5.3	5.9
262497	ECHO BAY*	Black Moutains Area	215	10	1990	2003	5.3	5.0	4.2	3.4	2.8	4.9	5.6
268588	VALLEY OF FIRE SP	Black Moutains Area	215	30	1977	2007	5.1	4.7	3.9	3.1	2.7	4.6	5.3
264527	LEONARD CREEK RCH*	Black Rock Desert	28	30	1971	2004	4.2	3.9	3.8	3.2	3.7	3.8	4.4

Appendix 11b cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
265907	PAHUTE MEADOWS RCH*	Black Rock Desert	28	4	1964	1974	4.2	3.6	3.6	2.9	3.5	3.5	4.4
267873	SULPHUR*	Black Rock Desert	28	21	1915	1953	4.5	3.8	3.8	3.1	3.7	3.6	4.7
261415	CARLIN NEWMONT MINE	Boulder Flat	61	24	1967	1999	3.3	2.7	2.6	2.2	2.5	2.5	3.4
262656	EMIGRANT PASS HWY STN	Boulder Flat	61	27	1964	1999	3.8	3.2	3.2	2.6	3.0	3.0	4.0
261660	CHARLESTON*	Bruneau River Area	38	4	1962	2005	4.1	2.3	2.0	1.7	1.7	1.8	4.3
263853	HUMBOLDT FLD	Buena Vista Valley	129	7	1940	1947	4.4	3.8	3.7	3.0	3.6	3.5	4.6
261311	BUFFALO RCH*	Buffalo Valley	131	7	1967	1978	4.0	3.7	3.5	2.9	3.3	3.5	4.2
262780	FALLON EXP STN*	Carson Desert	101	30	1973	2005	4.1	3.6	3.5	2.9	3.5	3.5	4.3
265191	MINDEN*	Carson Valley	105	30	1975	2007	4.3	3.6	3.5	2.9	3.3	3.4	4.5
264349	LAHONTAN DAM*	Churchill Valley	102	30	1969	2007	4.2	3.8	3.6	3.0	3.5	3.7	4.4
267463	SILVERPEAK*	Clayton Valley	143	30	1975	2007	5.5	4.7	4.6	3.8	4.2	4.7	5.7
261358	CALIENTE*	Clover Valley	204	22	1904	2006	4.9	4.5	4.2	3.5	3.9	4.1	5.2
261740	CLOVER VALLEY*	Clover Valley	177	30	1926	2007	4.0	3.3	3.3	2.7	3.1	3.1	4.2
260688	BATTLE MTN*	Clovers Area	64	25	1903	1944	4.6	4.0	3.9	3.2	3.7	3.8	4.8
264480	LAUGHLIN*	Colorado Valley	213	10	1989	2006	6.5	6.2	5.3	4.3	3.7	6.1	6.9

Appendix 11b cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
261755	COALDALE JUNCTION*	Columbus Salt Marsh Valley	118	6	1942	1958	5.5	4.7	4.4	3.6	4.3	4.3	5.8
265132	MIDDLEGATE-LOWERY*	Cowkick Valley	126	15	1989	2007	4.8	3.8	3.5	2.9	3.4	3.3	5.0
260795	BEOWAWE*	Crescent Valley	54	30	1976	2006	4.3	3.6	3.6	3.0	3.5	3.5	4.5
261975	CORTEZ GOLD MINE*	Crescent Valley	54	10	1969	1979	4.1	3.6	3.5	2.9	3.4	3.3	4.3
268761	VIRGINIA CITY	Dayton Valley	103	30	1975	2007	3.5	2.9	2.8	2.3	2.7	2.7	3.7
264108	JUNGO MEYER RCH*	Desert Valley	31	7	1969	1985	4.3	3.8	3.7	3.0	3.5	3.6	4.5
262296	DIAMOND VALLEY USDA*	Diamond Valley	153	19	1980	2006	4.1	3.2	3.1	2.5	3.0	2.9	4.3
262708	EUREKA	Diamond Valley	153	30	1975	2007	3.6	2.9	2.8	2.2	2.6	2.5	3.8
267690	SOUTH FORK SP*	Dixie Creek - Tenmile	48	8	1994	2007	4.3	3.4	3.3	2.7	3.0	3.1	4.5
261160	BRINKERHOFF RCH*	Dixie Valley	128	7	1967	1979	4.7	4.2	4.1	3.4	4.0	4.1	4.9
268838	WADSWORTH 4 N*	Dodge Flat	82	21	1975	2002	4.6	3.9	3.8	3.1	3.7	3.7	4.8
261485	CARSON CITY*	Eagle Valley	104	30	1974	2007	4.3	3.8	3.6	3.0	3.5	3.6	4.6
268538	URSINE	Eagle Valley	200	4	1965	1972	4.8	4.3	4.2	3.5	4.1	4.1	5.1
262477	EASTGATE*	Eastgate Valley Area	127	4	1957	1963	4.5	3.9	3.9	3.2	3.9	3.8	4.8
261071	BOULDER CITY*	Eldorado Valley	167	30	1969	2004	5.4	5.1	4.3	3.5	3.1	5.0	5.7
262573	ELKO RGNL AP*	Elko Segment	49	30	1978	2007	4.0	3.3	3.2	2.7	3.1	3.0	4.2

Appendix 11b cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
262570	ELKO*	Elko Segment	49	6	2000	2007	3.9	3.3	3.3	2.7	3.2	3.1	4.1
262840	FERNLEY*	Fernley Area	76	21	1908	1974	4.6	3.9	3.8	3.1	3.6	3.7	4.8
262431	DYER*	Fish Lake Valley	117	30	1974	2007	5.5	4.6	4.4	3.6	4.3	4.3	5.8
265931	PALMETTO	Fish Lake Valley	117	14	1891	1907	4.9	3.5	3.4	2.7	3.1	3.1	5.2
264457	LATHROP WELLS	Fortymile Canyon	227A	8	1943	1963	5.8	5.4	4.7	3.8	3.9	5.4	6.0
260046	ADAVEN	Garden Valley	172	30	1947	1978	3.8	3.1	3.1	2.5	2.9	2.9	4.0
265722	OASIS*	Goshute Valley	187	17	1988	2006	4.2	3.4	3.2	2.6	3.1	2.9	4.5
266148	PEQUOP	Goshute Valley	187	23	1960	1985	4.1	3.1	3.0	2.4	2.8	2.7	4.3
260800	BEOWAWE U OF N RCH*	Grass Valley	138	28	1973	2007	4.2	3.5	3.4	2.8	3.3	3.3	4.4
269168	WINNEMUCCA #2*	Grass Valley	71	6	2000	2007	4.4	3.9	3.8	3.1	3.6	3.7	4.7
262820	FERGUSON SPRINGS HMS*	Great Salt Lake Desert	192	7	1973	1982	3.6	2.9	2.9	2.3	2.7	2.7	3.7
267443	SHELDON	Guano Valley	6	30	1942	1972	3.5	2.5	2.3	1.9	2.2	2.2	3.6
260961	BLUE JAY HWY STN*	Hot Creek	156	7	1964	1983	4.8	3.9	3.9	3.2	3.7	3.7	5.0
266630	RATTLESNAKE	Hot Creek	156	13	1949	1961	4.3	3.6	3.6	2.9	3.5	3.4	4.5
268443	TWIN SPRING FALLINI*	Hot Creek	156	10	1986	2005	4.7	3.9	3.9	3.1	3.8	3.7	4.9
264095	JIGGS 8 SSE ZAGA*	Huntington Valley	47	19	1979	2007	4.0	3.2	3.0	2.5	2.8	2.8	4.2
263957	IMLAY*	Imlay Area	72	30	1964	2007	4.5	4.0	3.9	3.2	3.8	3.8	4.7

Appendix 11b cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
267192	RYE PATCH DAM*	Imlay Area	72	30	1973	2007	4.8	4.2	4.1	3.4	4.0	4.0	5.0
268346	TUSCARORA*	Independence Valley	36	30	1973	2006	3.7	3.0	2.8	2.3	2.6	2.6	3.9
263980	INDIAN SPRINGS*	Indian Springs Valley	161	23	1914	1964	6.0	5.4	4.9	4.0	4.2	5.3	6.3
263316	GOODSPRINGS*	Ivanpah Valley	164A	6	2000	2006	5.9	5.7	4.9	4.0	4.1	5.6	6.2
265371	MOORMAN RCH*	Jakes Valley	174	4	2003	2007	4.3	3.2	3.1	2.5	2.9	2.8	4.5
264039	JARBIDGE 7 N*	Jarbidge River Area	39	11	1996	2006	3.9	3.3	3.0	2.5	2.9	2.8	4.1
264038	JARBRIDGE 4 N	Jarbidge River Area	39	22	1965	1995	3.8	3.1	2.6	2.2	2.3	2.4	4.0
262119	DAGGET PASS	Lake Tahoe Basin	90	5	1989	2005	3.3	2.3	2.2	1.7	2.0	2.0	3.4
263205	GLENBROOK*	Lake Tahoe Basin	90	30	1969	2007	3.5	2.9	2.7	2.2	2.5	2.5	3.7
264858	MARLETTE LAKE	Lake Tahoe Basin	90	19	1917	1952	2.9	1.8	1.7	1.3	1.6	1.5	3.0
267806	STATELINE-HARRAH'S*	Lake Tahoe Basin	90	13	1985	1998	3.6	2.9	2.8	2.3	2.6	2.7	3.7
263101	GEYSER RCH*	Lake Valley	183	19	1972	2002	4.5	3.6	3.4	2.8	3.3	3.2	4.7
264384	LAKE VALLEY STEWARD	Lake Valley	183	22	1971	1998	3.8	3.2	3.1	2.5	3.0	2.9	4.0
264395	LAMOILLE PH	Lamoille Valley	45	30	1934	1972	3.6	3.1	2.9	2.4	2.8	2.8	3.8
264394	LAMOILLE YOST*	Lamoille Valley	45	22	1976	2003	3.9	3.0	2.8	2.3	2.7	2.6	4.1
262243	DESERT NWR*	Las Vegas Valley	212	30	1976	2007	6.2	5.9	5.1	4.1	4.2	5.7	6.5

Appendix 11b cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
264314	KYLE CANYON RS	Las Vegas Valley	212	4	1940	1948	4.5	3.4	3.0	2.4	3.2	2.7	4.7
264439	LAS VEGAS NWFO*	Las Vegas Valley	212	9	1997	2007	5.8	5.5	4.6	3.7	3.3	5.3	6.1
264436	LAS VEGAS WB AP*	Las Vegas Valley	212	30	1976	2005	5.8	5.6	4.9	4.0	3.4	5.7	6.0
23112	LAS VEGAS*	Las Vegas Valley	212	22	1949	1970	6.0	5.8	5.1	4.1	3.7	5.9	6.3
264429	LAS VEGAS*	Las Vegas Valley	212	30	1921	1956	6.6	6.4	5.6	4.6	4.3	6.5	6.9
264600	LITTLE RED ROCK	Las Vegas Valley	212	4	1966	1970	5.1	4.8	4.1	3.3	3.6	4.6	5.4
265400	MT CHARLESTON FS	Las Vegas Valley	212	6	1949	2007	4.4	3.4	2.7	2.1	3.1	2.4	4.7
265705	NORTH LAS VEGAS*	Las Vegas Valley	212	20	1952	2006	6.5	6.2	5.5	4.5	4.1	6.4	6.8
266691	RED ROCK CANYON SP	Las Vegas Valley	212	20	1978	2006	5.4	5.2	4.6	3.8	3.9	5.2	5.7
267820	STEAD*	Lemmon Valley	92B	14	1986	2006	4.2	3.7	3.6	3.0	3.5	3.6	4.4
262860	FISH CREEK RCH*	Little Smoky Valley	155A	14	1944	1964	4.5	3.1	3.1	2.5	2.9	2.9	4.8
267640	SNOWBALL RCH	Little Smoky Valley	155A	30	1972	2002	4.0	3.0	2.8	2.3	2.6	2.6	4.2
264700	LOVELOCK DERBY FLD*	Lovelock Valley	73	30	1970	2005	4.7	4.1	4.1	3.4	4.0	4.0	4.9
262562	ELGIN 3 SE*	Lower Meadow Valley Wash	205	15	1966	1985	4.9	4.6	3.9	3.2	3.5	4.5	5.1
262557	ELGIN*	Lower Meadow Valley Wash	205	20	1986	2006	4.9	4.6	4.1	3.3	3.8	4.5	5.2

Appendix 11b cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
264651	LOGANDALE*	Lower Moapa Valley	220	20	1969	1991	5.0	4.7	4.1	3.4	3.2	4.9	5.2
265846	OVERTON*	Lower Moapa Valley	220	30	1953	2007	5.2	4.9	4.3	3.6	3.2	5.1	5.5
260691	BATTLE MTN AP*	Lower Reese River Valley	59	30	1974	2006	4.3	3.8	3.7	3.1	3.5	3.6	4.5
263114	GIBBS RCH*	Marys River Area	42	30	1973	2007	3.9	3.0	2.9	2.4	2.8	2.8	4.1
264824	MALA VISTA RCH*	Marys River Area	42	16	1940	1965	4.1	3.1	2.9	2.4	2.8	2.7	4.3
265092	METROPOLIS*	Marys River Area	42	18	1966	1994	3.7	3.2	3.1	2.6	3.0	3.0	3.9
268988	WELLS*	Marys River Area	42	30	1975	2004	4.0	3.1	2.9	2.4	2.8	2.7	4.2
268822	WABUSKA 6 SE*	Mason Valley	108	27	1973	2006	4.2	3.5	3.4	2.8	3.3	3.3	4.4
269229	YERINGTON*	Mason Valley	108	30	1970	2007	4.1	3.5	3.4	2.8	3.3	3.5	4.3
266748	REESE VALLEY CARPER	Middle Reese River Valley	58	6	1977	1983	4.3	3.5	3.3	2.8	3.2	3.1	4.5
267188	RYNDON*	North Fork Area	44	6	2000	2007	4.3	3.5	3.1	2.6	3.0	2.9	4.5
267324	SAVAL RCH*	North Fork Area	44	5	1961	1965	3.5	2.6	2.3	1.9	2.3	2.1	3.7
260718	BEATTY 8 N*	Oasis Valley	228	28	1973	2004	5.3	4.9	4.3	3.5	4.1	4.8	5.6
260715	BEATTY*	Oasis Valley	228	30	1925	1972	5.6	5.2	4.6	3.7	4.2	5.1	5.9
265392	MTN CITY RS*	Owyhee River Area	37	30	1965	1998	4.2	2.8	2.5	2.1	2.4	2.3	4.4

Appendix 11b cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
265869	OWYHEE*	Owyhee River Area	37	30	1954	1984	3.8	3.2	3.1	2.6	3.0	2.9	4.0
269072	WILDHORSE RSVR*	Owyhee River Area	37	18	1983	2006	4.0	2.5	2.1	1.8	2.1	2.0	4.2
260099	ALAMO*	Pahranagat Valley	209	29	1923	1958	5.6	5.0	4.5	3.6	4.2	4.6	5.8
263671	HIKO*	Pahranagat Valley	209	15	1990	2006	5.0	4.5	4.2	3.4	3.8	4.4	5.2
265880	PAHRANAGAT WR*	Pahranagat Valley	209	30	1970	2006	5.2	4.8	4.3	3.5	3.7	4.6	5.4
265890	PAHRUMP*	Pahrump Valley	162	30	1976	2007	5.7	5.4	4.8	4.0	4.1	5.5	6.0
261590	CATHEDRAL GORGE SP*	Panaca Valley	203	4	2003	2007	5.0	4.7	4.4	3.7	4.3	4.3	5.3
266005	PARADISE VALLEY 1 NW*	Paradise Valley	69	30	1973	2007	4.6	3.8	3.6	3.0	3.5	3.4	4.8
266252	PIOCHE	Patterson Valley	202	30	1968	2006	4.1	3.6	3.4	2.8	3.3	3.3	4.3
266130	PENOYER VALLEY*	Penoyer Valley	170	5	1968	2004	5.1	4.3	4.3	3.5	4.2	4.2	5.4
267983	TEMPIUTE 4 NW*	Penoyer Valley	170	12	1973	1984	5.1	4.4	4.4	3.6	4.3	4.3	5.4
266228	PILOT VALLEY-LEE*	Pilot Creek Valley	191	6	2000	2007	4.2	3.4	3.3	2.7	3.1	3.1	4.4
266504	QUINN RVR CROSSING	Pine Forest Valley	29	10	1902	1950	4.5	3.6	3.5	2.8	3.4	3.3	4.8
266242	PINE VALLEY BAILEY RCH*	Pine Valley	53	11	1983	2003	4.5	3.4	3.2	2.7	3.0	3.0	4.7
266574	RAND RCH PALISADE*	Pine Valley	53	19	1958	1981	4.3	3.0	3.0	2.5	2.8	2.8	4.6
267369	SEARCHLIGHT	Piute Valley	214	30	1976	2006	5.0	4.7	4.1	3.3	3.3	4.7	5.2
265440	MT ROSE BOWL	Pleasant Valley	88	8	1974	1984	3.3	2.0	2.0	1.6	1.9	1.8	3.5

Appendix 11b cont.

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266055	PARIS RCH*	Pleasant Valley	130	22	1967	1990	4.6	4.2	4.1	3.4	3.9	4.0	4.9
262229	DENIO*	Pueblo Valley	1	30	1970	2005	4.3	3.7	3.6	3.0	3.5	3.5	4.5
265605	NIXON*	Pyramid Lake Valley	81	30	1931	1973	4.8	4.1	4.0	3.2	3.8	3.9	5.0
267953	SUTCLIFFE	Pyramid Lake Valley	81	27	1968	2006	3.9	3.7	3.4	2.8	3.3	3.6	4.1
265362	MONTGOMERY MNTC STN	Queen Valley	116	10	1961	1978	4.1	2.8	2.7	2.1	2.4	2.5	4.3
264935	MCDERMITT*	Quinn River Valley	33B	29	1974	2007	4.3	3.4	3.2	2.7	2.9	3.0	4.5
265818	OROVADA 3 W*	Quinn River Valley	33A	30	1973	2006	4.4	3.9	3.8	3.1	3.6	3.6	4.6
260955	BLUE EAGLE RCH HANKS*	Railroad Valley	173B	23	1979	2007	4.8	4.4	4.3	3.6	4.2	4.3	5.0
262091	CURRANT HWY STN	Railroad Valley	173B	7	1964	1977	4.3	3.0	3.0	2.4	2.7	2.7	4.5
262078	CURRANT*	Railroad Valley	173B	4	1942	1946	4.4	3.8	3.8	3.1	3.7	3.6	4.6
262276	DIABLO*	Railroad Valley	173A	10	1960	1978	4.8	4.2	4.1	3.4	4.0	4.1	5.0
262390	DUCKWATER*	Railroad Valley	173B	19	1967	1998	4.5	3.9	3.8	3.1	3.7	3.6	4.7
268170	TONOPAH*	Ralston Valley	141	30	1975	2005	5.1	4.4	4.3	3.6	4.3	4.3	5.3
29999	RED ROCK WC*	Red Rock Valley	99	4	2004	2007	4.0	3.1	2.9	2.4	2.9	2.7	4.2
260438	ARTHUR 4 NW*	Ruby Valley	176	30	1972	2007	3.8	3.1	3.0	2.5	2.9	2.8	4.0
267123	RUBY LAKE*	Ruby Valley	176	30	1976	2007	4.2	3.5	3.4	2.8	3.3	3.2	4.4

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261905	CONTACT*	Salmon Falls Creek Area	40	30	1958	1998	4.2	3.4	3.2	2.7	3.0	3.0	4.4
264016	JACKPOT*	Salmon Falls Creek Area	40	15	1987	2004	3.9	3.2	3.2	2.6	3.0	3.0	4.1
264268	KNOLL CREEK FLD STN	Salmon Falls Creek Area	40	6	1972	1979	4.0	2.9	2.7	2.1	2.5	2.4	4.2
267284	SAN JACINTO*	Salmon Falls Creek Area	40	21	1905	1947	4.1	3.2	3.0	2.5	2.9	2.8	4.3
262662	EMPIRE*	San Emidio Desert	22	6	1951	1976	4.4	3.9	3.9	3.2	3.8	3.9	4.6
263090	GERLACH*	San Emidio Desert	22	27	1963	2006	4.2	3.8	3.7	3.0	3.6	3.7	4.4
267319	SARCOBATUS*	Sarcobatus Flat	146	14	1942	1961	5.3	4.4	4.3	3.4	3.9	4.3	5.5
267609	SMITH 1 N*	Smith Valley	107	23	1938	1966	4.4	3.6	3.5	2.9	3.3	3.4	4.6
267612	SMITH 6 N*	Smith Valley	107	23	1974	2007	4.3	3.7	3.6	3.0	3.4	3.5	4.5
268977	WELLINGTON RS*	Smith Valley	107	27	1943	1972	4.2	3.6	3.5	2.9	3.4	3.5	4.4
267261	SAND PASS*	Smoke Creek Desert	21	30	1931	1970	4.5	4.0	4.0	3.3	3.9	3.9	4.7
267618	SMOKE CREEK ESPIL*	Smoke Creek Desert	21	14	1988	2004	4.7	4.2	4.1	3.4	4.0	4.0	4.9
263340	GREAT BASIN NP	Snake Valley	195	16	1988	2007	3.7	3.1	3.0	2.5	2.9	2.9	3.8
264514	LEHMAN CAVES NM	Snake Valley	195	30	1958	1987	3.6	2.9	2.8	2.3	2.7	2.6	3.8

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265168	MINA*	Soda Spring Valley	121A	30	1978	2007	4.9	4.3	4.1	3.3	3.9	4.1	5.1
263940	I-L RCH*	South Fork Owyhee River Area	35	3	1963	1967	4.2	3.0	2.9	2.4	2.8	2.7	4.4
267450	SHOSHONE 5 N*	Spring Valley	184	17	1989	2007	4.5	3.7	3.6	3.0	3.5	3.5	4.7
267750	SPRING VALLEY SP*	Spring Valley	201	24	1975	2007	4.9	3.6	3.5	2.8	3.3	3.2	5.1
267397	SEVENTY ONE RCH*	Starr Valley Area	43	4	1940	1951	4.1	3.3	2.9	2.4	2.8	2.7	4.3
262096	CURRIE HWY STN*	Steptoe Valley	179	10	1962	1989	4.7	3.2	3.1	2.5	2.9	2.8	4.9
262626	ELY 6 NE	Steptoe Valley	179	5	2000	2005	4.8	4.0	3.9	3.3	3.7	3.7	5.1
262631	ELY YELLAND FLD AP*	Steptoe Valley	179	30	1976	2005	4.5	3.5	3.3	2.7	3.2	3.0	4.7
264341	LAGES*	Steptoe Valley	179	21	1984	2006	4.5	3.6	3.5	2.8	3.3	3.2	4.7
264950	MCGILL*	Steptoe Valley	179	30	1977	2007	4.2	3.6	3.5	2.9	3.3	3.3	4.4
265760	OLD RUTH	Steptoe Valley	179	5	1979	1985	3.8	2.9	2.9	2.3	2.7	2.6	4.0
267175	RUTH	Steptoe Valley	179	30	1963	2007	4.3	3.0	2.7	2.3	2.6	2.5	4.5
268810	VYA	Surprise Valley	14	14	1960	1975	3.6	2.7	2.5	2.1	2.4	2.3	3.8
260668	BASALT	Teels Marsh Valley	114	10	1942	1957	4.4	3.4	3.4	2.7	3.3	3.2	4.7
265352	MONTELLO 2 SE*	Thousand Springs Valley	189D	30	1971	2007	4.4	3.5	3.4	2.7	3.2	3.1	4.6

Appendix 11b cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
269122	WILKINS*	Thousand Springs Valley	189A	16	1949	1964	4.3	2.9	2.8	2.3	2.7	2.5	4.5
268834	WADSWORTH*	Tracy Segment	83	6	1902	1947	4.6	4.1	3.8	3.1	3.5	3.6	4.9
266779	RENO TAHOE INTL AP*	Truckee Meadows	87	30	1978	2007	4.4	4.0	3.8	3.2	3.8	3.9	4.7
266791	RENO WFO*	Truckee Meadows	87	10	1997	2007	4.2	3.9	3.7	3.0	3.6	3.8	4.4
268500	UNIV OF NEVADA EXP FM*	Truckee Meadows	87	4	1949	1954	4.4	4.0	3.8	3.2	3.8	3.9	4.6
260507	AUSTIN #2*	Upper Reese River Valley	56	30	1972	2007	4.1	3.4	3.3	2.7	3.1	3.1	4.3
261630	CENTRAL NEVADA FLD LAB*	Upper Reese River Valley	56	13	1966	1985	4.5	3.3	3.1	2.6	3.0	2.9	4.7
266746	REESE RIVER*	Upper Reese River Valley	56	26	1973	2006	4.3	3.0	2.8	2.2	2.6	2.5	4.5
261327	BUNKERVILLE*	Virgin River Valley	222	6	1980	2007	5.1	4.8	4.0	3.3	3.1	4.7	5.4
265085	MESQUITE*	Virgin River Valley	222	13	1942	2006	5.1	5.0	4.4	3.6	3.3	5.0	5.4
262394	DUFURRENA*	Virgin Valley	4	30	1967	2004	4.4	3.3	3.1	2.6	3.0	2.9	4.6
263515	HAWTHORNE AP*	Walker Lake Valley	110C	30	1948	1990	4.7	4.2	3.9	3.2	3.8	4.0	5.0
263512	HAWTHORNE*	Walker Lake Valley	110C	13	1955	2007	4.8	4.3	4.0	3.2	3.7	3.9	5.0
267358	SCHURZ*	Walker Lake Valley	110A	30	1921	1955	4.6	3.9	3.9	3.2	3.8	3.9	4.9

Appendix 11b cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
268034	THORNE*	Walker Lake Valley	110C	24	1915	1950	4.6	4.1	3.9	3.1	3.8	3.9	4.8
264542	LEWERS RCH	Washoe Valley	89	15	1893	1913	4.5	3.9	3.6	2.9	3.5	3.4	4.7
39999	WASHOE VALLEY WC*	Washoe Valley	89	5	2004	2008	5.2	4.4	4.2	3.4	4.0	3.9	5.5
264199	KIMBERLY	White River Valley	207	28	1929	1958	3.9	3.0	2.9	2.4	2.8	2.7	4.1
264745	LUND*	White River Valley	207	30	1977	2007	4.5	3.9	3.8	3.2	3.7	3.7	4.8
267908	SUNNYSIDE*	White River Valley	207	30	1974	2007	4.7	4.0	3.8	3.1	3.6	3.6	4.9
265105	MIDAS 4 SE*	Willow Creek Valley	63	4	1962	1967	4.4	3.1	3.1	2.6	2.9	2.9	4.7
263245	GOLCONDA*	Winnemucca Segment	70	30	1970	2005	4.6	4.0	3.9	3.2	3.8	3.8	4.8
269171	WINNEMUCCA MUNI AP*	Winnemucca Segment	70	30	1978	2007	4.7	3.9	3.8	3.1	3.6	3.6	4.9

Appendix 12a. Mean annual Net Irrigation Water Requirement (NIWR) for each NWS weather station, sorted by station name. * Station was used in averaging or assigning NIWR to respective hydrographic areas. Number of years used for average and start and end years listed are for alfalfa and may vary slightly for other crop types due to possible missing data within crop specific growing seasons. See statistic data files for further details.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
260046	ADAVEN	Garden Valley	172	30	1947	1978	2.5	2.6	2.0	2.5	2.4	2.9
260099	ALAMO*	Pahranagat Valley	209	29	1922	1958	4.6	4.2	3.3	3.9	4.3	5.3
260150	AMARGOSA FARMS-GAREY*	Amargosa Desert	230	28	1966	2005	5.3	4.5	3.6	3.6	5.3	5.8
260282	ANTELOPE VALLEY FARR*	Antelope Valley	57	8	1985	1998	3.0	3.1	2.4	3.0	3.0	3.9
260438	ARTHUR 4 NW*	Ruby Valley	176	30	1971	2007	2.3	2.3	1.8	2.3	2.2	2.7
260507	AUSTIN #2*	Upper Reese River Valley	56	30	1972	2007	2.7	2.7	2.1	2.6	2.5	3.1
260668	BASALT	Teels Marsh Valley	114	10	1942	1957	3.2	3.2	2.5	3.1	3.0	4.2
260691	BATTLE MTN AP*	Lower Reese River Valley	59	30	1973	2006	3.0	3.1	2.4	2.9	3.0	3.8
260688	BATTLE MTN*	Clovers Area	64	25	1899	1944	3.5	3.4	2.8	3.3	3.3	4.3
260718	BEATTY 8 N*	Oasis Valley	228	28	1973	2004	4.5	3.9	3.1	3.8	4.5	5.1
260715	BEATTY*	Oasis Valley	228	30	1921	1972	4.9	4.3	3.4	4.0	4.8	5.5
260800	BEOWAWE U OF N RCH*	Grass Valley	138	28	1973	2006	2.7	2.8	2.2	2.7	2.7	3.5
260795	BEOWAWE*	Crescent Valley	54	30	1976	2006	2.9	3.0	2.4	2.9	2.9	3.7

Appendix 12a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
260955	BLUE EAGLE RCH HANKS*	Railroad Valley	173B	23	1979	2007	3.7	3.7	2.9	3.5	3.7	4.3
260961	BLUE JAY HWY STN*	Hot Creek	156	7	1964	1983	3.3	3.4	2.6	3.3	3.2	4.3
261071	BOULDER CITY*	Eldorado Valley	167	30	1968	2004	4.6	3.9	3.1	2.9	4.6	5.1
261160	BRINKERHOFF RCH*	Dixie Valley	128	7	1967	1979	3.6	3.5	2.8	3.4	3.6	4.3
261311	BUFFALO RCH*	Buffalo Valley	131	7	1967	1978	2.8	2.8	2.2	2.7	2.8	3.0
261327	BUNKERVILLE*	Virgin River Valley	222	6	1980	2007	4.3	3.7	2.9	2.9	4.3	4.9
261358	CALIENTE*	Clover Valley	204	22	1904	2005	3.8	3.7	2.9	3.4	3.6	4.4
261371	CALLVILLE BAY*	Black Moutains Area	215	8	1990	2003	4.9	4.1	3.3	2.8	4.9	5.5
261415	CARLIN NEWMONT MINE	Boulder Flat	61	24	1967	1999	2.0	2.0	1.6	1.9	1.9	2.3
261485	CARSON CITY*	Eagle Valley	104	30	1973	2007	3.2	3.1	2.5	3.0	3.1	3.7
261590	CATHEDRAL GORGE SP*	Panaca Valley	203	4	2003	2007	3.7	3.6	2.8	3.5	3.5	4.2
261630	CENTRAL NEVADA FLD LAB*	Upper Reese River Valley	56	13	1966	1985	2.7	2.6	2.0	2.5	2.4	4.1
261660	CHARLESTON*	Bruneau River Area	38	4	1962	2005	1.6	1.5	1.1	1.2	1.3	3.3
261740	CLOVER VALLEY*	Clover Valley	177	30	1923	2007	2.5	2.6	2.1	2.5	2.5	3.1
261755	COALDALE JUNCTION*	Columbus Salt Marsh Valley	118	6	1942	1957	4.4	4.2	3.3	4.1	4.1	5.4

Appendix 12a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
261905	CONTACT*	Salmon Falls Creek Area	40	30	1956	1998	2.6	2.4	1.9	2.3	2.3	3.5
261975	CORTEZ GOLD MINE*	Crescent Valley	54	10	1969	1979	2.9	2.9	2.3	2.8	2.8	3.5
262091	CURRANT HWY STN	Railroad Valley	173B	7	1964	1977	2.5	2.5	2.0	2.3	2.3	3.8
262078	CURRANT*	Railroad Valley	173B	4	1942	1946	3.3	3.4	2.6	3.2	3.2	4.1
262096	CURRIE HWY STN*	Steptoe Valley	179	10	1962	1989	2.8	2.7	2.1	2.5	2.5	4.3
262119	DAGGET PASS	Lake Tahoe Basin	90	5	1989	2005	1.9	1.9	1.4	1.7	1.7	1.3
262229	DENIO*	Pueblo Valley	1	30	1969	2005	3.1	3.1	2.5	3.0	3.0	3.7
262243	DESERT NWR*	Las Vegas Valley	212	30	1974	2007	5.5	4.7	3.7	4.0	5.4	6.1
262276	DIABLO*	Railroad Valley	173A	10	1960	1978	3.7	3.7	3.0	3.5	3.7	4.5
262296	DIAMOND VALLEY USDA*	Diamond Valley	153	19	1980	2006	2.5	2.5	2.0	2.4	2.4	3.5
262390	DUCKWATER*	Railroad Valley	173B	19	1967	1998	3.3	3.3	2.6	3.2	3.1	4.1
262394	DUFURRENA*	Virgin Valley	4	30	1965	2004	2.8	2.7	2.1	2.6	2.5	4.0
262431	DYER*	Fish Lake Valley	117	30	1974	2007	4.2	4.1	3.2	4.1	4.0	5.4
262477	EASTGATE*	Eastgate Valley Area	127	4	1957	1963	3.4	3.4	2.7	3.4	3.4	4.2
262497	ECHO BAY*	Black Moutains Area	215	10	1990	2003	4.5	3.8	3.0	2.6	4.6	5.1
262562	ELGIN 3 SE*	Lower Meadow Valley Wash	205	15	1966	1985	3.8	3.2	2.5	2.9	3.8	3.9

Appendix 12a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
262557	ELGIN*	Lower Meadow Valley Wash	205	20	1986	2006	3.9	3.4	2.7	3.3	3.9	4.2
262573	ELKO RGNL AP*	Elko Segment	49	30	1978	2007	2.6	2.6	2.1	2.5	2.5	3.3
262570	ELKO*	Elko Segment	49	6	2000	2007	2.6	2.7	2.1	2.6	2.5	3.2
262626	ELY 6 NE	Steptoe Valley	179	5	2000	2005	3.4	3.4	2.7	3.1	3.2	4.4
262631	ELY YELLAND FLD AP*	Steptoe Valley	179	30	1976	2005	2.8	2.7	2.1	2.6	2.5	3.9
262656	EMIGRANT PASS HWY STN	Boulder Flat	61	27	1964	1999	2.4	2.5	2.0	2.4	2.4	2.9
262662	EMPIRE*	San Emidio Desert	22	6	1951	1976	3.5	3.5	2.8	3.4	3.5	4.1
262708	EUREKA	Diamond Valley	153	30	1975	2007	2.3	2.3	1.7	2.2	2.1	2.8
262780	FALLON EXP STN*	Carson Desert	101	30	1973	2005	3.2	3.2	2.5	3.1	3.2	3.9
262820	FERGUSON SPRINGS HMS*	Great Salt Lake Desert	192	7	1973	1982	2.3	2.4	1.9	2.3	2.2	3.1
262840	FERNLEY*	Fernley Area	76	21	1908	1974	3.5	3.4	2.7	3.3	3.3	4.3
262860	FISH CREEK RCH*	Little Smoky Valley	155A	14	1944	1964	2.8	2.8	2.2	2.6	2.6	4.4
263090	GERLACH*	San Emidio Desert	22	27	1963	2006	3.1	3.2	2.5	3.1	3.2	3.7
263101	GEYSER RCH*	Lake Valley	183	19	1905	2002	3.0	2.9	2.3	2.7	2.7	4.0
263114	GIBBS RCH*	Marys River Area	42	30	1972	2006	2.3	2.3	1.8	2.2	2.1	3.2
263205	GLENBROOK*	Lake Tahoe Basin	90	30	1969	2007	2.3	2.2	1.7	2.1	2.1	2.2
263245	GOLCONDA*	Winnemucca Segment	70	30	1970	2005	3.4	3.4	2.7	3.3	3.4	4.2

Appendix 12a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
263285	GOLDFIELD	Alkali Spring Valley	142	30	1951	2004	3.4	3.3	2.6	3.2	3.2	4.2
263316	GOODSPRINGS*	Ivanpah Valley	164A	6	2000	2006	5.2	4.4	3.5	3.7	5.1	5.6
263340	GREAT BASIN NP	Snake Valley	195	16	1988	2007	2.3	2.4	1.8	2.3	2.3	2.7
263515	HAWTHORNE AP*	Walker Lake Valley	110C	30	1947	1990	3.8	3.6	2.8	3.5	3.6	4.6
263512	HAWTHORNE*	Walker Lake Valley	110C	13	1955	2007	3.9	3.6	2.8	3.4	3.6	4.6
263671	HIKO*	Pahranagat Valley	209	15	1990	2006	4.1	3.7	2.9	3.5	3.9	4.6
263853	HUMBOLDT FLD	Buena Vista Valley	129	7	1940	1947	3.2	3.2	2.5	3.1	3.1	4.0
263940	I-L RCH*	South Fork Owyhee River Area	35	3	1963	1967	1.8	1.9	1.5	2.0	1.8	3.1
263957	IMLAY*	Imlay Area	72	30	1964	2007	3.4	3.3	2.6	3.2	3.3	4.0
263980	INDIAN SPRINGS*	Indian Springs Valley	161	23	1914	1964	5.2	4.7	3.7	4.1	5.0	6.0
264016	JACKPOT*	Salmon Falls Creek Area	40	15	1987	2004	2.5	2.5	2.0	2.4	2.4	3.3
264039	JARBIDGE 7 N*	Jarbidge River Area	39	11	1996	2006	2.3	2.3	1.7	2.2	2.1	2.7
264038	JARBRIDGE 4 N	Jarbidge River Area	39	22	1917	1995	2.1	1.9	1.4	1.7	1.7	2.3
264095	JIGGS 8 SSE ZAGA*	Huntington Valley	47	19	1979	2007	2.4	2.4	1.8	2.2	2.2	3.0
264108	JUNGO MEYER RCH*	Desert Valley	31	7	1969	1985	3.1	3.2	2.5	3.1	3.1	3.8
264199	KIMBERLY	White River Valley	207	28	1929	1958	2.4	2.4	1.9	2.3	2.2	3.0

Appendix 12a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
264268	KNOLL CREEK FLD STN	Salmon Falls Creek Area	40	6	1972	1979	2.4	2.3	1.7	2.1	2.0	3.6
264314	KYLE CANYON RS	Las Vegas Valley	212	4	1940	1948	2.8	2.6	2.0	2.7	2.3	3.1
264341	LAGES*	Steptoe Valley	179	21	1984	2006	3.0	3.0	2.3	2.9	2.8	4.0
264349	LAHONTAN DAM*	Churchill Valley	102	30	1966	2003	3.4	3.2	2.6	3.1	3.4	4.0
264384	LAKE VALLEY STEWARD	Lake Valley	183	22	1971	1998	2.4	2.5	1.9	2.4	2.3	2.7
264395	LAMOILLE PH	Lamoille Valley	45	30	1934	1972	2.1	2.2	1.7	2.1	2.1	2.2
264394	LAMOILLE YOST*	Lamoille Valley	45	22	1976	2003	2.3	2.3	1.8	2.2	2.1	2.9
264439	LAS VEGAS NWFO*	Las Vegas Valley	212	9	1997	2007	5.1	4.3	3.3	3.2	5.0	5.6
264436	LAS VEGAS WB AP*	Las Vegas Valley	212	30	1976	2005	5.2	4.5	3.7	3.2	5.4	5.7
23112	LAS VEGAS*	Las Vegas Valley	212	22	1949	1970	5.5	4.8	3.9	3.6	5.6	6.0
264429	LAS VEGAS*	Las Vegas Valley	212	30	1915	1955	6.1	5.3	4.2	4.1	6.2	6.5
264457	LATHROP WELLS	Fortymile Canyon	227A	8	1943	1963	5.2	4.6	3.6	3.8	5.3	5.8
264480	LAUGHLIN*	Colorado Valley	213	10	1989	2006	5.8	5.0	3.9	3.6	5.8	6.4
264514	LEHMAN CAVES NM	Snake Valley	195	30	1958	1987	2.1	2.2	1.7	2.1	2.0	2.6
264527	LEONARD CREEK RCH*	Black Rock Desert	28	30	1971	2004	3.2	3.2	2.5	3.1	3.2	3.6
264542	LEWERS RCH	Washoe Valley	89	15	1893	1913	3.2	3.1	2.4	3.1	2.9	2.7

Appendix 12a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
264600	LITTLE RED ROCK	Las Vegas Valley	212	4	1966	1970	4.3	3.7	2.8	3.3	4.2	4.7
264651	LOGANDALE*	Lower Moapa Valley	220	20	1969	1991	4.3	3.7	3.0	2.9	4.5	4.8
264700	LOVELOCK DERBY FLD*	Lovelock Valley	73	30	1970	2005	3.7	3.7	3.0	3.6	3.6	4.5
264745	LUND*	White River Valley	207	30	1977	2007	3.1	3.1	2.4	2.9	2.9	3.9
264824	MALA VISTA RCH*	Marys River Area	42	16	1940	1965	2.4	2.3	1.8	2.2	2.2	3.5
264858	MARLETTE LAKE	Lake Tahoe Basin	90	19	1917	1952	1.4	1.5	1.1	1.4	1.3	0.7
264935	MCDERMITT*	Quinn River Valley	33B	29	1916	2007	2.8	2.7	2.1	2.3	2.5	3.8
264950	MCGILL*	Steptoe Valley	179	30	1977	2007	2.9	2.8	2.2	2.7	2.7	3.6
265085	MESQUITE*	Virgin River Valley	222	13	1942	2006	4.4	3.9	3.1	2.9	4.5	4.8
265092	METROPOLIS*	Marys River Area	42	18	1966	1994	2.4	2.4	1.9	2.4	2.3	2.8
265105	MIDAS 4 SE*	Willow Creek Valley	63	4	1962	1967	2.4	2.5	2.0	2.4	2.4	3.9
265132	MIDDLEGATE-LOWERY*	Cowkick Valley	126	15	1989	2007	3.4	3.2	2.5	3.1	3.0	4.5
265168	MINA*	Soda Spring Valley	121A	30	1978	2007	3.9	3.7	2.9	3.6	3.7	4.6
265191	MINDEN*	Carson Valley	105	30	1975	2007	3.0	3.0	2.4	2.9	3.0	3.7
265352	MONTELLO 2 SE*	Thousand Springs Valley	189D	30	1971	2007	2.9	2.9	2.2	2.8	2.6	4.0

Appendix 12a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
265362	MONTGOMERY MNTC STN	Queen Valley	116	10	1961	1978	2.3	2.3	1.8	2.1	2.1	3.6
265371	MOORMAN RCH*	Jakes Valley	174	4	2003	2007	2.7	2.6	2.0	2.5	2.4	3.7
265400	MT CHARLESTON FS	Las Vegas Valley	212	6	1949	2007	2.8	2.3	1.8	2.7	2.1	3.2
265440	MT ROSE BOWL	Pleasant Valley	88	8	1974	1984	1.6	1.7	1.3	1.6	1.5	1.0
265392	MTN CITY RS*	Owyhee River Area	37	30	1965	1998	2.1	2.0	1.6	1.9	1.8	3.3
265605	NIXON*	Pyramid Lake Valley	81	30	1931	1973	3.6	3.5	2.8	3.4	3.5	4.4
265705	NORTH LAS VEGAS*	Las Vegas Valley	212	20	1952	2006	5.9	5.2	4.2	3.9	6.0	6.4
265722	OASIS*	Goshute Valley	187	17	1988	2006	2.8	2.7	2.1	2.6	2.5	3.7
265760	OLD RUTH	Steptoe Valley	179	5	1979	1985	2.1	2.3	1.7	2.1	2.0	2.8
265818	OROVADA 3 W*	Quinn River Valley	33A	30	1971	2006	3.1	3.1	2.5	3.0	3.1	3.7
265846	OVERTON*	Lower Moapa Valley	220	30	1950	2007	4.6	4.0	3.2	2.9	4.7	5.1
265869	OWYHEE*	Owyhee River Area	37	30	1953	1984	2.3	2.4	1.9	2.3	2.2	2.8
265880	PAHRANAGAT WR*	Pahranagat Valley	209	30	1968	2006	4.3	3.8	3.0	3.5	4.2	4.9
265890	PAHRUMP*	Pahrump Valley	162	30	1973	2006	5.0	4.4	3.6	3.8	5.1	5.6
265907	PAHUTE MEADOWS RCH*	Black Rock Desert	28	4	1964	1974	3.2	3.2	2.6	3.2	3.1	3.8

Appendix 12a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
265931	PALMETTO	Fish Lake Valley	117	14	1891	1907	2.8	2.8	2.2	2.5	2.6	3.7
266005	PARADISE VALLEY 1 NW*	Paradise Valley	69	30	1972	2007	3.2	3.2	2.5	3.0	3.0	4.0
266055	PARIS RCH*	Pleasant Valley	130	22	1967	1990	3.5	3.4	2.8	3.3	3.4	4.1
266130	PENOYER VALLEY*	Penoyer Valley	170	5	1968	2004	3.9	4.0	3.2	3.8	3.9	4.9
266148	PEQUOP	Goshute Valley	187	23	1960	1985	2.4	2.3	1.8	2.3	2.1	3.2
266228	PILOT VALLEY-LEE*	Pilot Creek Valley	191	6	2000	2007	2.9	2.8	2.2	2.7	2.6	3.6
266242	PINE VALLEY BAILEY RCH*	Pine Valley	53	11	1983	2003	2.7	2.6	2.0	2.3	2.4	3.8
266252	PIOCHE	Patterson Valley	202	30	1968	2006	2.8	2.7	2.1	2.6	2.6	3.1
266504	QUINN RVR CROSSING	Pine Forest Valley	29	10	1902	1950	3.1	3.1	2.4	3.0	3.0	4.3
266574	RAND RCH PALISADE*	Pine Valley	53	19	1958	1981	2.3	2.3	1.8	2.2	2.2	3.7
266630	RATTLESNAKE	Hot Creek	156	13	1949	1961	3.2	3.3	2.6	3.2	3.1	4.1
266691	RED ROCK CANYON SP	Las Vegas Valley	212	20	1978	2006	4.4	3.9	3.1	3.4	4.5	4.7
29999	RED ROCK WC*	Red Rock Valley	99	4	2004	2007	2.6	2.6	2.0	2.5	2.4	3.4
266746	REESE RIVER*	Upper Reese River Valley	56	26	1973	2006	2.5	2.4	1.8	2.2	2.1	3.9
266748	REESE VALLEY CARPER	Middle Reese River Valley	58	6	1977	1983	2.8	2.8	2.2	2.6	2.6	3.7
266779	RENO TAHOE INTL AP*	Truckee Meadows	87	30	1978	2007	3.5	3.4	2.7	3.3	3.5	4.0

Appendix 12a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
266791	RENO WFO*	Truckee Meadows	87	10	1997	2007	3.3	3.2	2.6	3.2	3.4	3.7
267123	RUBY LAKE*	Ruby Valley	176	30	1975	2007	2.8	2.8	2.2	2.7	2.6	3.3
267175	RUTH	Steptoe Valley	179	30	1963	2007	2.3	2.2	1.7	2.1	2.0	3.5
267192	RYE PATCH DAM*	Imlay Area	72	30	1973	2007	3.6	3.5	2.8	3.4	3.4	4.3
267188	RYNDON*	North Fork Area	44	6	2000	2007	2.6	2.6	2.0	2.5	2.4	3.6
267284	SAN JACINTO*	Salmon Falls Creek Area	40	21	1905	1947	2.6	2.4	1.9	2.3	2.3	3.6
267261	SAND PASS*	Smoke Creek Desert	21	30	1930	1970	3.5	3.6	2.8	3.4	3.6	4.2
267319	SARCOBATUS*	Sarcobatus Flat	146	14	1942	1961	4.2	4.0	3.2	3.7	4.2	5.2
267324	SAVAL RCH*	North Fork Area	44	5	1961	1965	1.8	1.7	1.3	1.7	1.6	2.7
267358	SCHURZ*	Walker Lake Valley	110A	30	1920	1955	3.5	3.5	2.8	3.4	3.5	4.4
267369	SEARCHLIGHT	Piute Valley	214	30	1976	2006	4.2	3.6	2.8	3.0	4.2	4.6
267397	SEVENTY ONE RCH*	Starr Valley Area	43	4	1940	1945	2.4	2.3	1.8	2.2	2.2	3.3
267443	SHELDON	Guano Valley	6	30	1942	1972	1.8	1.8	1.4	1.7	1.7	2.6
267450	SHOSHONE 5 N*	Spring Valley	184	17	1989	2007	3.0	3.0	2.4	2.9	2.9	3.9
267463	SILVERPEAK*	Clayton Valley	143	30	1974	2007	4.4	4.3	3.4	3.9	4.4	5.3
267609	SMITH 1 N*	Smith Valley	107	23	1938	1966	3.0	3.0	2.4	2.8	2.9	4.0
267612	SMITH 6 N*	Smith Valley	107	23	1974	2007	3.1	3.1	2.5	3.0	3.1	4.0
267618	SMOKE CREEK ESPIL*	Smoke Creek Desert	21	14	1988	2004	3.6	3.6	2.9	3.5	3.6	4.3

Appendix 12a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
267620	SMOKEY VALLEY*	Big Smoky Valley	137B	30	1975	2007	3.6	3.5	2.8	3.5	3.4	4.5
267640	SNOWBALL RCH	Little Smoky Valley	155A	30	1972	2002	2.4	2.3	1.7	2.1	2.1	3.5
267690	SOUTH FORK SP*	Dixie Creek - Tenmile	48	8	1994	2007	2.8	2.7	2.1	2.4	2.6	3.7
267750	SPRING VALLEY SP*	Spring Valley	201	24	1975	2006	3.0	2.9	2.3	2.8	2.6	4.1
267806	STATELINE-HARRAH'S*	Lake Tahoe Basin	90	13	1985	1998	2.4	2.4	1.9	2.3	2.3	2.7
267820	STEAD*	Lemmon Valley	92B	14	1986	2006	3.1	3.1	2.5	3.0	3.1	3.4
267873	SULPHUR*	Black Rock Desert	28	21	1915	1953	3.4	3.4	2.7	3.4	3.3	4.2
267908	SUNNYSIDE*	White River Valley	207	30	1973	2007	3.3	3.3	2.5	3.1	3.1	4.1
267953	SUTCLIFFE	Pyramid Lake Valley	81	27	1968	2006	3.1	2.9	2.3	2.9	3.1	3.5
267983	TEMPIUTE 4 NW*	Penoyer Valley	170	12	1973	1984	3.8	3.8	3.1	3.7	3.8	4.7
268034	THORNE*	Walker Lake Valley	110C	24	1915	1950	3.8	3.7	2.9	3.6	3.7	4.6
268170	TONOPAH*	Ralston Valley	141	30	1975	2005	4.0	3.9	3.1	3.9	3.9	4.8
268186	TOPAZ LAKE 3N*	Antelope Valley	106	19	1958	1980	3.3	3.3	2.6	3.1	3.1	4.2
268202	TOPAZ LAKE 4 N*	Antelope Valley	106	11	1987	1997	3.2	3.1	2.5	3.2	3.2	3.7
268346	TUSCARORA*	Independence Valley	36	30	1973	2006	2.2	2.2	1.7	2.1	2.0	2.8
268443	TWIN SPRING FALLINI*	Hot Creek	156	10	1986	2005	3.5	3.5	2.8	3.4	3.3	4.4

Appendix 12a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
268500	UNIV OF NEVADA EXP FM*	Truckee Meadows	87	4	1949	1954	3.4	3.3	2.7	3.3	3.5	3.9
268538	URSINE	Eagle Valley	200	4	1965	1972	3.4	3.6	2.8	3.4	3.5	4.0
268588	VALLEY OF FIRE SP	Black Moutains Area	215	30	1977	2007	4.2	3.5	2.7	2.6	4.2	4.7
268761	VIRGINIA CITY	Dayton Valley	103	30	1974	2007	2.4	2.4	1.8	2.3	2.3	2.6
268810	VYA	Surprise Valley	14	14	1960	1975	2.0	1.9	1.5	1.8	1.8	2.7
268822	WABUSKA 6 SE*	Mason Valley	108	27	1973	2006	3.1	3.0	2.4	2.9	3.0	4.0
268838	WADSWORTH 4 N*	Dodge Flat	82	21	1975	2002	3.5	3.4	2.7	3.3	3.3	4.3
268834	WADSWORTH*	Tracy Segment	83	6	1902	1947	3.6	3.4	2.7	3.1	3.3	4.3
39999	WASHOE VALLEY WC*	Washoe Valley	89	5	2004	2008	3.7	3.8	2.9	3.5	3.5	4.7
268977	WELLINGTON RS*	Smith Valley	107	27	1943	1972	3.0	3.0	2.4	2.9	3.0	3.7
268988	WELLS*	Marys River Area	42	30	1975	2004	2.5	2.4	1.9	2.3	2.2	3.4
269072	WILDHORSE RSVR*	Owyhee River Area	37	18	1983	2006	1.8	1.7	1.3	1.6	1.5	3.0
269122	WILKINS*	Thousand Springs Valley	189A	16	1949	1964	2.2	2.2	1.7	2.1	2.0	3.6
269137	WILLOW SPRINGS*	Big Smoky Valley	137A	4	1942	1948	3.7	3.6	2.9	3.6	3.4	4.7
269168	WINNEMUCCA #2*	Grass Valley	71	6	2000	2007	3.3	3.4	2.6	3.2	3.2	4.0

Appendix 12a cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
269171	WINNEMUCCA MUNI AP*	Winnemucca Segment	70	30	1978	2007	3.4	3.3	2.6	3.1	3.2	4.2
269229	YERINGTON*	Mason Valley	108	30	1965	2007	3.1	3.0	2.4	2.9	3.1	3.8

Appendix 12b. Mean annual Net Irrigation Water Requirement (NIWR) for each NWS weather station, sorted by basin name.
* Station was used in averaging or assigning NIWR to respective hydrographic areas. Number of years used for average and start and end years listed are for alfalfa and may vary slightly for other crop types due to possible missing data within crop specific growing seasons.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
263285	GOLDFIELD	Alkali Spring Valley	142	30	1951	2004	3.4	3.3	2.6	3.2	3.2	4.2
260150	AMARGOSA FARMS-GAREY*	Amargosa Desert	230	28	1966	2005	5.3	4.5	3.6	3.6	5.3	5.8
260282	ANTELOPE VALLEY FARR*	Antelope Valley	57	8	1985	1998	3.0	3.1	2.4	3.0	3.0	3.9
268186	TOPAZ LAKE 3N*	Antelope Valley	106	19	1958	1980	3.3	3.3	2.6	3.1	3.1	4.2
268202	TOPAZ LAKE 4 N*	Antelope Valley	106	11	1987	1997	3.2	3.1	2.5	3.2	3.2	3.7
267620	SMOKEY VALLEY*	Big Smoky Valley	137B	30	1975	2007	3.6	3.5	2.8	3.5	3.4	4.5
269137	WILLOW SPRINGS*	Big Smoky Valley	137A	4	1942	1948	3.7	3.6	2.9	3.6	3.4	4.7
261371	CALLVILLE BAY*	Black Moutains Area	215	8	1990	2003	4.9	4.1	3.3	2.8	4.9	5.5
262497	ECHO BAY*	Black Moutains Area	215	10	1990	2003	4.5	3.8	3.0	2.6	4.6	5.1
268588	VALLEY OF FIRE SP	Black Moutains Area	215	30	1977	2007	4.2	3.5	2.7	2.6	4.2	4.7
264527	LEONARD CREEK RCH*	Black Rock Desert	28	30	1971	2004	3.2	3.2	2.5	3.1	3.2	3.6

Appendix 12b cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
265907	PAHUTE MEADOWS RCH*	Black Rock Desert	28	4	1964	1974	3.2	3.2	2.6	3.2	3.1	3.8
267873	SULPHUR*	Black Rock Desert	28	21	1915	1953	3.4	3.4	2.7	3.4	3.3	4.2
261415	CARLIN NEWMONT MINE	Boulder Flat	61	24	1967	1999	2.0	2.0	1.6	1.9	1.9	2.3
262656	EMIGRANT PASS HWY STN	Boulder Flat	61	27	1964	1999	2.4	2.5	2.0	2.4	2.4	2.9
261660	CHARLESTON*	Bruneau River Area	38	4	1962	2005	1.6	1.5	1.1	1.2	1.3	3.3
263853	HUMBOLDT FLD	Buena Vista Valley	129	7	1940	1947	3.2	3.2	2.5	3.1	3.1	4.0
261311	BUFFALO RCH*	Buffalo Valley	131	7	1967	1978	2.8	2.8	2.2	2.7	2.8	3.0
262780	FALLON EXP STN*	Carson Desert	101	30	1973	2005	3.2	3.2	2.5	3.1	3.2	3.9
265191	MINDEN*	Carson Valley	105	30	1975	2007	3.0	3.0	2.4	2.9	3.0	3.7
264349	LAHONTAN DAM*	Churchill Valley	102	30	1966	2003	3.4	3.2	2.6	3.1	3.4	4.0
267463	SILVERPEAK*	Clayton Valley	143	30	1974	2007	4.4	4.3	3.4	3.9	4.4	5.3
261358	CALIENTE*	Clover Valley	204	22	1904	2005	3.8	3.7	2.9	3.4	3.6	4.4
261740	CLOVER VALLEY*	Clover Valley	177	30	1923	2007	2.5	2.6	2.1	2.5	2.5	3.1
260688	BATTLE MTN*	Clovers Area	64	25	1899	1944	3.5	3.4	2.8	3.3	3.3	4.3
264480	LAUGHLIN*	Colorado Valley	213	10	1989	2006	5.8	5.0	3.9	3.6	5.8	6.4
261755	COALDALE JUNCTION*	Columbus Salt Marsh Valley	118	6	1942	1957	4.4	4.2	3.3	4.1	4.1	5.4

Appendix 12b cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
265132	MIDDLEGATE-LOWERY*	Cowkick Valley	126	15	1989	2007	3.4	3.2	2.5	3.1	3.0	4.5
260795	BEOWAWE*	Crescent Valley	54	30	1976	2006	2.9	3.0	2.4	2.9	2.9	3.7
261975	CORTEZ GOLD MINE*	Crescent Valley	54	10	1969	1979	2.9	2.9	2.3	2.8	2.8	3.5
268761	VIRGINIA CITY	Dayton Valley	103	30	1974	2007	2.4	2.4	1.8	2.3	2.3	2.6
264108	JUNGO MEYER RCH*	Desert Valley	31	7	1969	1985	3.1	3.2	2.5	3.1	3.1	3.8
262296	DIAMOND VALLEY USDA*	Diamond Valley	153	19	1980	2006	2.5	2.5	2.0	2.4	2.4	3.5
262708	EUREKA	Diamond Valley	153	30	1975	2007	2.3	2.3	1.7	2.2	2.1	2.8
267690	SOUTH FORK SP*	Dixie Creek - Tenmile	48	8	1994	2007	2.8	2.7	2.1	2.4	2.6	3.7
261160	BRINKERHOFF RCH*	Dixie Valley	128	7	1967	1979	3.6	3.5	2.8	3.4	3.6	4.3
268838	WADSWORTH 4 N*	Dodge Flat	82	21	1975	2002	3.5	3.4	2.7	3.3	3.3	4.3
261485	CARSON CITY*	Eagle Valley	104	30	1973	2007	3.2	3.1	2.5	3.0	3.1	3.7
268538	URSINE	Eagle Valley	200	4	1965	1972	3.4	3.6	2.8	3.4	3.5	4.0
262477	EASTGATE*	Eastgate Valley Area	127	4	1957	1963	3.4	3.4	2.7	3.4	3.4	4.2
261071	BOULDER CITY*	Eldorado Valley	167	30	1968	2004	4.6	3.9	3.1	2.9	4.6	5.1
262573	ELKO RGNL AP*	Elko Segment	49	30	1978	2007	2.6	2.6	2.1	2.5	2.5	3.3
262570	ELKO*	Elko Segment	49	6	2000	2007	2.6	2.7	2.1	2.6	2.5	3.2
262840	FERNLEY*	Fernley Area	76	21	1908	1974	3.5	3.4	2.7	3.3	3.3	4.3
262431	DYER*	Fish Lake Valley	117	30	1974	2007	4.2	4.1	3.2	4.1	4.0	5.4

Appendix 12b cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
265931	PALMETTO	Fish Lake Valley	117	14	1891	1907	2.8	2.8	2.2	2.5	2.6	3.7
264457	LATHROP WELLS	Fortymile Canyon	227A	8	1943	1963	5.2	4.6	3.6	3.8	5.3	5.8
260046	ADAVEN	Garden Valley	172	30	1947	1978	2.5	2.6	2.0	2.5	2.4	2.9
265722	OASIS*	Goshute Valley	187	17	1988	2006	2.8	2.7	2.1	2.6	2.5	3.7
266148	PEQUOP	Goshute Valley	187	23	1960	1985	2.4	2.3	1.8	2.3	2.1	3.2
260800	BEOWAWE U OF N RCH*	Grass Valley	138	28	1973	2006	2.7	2.8	2.2	2.7	2.7	3.5
269168	WINNEMUCCA #2*	Grass Valley	71	6	2000	2007	3.3	3.4	2.6	3.2	3.2	4.0
262820	FERGUSON SPRINGS HMS*	Great Salt Lake Desert	192	7	1973	1982	2.3	2.4	1.9	2.3	2.2	3.1
267443	SHELDON	Guano Valley	6	30	1942	1972	1.8	1.8	1.4	1.7	1.7	2.6
260961	BLUE JAY HWY STN*	Hot Creek	156	7	1964	1983	3.3	3.4	2.6	3.3	3.2	4.3
266630	RATTLESNAKE	Hot Creek	156	13	1949	1961	3.2	3.3	2.6	3.2	3.1	4.1
268443	TWIN SPRING FALLINI*	Hot Creek	156	10	1986	2005	3.5	3.5	2.8	3.4	3.3	4.4
264095	JIGGS 8 SSE ZAGA*	Huntington Valley	47	19	1979	2007	2.4	2.4	1.8	2.2	2.2	3.0
263957	IMLAY*	Imlay Area	72	30	1964	2007	3.4	3.3	2.6	3.2	3.3	4.0
267192	RYE PATCH DAM*	Imlay Area	72	30	1973	2007	3.6	3.5	2.8	3.4	3.4	4.3
268346	TUSCARORA*	Independence Valley	36	30	1973	2006	2.2	2.2	1.7	2.1	2.0	2.8
263980	INDIAN SPRINGS*	Indian Springs Valley	161	23	1914	1964	5.2	4.7	3.7	4.1	5.0	6.0

Appendix 12b cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
263316	GOODSPRINGS*	Ivanpah Valley	164A	6	2000	2006	5.2	4.4	3.5	3.7	5.1	5.6
265371	MOORMAN RCH*	Jakes Valley	174	4	2003	2007	2.7	2.6	2.0	2.5	2.4	3.7
264039	JARBIDGE 7 N*	Jarbidge River Area	39	11	1996	2006	2.3	2.3	1.7	2.2	2.1	2.7
264038	JARBRIDGE 4 N	Jarbidge River Area	39	22	1917	1995	2.1	1.9	1.4	1.7	1.7	2.3
262119	DAGGET PASS	Lake Tahoe Basin	90	5	1989	2005	1.9	1.9	1.4	1.7	1.7	1.3
263205	GLENBROOK*	Lake Tahoe Basin	90	30	1969	2007	2.3	2.2	1.7	2.1	2.1	2.2
264858	MARLETTE LAKE	Lake Tahoe Basin	90	19	1917	1952	1.4	1.5	1.1	1.4	1.3	0.7
267806	STATELINE-HARRAH'S*	Lake Tahoe Basin	90	13	1985	1998	2.4	2.4	1.9	2.3	2.3	2.7
263101	GEYSER RCH*	Lake Valley	183	19	1905	2002	3.0	2.9	2.3	2.7	2.7	4.0
264384	LAKE VALLEY STEWARD	Lake Valley	183	22	1971	1998	2.4	2.5	1.9	2.4	2.3	2.7
264395	LAMOILLE PH	Lamoille Valley	45	30	1934	1972	2.1	2.2	1.7	2.1	2.1	2.2
264394	LAMOILLE YOST*	Lamoille Valley	45	22	1976	2003	2.3	2.3	1.8	2.2	2.1	2.9
262243	DESERT NWR*	Las Vegas Valley	212	30	1974	2007	5.5	4.7	3.7	4.0	5.4	6.1
264314	KYLE CANYON RS	Las Vegas Valley	212	4	1940	1948	2.8	2.6	2.0	2.7	2.3	3.1
264439	LAS VEGAS NWFO*	Las Vegas Valley	212	9	1997	2007	5.1	4.3	3.3	3.2	5.0	5.6
264436	LAS VEGAS WB AP*	Las Vegas Valley	212	30	1976	2005	5.2	4.5	3.7	3.2	5.4	5.7
23112	LAS VEGAS*	Las Vegas Valley	212	22	1949	1970	5.5	4.8	3.9	3.6	5.6	6.0

Appendix 12b cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
264429	LAS VEGAS*	Las Vegas Valley	212	30	1915	1955	6.1	5.3	4.2	4.1	6.2	6.5
264600	LITTLE RED ROCK	Las Vegas Valley	212	4	1966	1970	4.3	3.7	2.8	3.3	4.2	4.7
265400	MT CHARLESTON FS	Las Vegas Valley	212	6	1949	2007	2.8	2.3	1.8	2.7	2.1	3.2
265705	NORTH LAS VEGAS*	Las Vegas Valley	212	20	1952	2006	5.9	5.2	4.2	3.9	6.0	6.4
266691	RED ROCK CANYON SP	Las Vegas Valley	212	20	1978	2006	4.4	3.9	3.1	3.4	4.5	4.7
267820	STEAD*	Lemmon Valley	92B	14	1986	2006	3.1	3.1	2.5	3.0	3.1	3.4
262860	FISH CREEK RCH*	Little Smoky Valley	155A	14	1944	1964	2.8	2.8	2.2	2.6	2.6	4.4
267640	SNOWBALL RCH	Little Smoky Valley	155A	30	1972	2002	2.4	2.3	1.7	2.1	2.1	3.5
264700	LOVELOCK DERBY FLD*	Lovelock Valley	73	30	1970	2005	3.7	3.7	3.0	3.6	3.6	4.5
262562	ELGIN 3 SE*	Lower Meadow Valley Wash	205	15	1966	1985	3.8	3.2	2.5	2.9	3.8	3.9
262557	ELGIN*	Lower Meadow Valley Wash	205	20	1986	2006	3.9	3.4	2.7	3.3	3.9	4.2
264651	LOGANDALE*	Lower Moapa Valley	220	20	1969	1991	4.3	3.7	3.0	2.9	4.5	4.8
265846	OVERTON*	Lower Moapa Valley	220	30	1950	2007	4.6	4.0	3.2	2.9	4.7	5.1
260691	BATTLE MTN AP*	Lower Reese River Valley	59	30	1973	2006	3.0	3.1	2.4	2.9	3.0	3.8

Appendix 12b cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
263114	GIBBS RCH*	Marys River Area	42	30	1972	2006	2.3	2.3	1.8	2.2	2.1	3.2
264824	MALA VISTA RCH*	Marys River Area	42	16	1940	1965	2.4	2.3	1.8	2.2	2.2	3.5
265092	METROPOLIS*	Marys River Area	42	18	1966	1994	2.4	2.4	1.9	2.4	2.3	2.8
268988	WELLS*	Marys River Area	42	30	1975	2004	2.5	2.4	1.9	2.3	2.2	3.4
268822	WABUSKA 6 SE*	Mason Valley	108	27	1973	2006	3.1	3.0	2.4	2.9	3.0	4.0
269229	YERINGTON*	Mason Valley	108	30	1965	2007	3.1	3.0	2.4	2.9	3.1	3.8
266748	REESE VALLEY CARPER	Middle Reese River Valley	58	6	1977	1983	2.8	2.8	2.2	2.6	2.6	3.7
267188	RYNDON*	North Fork Area	44	6	2000	2007	2.6	2.6	2.0	2.5	2.4	3.6
267324	SAVAL RCH*	North Fork Area	44	5	1961	1965	1.8	1.7	1.3	1.7	1.6	2.7
260718	BEATTY 8 N*	Oasis Valley	228	28	1973	2004	4.5	3.9	3.1	3.8	4.5	5.1
260715	BEATTY*	Oasis Valley	228	30	1921	1972	4.9	4.3	3.4	4.0	4.8	5.5
265392	MTN CITY RS*	Owyhee River Area	37	30	1965	1998	2.1	2.0	1.6	1.9	1.8	3.3
265869	OWYHEE*	Owyhee River Area	37	30	1953	1984	2.3	2.4	1.9	2.3	2.2	2.8
269072	WILDHORSE RSVR*	Owyhee River Area	37	18	1983	2006	1.8	1.7	1.3	1.6	1.5	3.0
260099	ALAMO*	Pahranagat Valley	209	29	1922	1958	4.6	4.2	3.3	3.9	4.3	5.3
263671	HIKO*	Pahranagat Valley	209	15	1990	2006	4.1	3.7	2.9	3.5	3.9	4.6
265880	PAHRANAGAT WR*	Pahranagat Valley	209	30	1968	2006	4.3	3.8	3.0	3.5	4.2	4.9

Appendix 12b cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
265890	PAHRUMP*	Pahrump Valley	162	30	1973	2006	5.0	4.4	3.6	3.8	5.1	5.6
261590	CATHEDRAL GORGE SP*	Panaca Valley	203	4	2003	2007	3.7	3.6	2.8	3.5	3.5	4.2
266005	PARADISE VALLEY 1 NW*	Paradise Valley	69	30	1972	2007	3.2	3.2	2.5	3.0	3.0	4.0
266252	PIOCHE	Patterson Valley	202	30	1968	2006	2.8	2.7	2.1	2.6	2.6	3.1
266130	PENOYER VALLEY*	Penoyer Valley	170	5	1968	2004	3.9	4.0	3.2	3.8	3.9	4.9
267983	TEMPIUTE 4 NW*	Penoyer Valley	170	12	1973	1984	3.8	3.8	3.1	3.7	3.8	4.7
266228	PILOT VALLEY-LEE*	Pilot Creek Valley	191	6	2000	2007	2.9	2.8	2.2	2.7	2.6	3.6
266504	QUINN RVR CROSSING	Pine Forest Valley	29	10	1902	1950	3.1	3.1	2.4	3.0	3.0	4.3
266242	PINE VALLEY BAILEY RCH*	Pine Valley	53	11	1983	2003	2.7	2.6	2.0	2.3	2.4	3.8
266574	RAND RCH PALISADE*	Pine Valley	53	19	1958	1981	2.3	2.3	1.8	2.2	2.2	3.7
267369	SEARCHLIGHT	Piute Valley	214	30	1976	2006	4.2	3.6	2.8	3.0	4.2	4.6
265440	MT ROSE BOWL	Pleasant Valley	88	8	1974	1984	1.6	1.7	1.3	1.6	1.5	1.0
266055	PARIS RCH*	Pleasant Valley	130	22	1967	1990	3.5	3.4	2.8	3.3	3.4	4.1
262229	DENIO*	Pueblo Valley	1	30	1969	2005	3.1	3.1	2.5	3.0	3.0	3.7
265605	NIXON*	Pyramid Lake Valley	81	30	1931	1973	3.6	3.5	2.8	3.4	3.5	4.4
267953	SUTCLIFFE	Pyramid Lake Valley	81	27	1968	2006	3.1	2.9	2.3	2.9	3.1	3.5
265362	MONTGOMERY MNTC STN	Queen Valley	116	10	1961	1978	2.3	2.3	1.8	2.1	2.1	3.6

Appendix 12b cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
264935	MCDERMITT*	Quinn River Valley	33B	29	1916	2007	2.8	2.7	2.1	2.3	2.5	3.8
265818	OROVADA 3 W*	Quinn River Valley	33A	30	1971	2006	3.1	3.1	2.5	3.0	3.1	3.7
260955	BLUE EAGLE RCH HANKS*	Railroad Valley	173B	23	1979	2007	3.7	3.7	2.9	3.5	3.7	4.3
262091	CURRANT HWY STN	Railroad Valley	173B	7	1964	1977	2.5	2.5	2.0	2.3	2.3	3.8
262078	CURRANT*	Railroad Valley	173B	4	1942	1946	3.3	3.4	2.6	3.2	3.2	4.1
262276	DIABLO*	Railroad Valley	173A	10	1960	1978	3.7	3.7	3.0	3.5	3.7	4.5
262390	DUCKWATER*	Railroad Valley	173B	19	1967	1998	3.3	3.3	2.6	3.2	3.1	4.1
268170	TONOPAH*	Ralston Valley	141	30	1975	2005	4.0	3.9	3.1	3.9	3.9	4.8
29999	RED ROCK WC*	Red Rock Valley	99	4	2004	2007	2.6	2.6	2.0	2.5	2.4	3.4
260438	ARTHUR 4 NW*	Ruby Valley	176	30	1971	2007	2.3	2.3	1.8	2.3	2.2	2.7
267123	RUBY LAKE*	Ruby Valley	176	30	1975	2007	2.8	2.8	2.2	2.7	2.6	3.3
261905	CONTACT*	Salmon Falls Creek Area	40	30	1956	1998	2.6	2.4	1.9	2.3	2.3	3.5
264016	JACKPOT*	Salmon Falls Creek Area	40	15	1987	2004	2.5	2.5	2.0	2.4	2.4	3.3
264268	KNOLL CREEK FLD STN	Salmon Falls Creek Area	40	6	1972	1979	2.4	2.3	1.7	2.1	2.0	3.6
267284	SAN JACINTO*	Salmon Falls Creek Area	40	21	1905	1947	2.6	2.4	1.9	2.3	2.3	3.6
262662	EMPIRE*	San Emidio Desert	22	6	1951	1976	3.5	3.5	2.8	3.4	3.5	4.1
263090	GERLACH*	San Emidio Desert	22	27	1963	2006	3.1	3.2	2.5	3.1	3.2	3.7

Appendix 12b cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
267319	SARCOBATUS*	Sarcobatus Flat	146	14	1942	1961	4.2	4.0	3.2	3.7	4.2	5.2
267609	SMITH 1 N*	Smith Valley	107	23	1938	1966	3.0	3.0	2.4	2.8	2.9	4.0
267612	SMITH 6 N*	Smith Valley	107	23	1974	2007	3.1	3.1	2.5	3.0	3.1	4.0
268977	WELLINGTON RS*	Smith Valley	107	27	1943	1972	3.0	3.0	2.4	2.9	3.0	3.7
267261	SAND PASS*	Smoke Creek Desert	21	30	1930	1970	3.5	3.6	2.8	3.4	3.6	4.2
267618	SMOKE CREEK ESPIL*	Smoke Creek Desert	21	14	1988	2004	3.6	3.6	2.9	3.5	3.6	4.3
263340	GREAT BASIN NP	Snake Valley	195	16	1988	2007	2.3	2.4	1.8	2.3	2.3	2.7
264514	LEHMAN CAVES NM	Snake Valley	195	30	1958	1987	2.1	2.2	1.7	2.1	2.0	2.6
265168	MINA*	Soda Spring Valley	121A	30	1978	2007	3.9	3.7	2.9	3.6	3.7	4.6
263940	I-L RCH*	South Fork Owyhee River Area	35	3	1963	1967	1.8	1.9	1.5	2.0	1.8	3.1
267450	SHOSHONE 5 N*	Spring Valley	184	17	1989	2007	3.0	3.0	2.4	2.9	2.9	3.9
267750	SPRING VALLEY SP*	Spring Valley	201	24	1975	2006	3.0	2.9	2.3	2.8	2.6	4.1
267397	SEVENTY ONE RCH*	Starr Valley Area	43	4	1940	1945	2.4	2.3	1.8	2.2	2.2	3.3
262096	CURRIE HWY STN*	Steptoe Valley	179	10	1962	1989	2.8	2.7	2.1	2.5	2.5	4.3
262626	ELY 6 NE	Steptoe Valley	179	5	2000	2005	3.4	3.4	2.7	3.1	3.2	4.4
262631	ELY YELLAND FLD AP*	Steptoe Valley	179	30	1976	2005	2.8	2.7	2.1	2.6	2.5	3.9
264341	LAGES*	Steptoe Valley	179	21	1984	2006	3.0	3.0	2.3	2.9	2.8	4.0

Appendix 12b cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
264950	MCGILL*	Steptoe Valley	179	30	1977	2007	2.9	2.8	2.2	2.7	2.7	3.6
265760	OLD RUTH	Steptoe Valley	179	5	1979	1985	2.1	2.3	1.7	2.1	2.0	2.8
267175	RUTH	Steptoe Valley	179	30	1963	2007	2.3	2.2	1.7	2.1	2.0	3.5
268810	VYA	Surprise Valley	14	14	1960	1975	2.0	1.9	1.5	1.8	1.8	2.7
260668	BASALT	Teels Marsh Valley	114	10	1942	1957	3.2	3.2	2.5	3.1	3.0	4.2
265352	MONTELLO 2 SE*	Thousand Springs Valley	189D	30	1971	2007	2.9	2.9	2.2	2.8	2.6	4.0
269122	WILKINS*	Thousand Springs Valley	189A	16	1949	1964	2.2	2.2	1.7	2.1	2.0	3.6
268834	WADSWORTH*	Tracy Segment	83	6	1902	1947	3.6	3.4	2.7	3.1	3.3	4.3
266779	RENO TAHOE INTL AP*	Truckee Meadows	87	30	1978	2007	3.5	3.4	2.7	3.3	3.5	4.0
266791	RENO WFO*	Truckee Meadows	87	10	1997	2007	3.3	3.2	2.6	3.2	3.4	3.7
268500	UNIV OF NEVADA EXP FM*	Truckee Meadows	87	4	1949	1954	3.4	3.3	2.7	3.3	3.5	3.9
260507	AUSTIN #2*	Upper Reese River Valley	56	30	1972	2007	2.7	2.7	2.1	2.6	2.5	3.1
261630	CENTRAL NEVADA FLD LAB*	Upper Reese River Valley	56	13	1966	1985	2.7	2.6	2.0	2.5	2.4	4.1
266746	REESE RIVER*	Upper Reese River Valley	56	26	1973	2006	2.5	2.4	1.8	2.2	2.1	3.9
261327	BUNKERVILLE*	Virgin River Valley	222	6	1980	2007	4.3	3.7	2.9	2.9	4.3	4.9

Appendix 12b cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	NUMBER OF YEARS USED FOR AVERAGE	START YEAR	END YEAR	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
265085	MESQUITE*	Virgin River Valley	222	13	1942	2006	4.4	3.9	3.1	2.9	4.5	4.8
262394	DUFURRENA*	Virgin Valley	4	30	1965	2004	2.8	2.7	2.1	2.6	2.5	4.0
263515	HAWTHORNE AP*	Walker Lake Valley	110C	30	1947	1990	3.8	3.6	2.8	3.5	3.6	4.6
263512	HAWTHORNE*	Walker Lake Valley	110C	13	1955	2007	3.9	3.6	2.8	3.4	3.6	4.6
267358	SCHURZ*	Walker Lake Valley	110A	30	1920	1955	3.5	3.5	2.8	3.4	3.5	4.4
268034	THORNE*	Walker Lake Valley	110C	24	1915	1950	3.8	3.7	2.9	3.6	3.7	4.6
264542	LEWERS RCH	Washoe Valley	89	15	1893	1913	3.2	3.1	2.4	3.1	2.9	2.7
39999	WASHOE VALLEY WC*	Washoe Valley	89	5	2004	2008	3.7	3.8	2.9	3.5	3.5	4.7
264199	KIMBERLY	White River Valley	207	28	1929	1958	2.4	2.4	1.9	2.3	2.2	3.0
264745	LUND*	White River Valley	207	30	1977	2007	3.1	3.1	2.4	2.9	2.9	3.9
267908	SUNNYSIDE*	White River Valley	207	30	1973	2007	3.3	3.3	2.5	3.1	3.1	4.1
265105	MIDAS 4 SE*	Willow Creek Valley	63	4	1962	1967	2.4	2.5	2.0	2.4	2.4	3.9
263245	GOLCONDA*	Winnemucca Segment	70	30	1970	2005	3.4	3.4	2.7	3.3	3.4	4.2
269171	WINNEMUCCA MUNI AP*	Winnemucca Segment	70	30	1978	2007	3.4	3.3	2.6	3.1	3.2	4.2

Appendix 13. Example of assignment and weighting of the mean annual Net Irrigation Water Requirement (NIWR) of alfalfa for respective HAs. Values of the NIWR were either assigned or averaged for HAs with multiple stations according to valid period of record for each station used in computing the annual average. The NIWR is listed in order of HA name, with shaded areas denoting the weighted average, and respective HA name and number.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	ALFALFA NIWR (ft)	START YEAR	END YEAR	NUMBER OF YEARS IN AVERAGE	WEIGHT BASED ON NUMBER OF YEARS USED IN AVERAGE	WEIGHT x ALFALFA NIWR (ft)	WEIGHTED AVERAGE ALFALFA NIWR (ft)
260150	AMARGOSA FARMS-GAREY*	Amargosa Desert	230	5.3	1966	2005	28	1.00	5.3	5.3
260282	ANTELOPE VALLEY FARR*	Antelope Valley	57	3.0	1985	1998	8	1.00	3.0	3.0
268186	TOPAZ LAKE 3N*	Antelope Valley	106	3.3	1958	1980	19	0.63	2.1	
268202	TOPAZ LAKE 4 N*	Antelope Valley	106	3.2	1987	1997	11	0.37	1.2	3.3
269137	WILLOW SPRINGS*	Big Smoky Valley	137A	3.7	1942	1948	4	1.00	3.7	3.7
267620	SMOKEY VALLEY*	Big Smoky Valley	137B	3.6	1975	2007	30	1.00	3.6	3.6
261371	CALLVILLE BAY*	Black Moutains Area	215	4.9	1990	2003	8	0.44	2.2	
262497	ECHO BAY*	Black Moutains Area	215	4.5	1990	2003	10	0.56	2.5	4.7
263090	GERLACH*	San Emidio Desert	22	3.1	1963	2006	27	0.33	1.0	
264527	LEONARD CREEK RCH*	Black Rock Desert	28	3.2	1971	2004	30	0.37	1.2	
265907	PAHUTE MEADOWS RCH*	Black Rock Desert	28	3.2	1964	1974	4	0.05	0.2	
267873	SULPHUR*	Black Rock Desert	28	3.4	1915	1953	21	0.26	0.9	3.2

Appendix 13 cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	ALFALFA NIWR (ft)	START YEAR	END YEAR	NUMBER OF YEARS IN AVERAGE	WEIGHT BASED ON NUMBER OF YEARS USED IN AVERAGE	WEIGHT x ALFALFA NIWR (ft)	WEIGHTED AVERAGE ALFALFA NIWR (ft)
261660	CHARLESTON*	Bruneau River Area	38	1.6	1962	2005	4	1.00	1.6	1.6
261311	BUFFALO RCH*	Buffalo Valley	131	2.8	1967	1978	7	1.00	2.8	2.8
264349	LAHONTAN DAM*	Churchill Valley	102	3.4	1966	2003	30	0.50	1.7	
262780	FALLON EXP STN*	Carson Desert	101	3.2	1973	2005	30	0.50	1.6	3.3
265191	MINDEN*	Carson Valley	105	3.0	1975	2007	30	1.00	3.0	3.0
262780	FALLON EXP STN*	Carson Desert	101	3.2	1973	2005	30	0.50	1.6	
264349	LAHONTAN DAM*	Churchill Valley	102	3.4	1966	2003	30	0.50	1.7	3.3
267463	SILVERPEAK*	Clayton Valley	143	4.4	1974	2007	30	1.00	4.4	4.4
261740	CLOVER VALLEY*	Clover Valley	177	2.5	1923	2007	30	1.00	2.5	2.5
261358	CALIENTE*	Clover Valley	204	3.8	1904	2005	22	1.00	3.8	3.8
260691	BATTLE MTN AP*	Lower Reese River Valley	59	3.0	1973	2006	30	0.55	1.7	
260688	BATTLE MTN*	Clovers Area	64	3.5	1899	1944	25	0.45	1.6	3.2
264480	LAUGHLIN*	Colorado Valley	213	5.8	1989	2006	10	1.00	5.8	5.8
261755	COALDALE JUNCTION*	Columbus Salt Marsh Valley	118	4.4	1942	1957	6	1.00	4.4	4.4
265132	MIDDLEGATE-LOWERY*	Cowkick Valley	126	3.4	1989	2007	15	1.00	3.4	3.4
260795	BEOWAWE*	Crescent Valley	54	2.9	1976	2006	30	0.75	2.2	
261975	CORTEZ GOLD MINE*	Crescent Valley	54	2.9	1969	1979	10	0.25	0.7	2.9
264108	JUNGO MEYER RCH*	Desert Valley	31	3.1	1969	1985	7	1.00	3.1	3.1

Appendix 13 cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	ALFALFA NIWR (ft)	START YEAR	END YEAR	NUMBER OF YEARS IN AVERAGE	WEIGHT BASED ON NUMBER OF YEARS USED IN AVERAGE	WEIGHT x ALFALFA NIWR (ft)	WEIGHTED AVERAGE ALFALFA NIWR (ft)
262296	DIAMOND VALLEY USDA*	Diamond Valley	153	2.5	1980	2006	19	1.00	2.5	2.5
267690	SOUTH FORK SP*	Dixie Creek - Tenmile	48	2.8	1994	2007	8	1.00	2.8	2.8
261160	BRINKERHOFF RCH*	Dixie Valley	128	3.6	1967	1979	7	1.00	3.6	3.6
262840	FERNLEY*	Fernley Area	76	3.5	1908	1974	21	0.44	1.5	
268834	WADSWORTH*	Tracy Segment	83	3.6	1902	1947	6	0.13	0.5	
268838	WADSWORTH 4 N*	Dodge Flat	82	3.5	1975	2002	21	0.44	1.5	3.5
261485	CARSON CITY*	Eagle Valley	104	3.2	1973	2007	30	1.00	3.2	3.2
262477	EASTGATE*	Eastgate Valley Area	127	3.4	1957	1963	4	1.00	3.4	3.4
261071	BOULDER CITY*	Eldorado Valley	167	4.6	1968	2004	30	1.00	4.6	4.6
262570	ELKO*	Elko Segment	49	2.6	2000	2007	6	0.17	0.4	
262573	ELKO RGNL AP*	Elko Segment	49	2.6	1978	2007	30	0.83	2.2	2.6
268838	WADSWORTH 4 N*	Dodge Flat	82	3.5	1975	2002	21	0.44	1.5	
268834	WADSWORTH*	Tracy Segment	83	3.6	1902	1947	6	0.13	0.5	
262840	FERNLEY*	Fernley Area	76	3.5	1908	1974	21	0.44	1.5	3.5
262431	DYER*	Fish Lake Valley	117	4.2	1974	2007	30	1.00	4.2	4.2
265722	OASIS*	Goshute Valley	187	2.8	1988	2006	17	1.00	2.8	2.8
269171	WINNEMUCCA MUNI AP*	Winnemucca Segment	70	3.4	1978	2007	30	0.83	2.8	
269168	WINNEMUCCA #2*	Grass Valley	71	3.3	2000	2007	6	0.17	0.5	3.3

Appendix 13 cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	ALFALFA NIWR (ft)	START YEAR	END YEAR	NUMBER OF YEARS IN AVERAGE	WEIGHT BASED ON NUMBER OF YEARS USED IN AVERAGE	WEIGHT x ALFALFA NIWR (ft)	WEIGHTED AVERAGE ALFALFA NIWR (ft)
260800	BEOWAWE U OF N RCH*	Grass Valley	138	2.7	1973	2006	28	1.00	2.7	2.7
262820	FERGUSON SPRINGS HMS*	Great Salt Lake Desert	192	2.3	1973	1982	7	1.00	2.3	2.3
260961	BLUE JAY HWY STN*	Hot Creek	156	3.3	1964	1983	7	0.41	1.4	
268443	TWIN SPRING FALLINI*	Hot Creek	156	3.5	1986	2005	10	0.59	2.0	3.4
264095	JIGGS 8 SSE ZAGA*	Huntington Valley	47	2.4	1979	2007	19	1.00	2.4	2.4
263957	IMLAY*	Imlay Area	72	3.4	1964	2007	30	0.50	1.7	
267192	RYE PATCH DAM*	Imlay Area	72	3.6	1973	2007	30	0.50	1.8	3.5
268346	TUSCARORA*	Independence Valley	36	2.2	1973	2006	30	1.00	2.2	2.2
263980	INDIAN SPRINGS*	Indian Springs Valley	161	5.2	1914	1964	23	1.00	5.2	5.2
263316	GOODSPRINGS*	Ivanpah Valley	164A	5.2	2000	2006	6	1.00	5.2	5.2
265371	MOORMAN RCH*	Jakes Valley	174	2.7	2003	2007	4	1.00	2.7	2.7
264039	JARBIDGE 7 N*	Jarbidge River Area	39	2.3	1996	2006	11	1.00	2.3	2.3
263205	GLENBROOK*	Lake Tahoe Basin	90	2.3	1969	2007	30	0.70	1.6	
267806	STATELINE-HARRAH'S*	Lake Tahoe Basin	90	2.4	1985	1998	13	0.30	0.7	2.3
263101	GEYSER RCH*	Lake Valley	183	3.0	1905	2002	19	1.00	3.0	3.0
264394	LAMOILLE YOST*	Lamoille Valley	45	2.3	1976	2003	22	1.00	2.3	2.3
23112	LAS VEGAS*	Las Vegas Valley	212	5.5	1949	1970	22	0.16	0.9	
262243	DESERT NWR*	Las Vegas Valley	212	5.5	1974	2007	30	0.21	1.2	

Appendix 13 cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	ALFALFA NIWR (ft)	START YEAR	END YEAR	NUMBER OF YEARS IN AVERAGE	WEIGHT BASED ON NUMBER OF YEARS USED IN AVERAGE	WEIGHT x ALFALFA NIWR (ft)	WEIGHTED AVERAGE ALFALFA NIWR (ft)
264429	LAS VEGAS*	Las Vegas Valley	212	6.1	1915	1955	30	0.21	1.3	
264436	LAS VEGAS WB AP*	Las Vegas Valley	212	5.2	1976	2005	30	0.21	1.1	
264439	LAS VEGAS NWFO*	Las Vegas Valley	212	5.1	1997	2007	9	0.06	0.3	
265705	NORTH LAS VEGAS*	Las Vegas Valley	212	5.9	1952	2006	20	0.14	0.8	5.6
267820	STEAD*	Lemmon Valley	92B	3.1	1986	2006	14	1.00	3.1	3.1
262860	FISH CREEK RCH*	Little Smoky Valley	155A	2.8	1944	1964	14	1.00	2.8	2.8
264700	LOVELOCK DERBY FLD*	Lovelock Valley	73	3.7	1970	2005	30	1.00	3.7	3.7
264651	LOGANDALE*	Lower Moapa Valley	220	4.3	1969	1991	20	0.24	1.0	
265846	OVERTON*	Lower Moapa Valley	220	4.6	1950	2007	30	0.35	1.6	
262557	ELGIN*	Lower Meadow Valley Wash	205	3.9	1986	2006	20	0.24	0.9	
262562	ELGIN 3 SE*	Lower Meadow Valley Wash	205	3.8	1966	1985	15	0.18	0.7	4.2
264651	LOGANDALE*	Lower Moapa Valley	220	4.3	1969	1991	20	0.40	1.7	
265846	OVERTON*	Lower Moapa Valley	220	4.6	1950	2007	30	0.60	2.7	4.5
260688	BATTLE MTN*	Clovers Area	64	3.5	1899	1944	25	0.45	1.6	
260691	BATTLE MTN AP*	Lower Reese River Valley	59	3.0	1973	2006	30	0.55	1.7	3.2
263114	GIBBS RCH*	Marys River Area	42	2.3	1972	2006	30	0.32	0.7	

Appendix 13 cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	ALFALFA NIWR (ft)	START YEAR	END YEAR	NUMBER OF YEARS IN AVERAGE	WEIGHT BASED ON NUMBER OF YEARS USED IN AVERAGE	WEIGHT x ALFALFA NIWR (ft)	WEIGHTED AVERAGE ALFALFA NIWR (ft)
264824	MALA VISTA RCH*	Marys River Area	42	2.4	1940	1965	16	0.17	0.4	
265092	METROPOLIS*	Marys River Area	42	2.4	1966	1994	18	0.19	0.5	
268988	WELLS*	Marys River Area	42	2.5	1975	2004	30	0.32	0.8	2.4
268822	WABUSKA 6 SE*	Mason Valley	108	3.1	1973	2006	27	0.47	1.5	
269229	YERINGTON*	Mason Valley	108	3.1	1965	2007	30	0.53	1.6	3.1
267188	RYNDON*	North Fork Area	44	2.6	2000	2007	6	0.55	1.4	
267324	SAVAL RCH*	North Fork Area	44	1.8	1961	1965	5	0.45	0.8	2.2
260715	BEATTY*	Oasis Valley	228	4.9	1921	1972	30	0.52	2.5	
260718	BEATTY 8 N*	Oasis Valley	228	4.5	1973	2004	28	0.48	2.2	4.7
265392	MTN CITY RS*	Owyhee River Area	37	2.1	1965	1998	30	0.38	0.8	
265869	OWYHEE*	Owyhee River Area	37	2.3	1953	1984	30	0.38	0.9	
269072	WILDHORSE RSVR*	Owyhee River Area	37	1.8	1983	2006	18	0.23	0.4	2.1
260099	ALAMO*	Pahranagat Valley	209	4.6	1922	1958	29	0.39	1.8	
263671	HIKO*	Pahranagat Valley	209	4.1	1990	2006	15	0.20	0.8	
265880	PAHRANAGAT WR*	Pahranagat Valley	209	4.3	1968	2006	30	0.41	1.7	4.4
265890	PAHRUMP*	Pahrump Valley	162	5.0	1973	2006	30	1.00	5.0	5.0
261358	CALIENTE*	Clover Valley	204	3.8	1904	2005	22	0.85	3.2	
261590	CATHEDRAL GORGE SP*	Panaca Valley	203	3.7	2003	2007	4	0.15	0.6	3.8

Appendix 13 cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	ALFALFA NIWR (ft)	START YEAR	END YEAR	NUMBER OF YEARS IN AVERAGE	WEIGHT BASED ON NUMBER OF YEARS USED IN AVERAGE	WEIGHT x ALFALFA NIWR (ft)	WEIGHTED AVERAGE ALFALFA NIWR (ft)
266005	PARADISE VALLEY 1 NW*	Paradise Valley	69	3.2	1972	2007	30	1.00	3.2	3.2
266130	PENOYER VALLEY*	Penoyer Valley	170	3.9	1968	2004	5	0.29	1.2	
267983	TEMPIUTE 4 NW*	Penoyer Valley	170	3.8	1973	1984	12	0.71	2.7	3.9
266228	PILOT VALLEY-LEE*	Pilot Creek Valley	191	2.9	2000	2007	6	1.00	2.9	2.9
266242	PINE VALLEY BAILEY RCH*	Pine Valley	53	2.7	1983	2003	11	0.37	1.0	
266574	RAND RCH PALISADE*	Pine Valley	53	2.3	1958	1981	19	0.63	1.5	2.5
266055	PARIS RCH*	Pleasant Valley	130	3.5	1967	1990	22	1.00	3.5	3.5
262229	DENIO*	Pueblo Valley	1	3.1	1969	2005	30	1.00	3.1	3.1
265605	NIXON*	Pyramid Lake Valley	81	3.6	1931	1973	30	1.00	3.6	3.6
265818	OROVADA 3 W*	Quinn River Valley	33A	3.1	1971	2006	30	1.00	3.1	3.1
264935	MCDERMITT*	Quinn River Valley	33B	2.8	1916	2007	29	1.00	2.8	2.8
262276	DIABLO*	Railroad Valley	173A	3.7	1960	1978	10	1.00	3.7	3.7
260955	BLUE EAGLE RCH HANKS*	Railroad Valley	173B	3.7	1979	2007	23	0.50	1.8	
262078	CURRANT*	Railroad Valley	173B	3.3	1942	1946	4	0.09	0.3	
262390	DUCKWATER*	Railroad Valley	173B	3.3	1967	1998	19	0.41	1.4	3.5
268170	TONOPAH*	Ralston Valley	141	4.0	1975	2005	30	1.00	4.0	4.0
29999	RED ROCK WC*	Red Rock Valley	99	2.6	2004	2007	4	1.00	2.6	2.6

Appendix 13 cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	ALFALFA NIWR (ft)	START YEAR	END YEAR	NUMBER OF YEARS IN AVERAGE	WEIGHT BASED ON NUMBER OF YEARS USED IN AVERAGE	WEIGHT x ALFALFA NIWR (ft)	WEIGHTED AVERAGE ALFALFA NIWR (ft)
260438	ARTHUR 4 NW*	Ruby Valley	176	2.3	1971	2007	30	0.50	1.1	
267123	RUBY LAKE*	Ruby Valley	176	2.8	1975	2007	30	0.50	1.4	2.5
261905	CONTACT*	Salmon Falls Creek Area	40	2.6	1956	1998	30	0.45	1.2	
264016	JACKPOT*	Salmon Falls Creek Area	40	2.5	1987	2004	15	0.23	0.6	
267284	SAN JACINTO*	Salmon Falls Creek Area	40	2.6	1905	1947	21	0.32	0.8	2.6
262662	EMPIRE*	San Emidio Desert	22	3.5	1951	1976	6	0.18	0.6	
263090	GERLACH*	San Emidio Desert	22	3.1	1963	2006	27	0.82	2.6	3.2
267319	SARCOBATUS*	Sarcobatus Flat	146	4.2	1942	1961	14	1.00	4.2	4.2
267609	SMITH 1 N*	Smith Valley	107	3.0	1938	1966	23	0.32	1.0	
267612	SMITH 6 N*	Smith Valley	107	3.1	1974	2007	23	0.32	1.0	
268977	WELLINGTON RS*	Smith Valley	107	3.0	1943	1972	27	0.37	1.1	3.1
263090	GERLACH*	San Emidio Desert	22	3.1	1963	2006	27	0.38	1.2	
267261	SAND PASS*	Smoke Creek Desert	21	3.5	1930	1970	30	0.42	1.5	
267618	SMOKE CREEK ESPIL*	Smoke Creek Desert	21	3.6	1988	2004	14	0.20	0.7	3.4
265168	MINA*	Soda Spring Valley	121A	3.9	1978	2007	30	1.00	3.9	3.9
263940	I-L RCH*	South Fork Owyhee River Area	35	1.8	1963	1967	3	1.00	1.8	1.8
267450	SHOSHONE 5 N*	Spring Valley	184	3.0	1989	2007	17	1.00	3.0	3.0

Appendix 13 cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	ALFALFA NIWR (ft)	START YEAR	END YEAR	NUMBER OF YEARS IN AVERAGE	WEIGHT BASED ON NUMBER OF YEARS USED IN AVERAGE	WEIGHT x ALFALFA NIWR (ft)	WEIGHTED AVERAGE ALFALFA NIWR (ft)
267750	SPRING VALLEY SP*	Spring Valley	201	3.0	1975	2006	24	1.00	3.0	3.0
267397	SEVENTY ONE RCH*	Starr Valley Area	43	2.4	1940	1945	4	1.00	2.4	2.4
262096	CURRIE HWY STN*	Steptoe Valley	179	2.8	1962	1989	10	0.11	0.3	
262631	ELY YELLAND FLD AP*	Steptoe Valley	179	2.8	1976	2005	30	0.33	0.9	
264341	LAGES*	Steptoe Valley	179	3.0	1984	2006	21	0.23	0.7	
264950	MCGILL*	Steptoe Valley	179	2.9	1977	2007	30	0.33	0.9	2.9
269122	WILKINS*	Thousand Springs Valley	189A	2.2	1949	1964	16	1.00	2.2	2.2
265352	MONTELLO 2 SE*	Thousand Springs Valley	189D	2.9	1971	2007	30	1.00	2.9	2.9
262840	FERNLEY*	Fernley Area	76	3.5	1908	1974	21	0.44	1.5	
268838	WADSWORTH 4 N*	Dodge Flat	82	3.5	1975	2002	21	0.44	1.5	
268834	WADSWORTH*	Tracy Segment	83	3.6	1902	1947	6	0.13	0.5	3.5
266779	RENO TAHOE INTL AP*	Truckee Meadows	87	3.5	1978	2007	30	0.68	2.4	
266791	RENO WFO*	Truckee Meadows	87	3.3	1997	2007	10	0.23	0.8	
268500	UNIV OF NEVADA EXP FM*	Truckee Meadows	87	3.4	1949	1954	4	0.09	0.3	3.4
260507	AUSTIN #2*	Upper Reese River Valley	56	2.7	1972	2007	30	0.43	1.2	
261630	CENTRAL NEVADA FLD LAB*	Upper Reese River Valley	56	2.7	1966	1985	13	0.19	0.5	

Appendix 13 cont.

STATION NUMBER	STATION NAME	BASIN NAME	BASIN NUMBER	ALFALFA NIWR (ft)	START YEAR	END YEAR	NUMBER OF YEARS IN AVERAGE	WEIGHT BASED ON NUMBER OF YEARS USED IN AVERAGE	WEIGHT x ALFALFA NIWR (ft)	WEIGHTED AVERAGE ALFALFA NIWR (ft)
266746	REESE RIVER*	Upper Reese River Valley	56	2.5	1973	2006	26	0.38	0.9	2.6
261327	BUNKERVILLE*	Virgin River Valley	222	4.3	1980	2007	6	0.32	1.4	
265085	MESQUITE*	Virgin River Valley	222	4.4	1942	2006	13	0.68	3.0	4.4
262394	DUFURRENA*	Virgin Valley	4	2.8	1965	2004	30	1.00	2.8	2.8
267358	SCHURZ*	Walker Lake Valley	110A	3.5	1920	1955	30	1.00	3.5	3.5
263512	HAWTHORNE*	Walker Lake Valley	110C	3.9	1955	2007	13	0.19	0.8	
263515	HAWTHORNE AP*	Walker Lake Valley	110C	3.8	1947	1990	30	0.45	1.7	
268034	THORNE*	Walker Lake Valley	110C	3.8	1915	1950	24	0.36	1.4	3.8
39999	WASHOE VALLEY WC*	Washoe Valley	89	3.7	2004	2008	5	1.00	3.7	3.7
264745	LUND*	White River Valley	207	3.1	1977	2007	30	0.50	1.6	
267908	SUNNYSIDE*	White River Valley	207	3.3	1973	2007	30	0.50	1.7	3.2
265105	MIDAS 4 SE*	Willow Creek Valley	63	2.4	1962	1967	4	1.00	2.4	2.4
269168	WINNEMUCCA #2*	Grass Valley	71	3.3	2000	2007	6	0.09	0.3	
263245	GOLCONDA*	Winnemucca Segment	70	3.4	1970	2005	30	0.45	1.6	
269171	WINNEMUCCA MUNI AP*	Winnemucca Segment	70	3.4	1978	2007	30	0.45	1.5	3.4

Appendix 14. Mean annual reference (ET_{os}) and actual crop evapotranspiration (ET_{act}) of alfalfa, grass hay, pasture grass, turf grass, and small shallow open water bodies for all HAs. Values of the ET_{os} and ET_{act} for each HA were either assigned for HAs with single stations, computed using a valid period of record weighted average for HAs with multiple stations, or estimated from spatial interpolation for HAs with no stations. * indicates that the ET_{os} and ET_{act} was estimated using spatial interpolation.

BASIN NAME	BASIN NUMBER	BASIN REGION	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
Adobe Valley*	115	Central Region	5.0	4.3	4.1	3.3	3.9	4.0	5.2
Alkali Spring Valley*	142	Central Region	5.2	4.5	4.4	3.6	4.2	4.4	5.5
Alkali Valley*	111A	Central Region	4.7	4.1	3.9	3.1	3.7	3.9	4.9
Alkali Valley*	111B	Central Region	4.7	4.1	3.9	3.1	3.7	3.9	4.9
Amargosa Desert	230	Death Valley Basin	5.8	5.6	4.8	3.9	3.7	5.6	6.1
Antelope Valley	57	Humboldt River Basin	4.4	3.6	3.6	3.0	3.5	3.5	4.6
Antelope Valley	106	Walker River Basin	4.6	3.8	3.7	3.0	3.6	3.6	4.8
Antelope Valley*	186B	Central Region	4.1	3.2	3.1	2.5	2.9	2.9	4.3
Antelope Valley*	186A	Central Region	4.2	3.3	3.2	2.6	3.1	3.0	4.4
Antelope Valley*	93	Western Region	4.3	3.7	3.6	2.9	3.5	3.5	4.5
Antelope Valley*	151	Central Region	4.4	3.3	3.3	2.7	3.1	3.0	4.6
Bedell Flat*	94	Western Region	4.1	3.4	3.3	2.7	3.2	3.1	4.3
Big Smoky Valley	137B	Central Region	4.8	4.1	4.0	3.2	3.9	3.7	5.1
Big Smoky Valley	137A	Central Region	4.8	3.9	3.8	3.0	3.8	3.5	5.0
Black Moutains Area	215	Colorado River Basin	5.5	5.1	4.4	3.5	2.8	5.1	5.7
Black Rock Desert	28	Black Rock Desert Region	4.3	3.8	3.7	3.1	3.7	3.7	4.5
Boulder Flat*	61	Humboldt River Basin	4.2	3.5	3.4	2.8	3.3	3.3	4.4
Boulder Valley*	15	Northwest Region	4.3	3.8	3.7	3.0	3.6	3.6	4.6
Bradys Hot Springs Area*	75	West Central Region	4.5	3.9	3.8	3.1	3.6	3.7	4.8
Bruneau River Area	38	Snake River Basin	4.1	2.3	2.0	1.7	1.7	1.8	4.3

Appendix 14 cont.

BASIN NAME	BASIN NUMBER	BASIN REGION	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
Buena Vista Valley*	129	Central Region	4.6	4.1	3.9	3.3	3.8	3.9	4.8
Buffalo Valley	131	Central Region	4.0	3.7	3.5	2.9	3.3	3.5	4.2
Butte Valley*	178A	Central Region	4.3	3.3	3.1	2.6	3.0	2.9	4.5
Butte Valley*	178B	Central Region	4.3	3.4	3.3	2.7	3.1	3.1	4.5
Cactus Flat*	148	Central Region	5.0	4.3	4.2	3.4	4.0	4.2	5.3
California Wash*	218	Colorado River Basin	5.5	5.2	4.5	3.7	3.3	5.3	5.7
Carico Lake Valley*	55	Humboldt River Basin	4.3	3.6	3.5	2.9	3.4	3.4	4.5
Carson Desert	101	Carson River Basin	4.2	3.7	3.6	2.9	3.5	3.6	4.4
Carson Desert*	101A	Carson River Basin	4.6	4.1	4.0	3.3	3.8	3.9	4.8
Carson Valley	105	Carson River Basin	4.3	3.6	3.5	2.9	3.3	3.4	4.5
Cave Valley*	180	Central Region	4.6	3.9	3.7	3.0	3.5	3.5	4.8
Churchill Valley	102	Carson River Basin	4.2	3.7	3.6	2.9	3.5	3.6	4.4
Clayton Valley	143	Central Region	5.5	4.7	4.6	3.8	4.2	4.7	5.7
Clover Valley	177	Central Region	4.0	3.3	3.3	2.7	3.1	3.1	4.2
Clover Valley	204	Colorado River Basin	4.9	4.5	4.2	3.5	3.9	4.1	5.2
Clovers Area	64	Humboldt River Basin	4.4	3.8	3.8	3.1	3.6	3.7	4.7
Coal Valley*	171	Central Region	5.0	4.4	4.2	3.4	4.0	4.2	5.2
Cold Spring Valley*	100	Western Region	4.2	3.7	3.6	3.0	3.5	3.6	4.4
Cold Spring Valley*	100A	Western Region	4.2	3.6	3.4	2.8	3.4	3.4	4.4
Coleman Valley*	11	Northwest Region	4.3	3.7	3.6	2.9	3.4	3.4	4.5
Colorado Valley	213	Colorado River Basin	6.5	6.2	5.3	4.3	3.7	6.1	6.9
Columbus Salt Marsh Valley	118	Central Region	5.5	4.7	4.4	3.6	4.3	4.3	5.8
Continental Lake Valley*	2	Northwest Region	4.3	3.6	3.5	2.9	3.4	3.4	4.5
Cowkick Valley	126	Central Region	4.8	3.8	3.5	2.9	3.4	3.3	5.0
Coyote spring Valley*	210	Colorado River Basin	5.4	5.1	4.5	3.6	3.7	5.0	5.7

Appendix 14 cont.

BASIN NAME	BASIN NUMBER	BASIN REGION	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
Crater Flat*	229	Death Valley Basin	5.6	5.2	4.6	3.7	4.0	5.1	5.9
Crescent Valley	54	Humboldt River Basin	4.2	3.6	3.6	3.0	3.4	3.4	4.4
Dayton Valley*	103	Carson River Basin	4.4	3.8	3.7	3.0	3.5	3.6	4.6
Deep Creek Valley*	193	Great Salt Lake Basin	4.2	3.3	3.2	2.6	3.1	3.0	4.4
Delamar Valley*	182	Central Region	5.1	4.6	4.2	3.4	3.9	4.4	5.4
Desert Valley	31	Black Rock Desert Region	4.3	3.8	3.7	3.0	3.5	3.6	4.5
Diamond Valley	153	Central Region	4.1	3.2	3.1	2.5	3.0	2.9	4.3
Dixie Creek-Tenmile Creek Area	48	Humboldt River Basin	4.3	3.4	3.3	2.7	3.0	3.1	4.5
Dixie Valley	128	Central Region	4.7	4.2	4.1	3.4	4.0	4.1	4.9
Dodge Flat	82	Truckee River Basin	4.6	3.9	3.8	3.1	3.7	3.7	4.8
Dry Lake Valley*	181	Central Region	4.9	4.3	4.1	3.3	3.8	4.0	5.1
Dry Valley*	19	Black Rock Desert Region	4.5	4.0	3.9	3.2	3.8	3.9	4.7
Dry Valley*	95	Western Region	4.1	3.4	3.2	2.6	3.2	3.1	4.3
Dry Valley*	198	Colorado River Basin	4.9	4.2	4.0	3.3	3.8	3.9	5.2
Duck Lake Valley*	16	Northwest Region	4.4	3.9	3.8	3.1	3.7	3.7	4.6
Eagle Valley	104	Carson River Basin	4.3	3.8	3.6	3.0	3.5	3.6	4.6
Eagle Valley*	200	Colorado River Basin	4.9	3.8	3.6	2.9	3.4	3.3	5.1
East Walker Area*	109	Walker River Basin	4.6	3.9	3.8	3.1	3.6	3.8	4.8
Eastgate Valley Area	127	Central Region	4.5	3.9	3.9	3.2	3.9	3.8	4.8
Edwards Creek Valley*	133	Central Region	4.5	3.7	3.6	2.9	3.5	3.4	4.7
Eldorado Valley	167	Central Region	5.4	5.1	4.3	3.5	3.1	5.0	5.7
Elko Segment	49	Humboldt River Basin	4.0	3.3	3.2	2.7	3.1	3.0	4.2
Emigrant Valley*	158A	Central Region	5.3	4.7	4.4	3.6	4.1	4.5	5.5
Emigrant Valley*	158B	Central Region	5.5	5.0	4.5	3.7	4.1	4.8	5.8
Escalante Desert*	197	Escalante Desert	4.9	4.3	4.0	3.3	3.8	4.0	5.2

Appendix 14 cont.

BASIN NAME	BASIN NUMBER	BASIN REGION	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
Fairview Valley*	124	Central Region	4.6	3.8	3.6	3.0	3.5	3.5	4.8
Fernley Area	76	West Central Region	4.6	3.9	3.8	3.1	3.7	3.7	4.8
Fireball Valley*	77	West Central Region	4.6	4.0	3.8	3.1	3.7	3.7	4.8
Fish Lake Valley	117	Central Region	5.5	4.6	4.4	3.6	4.3	4.3	5.8
Fortymile Canyon*	227B	Death Valley Basin	5.4	4.9	4.5	3.6	4.0	4.8	5.7
Fortymile Canyon*	227A	Death Valley Basin	5.6	5.3	4.6	3.8	4.0	5.2	5.9
Frenchman Flat*	160	Central Region	5.7	5.3	4.7	3.8	4.1	5.2	6.0
Gabbs Valley*	122	Central Region	4.7	4.0	3.8	3.0	3.6	3.7	4.9
Garden Valley*	172	Central Region	4.9	4.2	4.1	3.4	4.0	4.1	5.1
Garfield Flat*	120	Central Region	4.8	4.3	4.0	3.2	3.9	4.0	5.1
Garnet Valley*	216	Colorado River Basin	5.9	5.6	4.9	4.0	3.6	5.6	6.2
Gold Butte Area*	223	Colorado River Basin	5.4	5.1	4.4	3.5	3.1	5.1	5.6
Gold Flat*	147	Central Region	5.2	4.5	4.3	3.5	4.0	4.4	5.4
Goose Creek Area*	41	Snake River Basin	4.1	3.2	3.1	2.6	3.0	2.9	4.3
Goshute Valley	187	Central Region	4.2	3.4	3.2	2.6	3.1	2.9	4.5
Granite Basin*	23	Black Rock Desert Region	4.3	3.8	3.8	3.1	3.7	3.7	4.5
Granite Springs Valley*	78	West Central Region	4.6	4.0	3.9	3.2	3.8	3.8	4.8
Grapevine Canyon*	231	Death Valley Basin	5.4	4.7	4.4	3.5	4.0	4.6	5.6
Grass Valley	71	Humboldt River Basin	4.6	3.9	3.8	3.1	3.6	3.6	4.9
Grass Valley	138	Central Region	4.2	3.5	3.4	2.8	3.3	3.3	4.4
Greasewood Basin*	224	Colorado River Basin	5.3	5.1	4.4	3.6	3.1	5.1	5.6
Great Salt Lake Desert	192	Great Salt Lake Basin	3.6	2.9	2.9	2.3	2.7	2.7	3.7
Gridley Lake Valley*	3	Northwest Region	4.3	3.7	3.6	2.9	3.5	3.5	4.5
Grouse Creek Valley*	190	Great Salt Lake Basin	4.2	3.3	3.2	2.6	3.0	3.0	4.4
Guano Valley*	6	Northwest Region	4.3	3.6	3.5	2.8	3.3	3.3	4.5

Appendix 14 cont.

BASIN NAME	BASIN NUMBER	BASIN REGION	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
Hamlin Valley*	196	Great Salt Lake Basin	4.6	3.8	3.7	3.0	3.5	3.5	4.9
Hardscrabble Area*	68	Humboldt River Basin	4.4	3.7	3.6	2.9	3.4	3.4	4.7
Hidden Valley*	217	Colorado River Basin	5.9	5.6	4.9	3.9	3.6	5.6	6.2
Hidden Valley*	166	Central Region	5.9	5.7	4.9	4.0	3.6	5.6	6.2
High Rock Lake Valley*	25	Black Rock Desert Region	4.3	3.8	3.7	3.0	3.6	3.6	4.5
Honey Lake Valley*	97	Western Region	4.4	3.8	3.7	3.0	3.6	3.6	4.6
Hot Creek	156	Central Region	4.7	3.9	3.9	3.2	3.8	3.7	4.9
Hualapai Flat*	24	Black Rock Desert Region	4.3	3.9	3.8	3.1	3.7	3.7	4.6
Huntington Valley	47	Humboldt River Basin	4.0	3.2	3.0	2.5	2.8	2.8	4.2
Huntoon Valley*	113	Central Region	4.9	4.2	4.0	3.2	3.8	4.0	5.1
Imlay Area	72	Humboldt River Basin	4.7	4.1	4.0	3.3	3.9	3.9	4.9
Independence Valley	36	Snake River Basin	3.7	3.0	2.8	2.3	2.6	2.6	3.9
Independence Valley*	188	Central Region	4.1	3.2	3.1	2.5	3.0	2.9	4.3
Indian Springs Valley	161	Central Region	6.0	5.4	4.9	4.0	4.2	5.3	6.3
Ione Valley*	135	Central Region	4.7	3.8	3.6	2.9	3.5	3.5	4.9
Ivanpah Valley	164A	Central Region	5.9	5.7	4.9	4.0	4.1	5.6	6.2
Ivanpah Valley*	164B	Central Region	5.9	5.7	4.9	4.0	3.7	5.7	6.2
Jakes Valley	174	Central Region	4.3	3.2	3.1	2.5	2.9	2.8	4.5
Jarbidge River Area	39	Snake River Basin	3.9	3.3	3.0	2.5	2.9	2.8	4.1
Jean Lake Valley*	165	Central Region	5.9	5.7	4.9	4.0	3.7	5.6	6.2
Jersey Valley*	132	Central Region	4.4	4.0	3.9	3.2	3.7	3.8	4.7
Kane Springs Valley*	206	Colorado River Basin	5.0	4.7	4.1	3.4	3.7	4.5	5.3
Kawich Valley*	157	Central Region	5.1	4.5	4.3	3.5	4.1	4.4	5.4
Kelley Creek Area*	66	Humboldt River Basin	4.4	3.7	3.6	3.0	3.4	3.4	4.7
Kings River Valley*	30A	Black Rock Desert Region	4.3	3.7	3.6	3.0	3.5	3.5	4.6

Appendix 14 cont.

BASIN NAME	BASIN NUMBER	BASIN REGION	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
Kings River Valley*	30B	Black Rock Desert Region	4.4	3.8	3.7	3.0	3.5	3.6	4.6
Kobeh Valley*	139	Central Region	4.2	3.4	3.3	2.7	3.1	3.1	4.4
Kumiva Valley*	79	West Central Region	4.4	3.9	3.9	3.2	3.7	3.8	4.7
Lake Tahoe Basin	90	Truckee River Basin	3.6	2.9	2.7	2.2	2.6	2.6	3.7
Lake Valley	183	Central Region	4.5	3.6	3.4	2.8	3.3	3.2	4.7
Lamoille Valley	45	Humboldt River Basin	3.9	3.0	2.8	2.3	2.7	2.6	4.1
Las Vegas Valley	212	Colorado River Basin	6.2	6.0	5.2	4.2	3.9	6.0	6.5
Lemmon Valley	92B	Western Region	4.2	3.7	3.6	3.0	3.5	3.6	4.4
Lemmon Valley*	92A	Western Region	4.2	3.7	3.6	3.0	3.5	3.6	4.4
Lida Valley*	144	Central Region	5.3	4.6	4.4	3.5	4.1	4.4	5.6
Little Fish Lake Valley*	150	Central Region	4.6	3.7	3.7	3.0	3.5	3.5	4.8
Little Humboldt Valley*	67	Humboldt River Basin	4.4	3.5	3.4	2.8	3.2	3.2	4.6
Little Owyhee River Area*	34	Snake River Basin	4.2	3.3	3.1	2.6	3.0	2.9	4.4
Little Smoky Valley	155A	Central Region	4.5	3.1	3.1	2.5	2.9	2.9	4.8
Little Smoky Valley*	155C	Central Region	4.6	3.9	3.8	3.1	3.7	3.7	4.9
Little Smoky Valley*	155B	Central Region	4.6	3.8	3.7	3.0	3.6	3.5	4.8
Long Valley*	9	Northwest Region	4.3	3.7	3.6	3.0	3.5	3.5	4.5
Long Valley*	175	Central Region	4.3	3.4	3.2	2.7	3.1	3.0	4.5
Lovelock Valley	73	Humboldt River Basin	4.7	4.1	4.1	3.4	4.0	4.0	4.9
Lovelock Valley*	73A	Humboldt River Basin	4.7	4.2	4.0	3.3	3.9	3.9	4.9
Lower Meadow Valley Wash	205	Colorado River Basin	5.0	4.7	4.2	3.4	3.4	4.8	5.3
Lower Moapa Valley	220	Colorado River Basin	5.1	4.9	4.3	3.5	3.2	5.0	5.4
Lower Reese River Valley	59	Humboldt River Basin	4.4	3.8	3.8	3.1	3.6	3.7	4.7
Macy Flat*	10	Northwest Region	4.3	3.6	3.5	2.9	3.4	3.4	4.5
Maggie Creek Area*	51	Humboldt River Basin	4.0	3.2	3.0	2.5	2.9	2.8	4.2

Appendix 14 cont.

BASIN NAME	BASIN NUMBER	BASIN REGION	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
Marys Creek Area*	52	Humboldt River Basin	4.2	3.5	3.3	2.8	3.2	3.2	4.4
Marys River Area	42	Humboldt River Basin	3.9	3.1	3.0	2.5	2.9	2.8	4.1
Mason Valley	108	Walker River Basin	4.1	3.5	3.4	2.8	3.3	3.4	4.4
Massacre Lake Valley*	8	Northwest Region	4.3	3.7	3.6	2.9	3.5	3.5	4.5
Mercury Valley*	225	Death Valley Basin	5.9	5.5	4.9	4.0	4.0	5.5	6.2
Mesquite Valley*	163	Central Region	5.9	5.7	4.9	4.0	3.9	5.7	6.2
Middle Reese River Valley*	58	Humboldt River Basin	4.3	3.8	3.7	3.0	3.5	3.6	4.6
Monitor Valley*	140A	Central Region	4.4	3.5	3.4	2.8	3.3	3.2	4.7
Monitor Valley*	140B	Central Region	4.7	3.8	3.7	3.0	3.6	3.5	4.9
Mono Valley*	112	Central Region	4.8	4.1	3.9	3.2	3.8	3.9	5.0
Monte Cristo Valley*	136	Central Region	5.0	4.3	4.1	3.3	4.0	4.1	5.3
Mosquito Valley*	12	Northwest Region	4.3	3.7	3.6	2.9	3.5	3.5	4.5
Mud Meadow*	26	Black Rock Desert Region	4.3	3.7	3.7	3.0	3.6	3.6	4.5
Muddy River Springs Area*	219	Colorado River Basin	5.4	5.1	4.4	3.6	3.4	5.1	5.6
Newark Valley*	154	Central Region	4.3	3.3	3.2	2.7	3.1	3.0	4.5
Newcomb Lake Valley*	96	Western Region	4.2	3.5	3.4	2.8	3.3	3.2	4.4
North Fork Area	44	Humboldt River Basin	4.0	3.1	2.8	2.3	2.7	2.6	4.2
Oasis Valley	228	Death Valley Basin	5.5	5.1	4.5	3.6	4.1	5.0	5.7
Oriental Wash*	232	Death Valley Basin	5.3	4.6	4.4	3.5	4.1	4.5	5.6
Owyhee River Area	37	Snake River Basin	4.0	2.9	2.7	2.2	2.5	2.4	4.2
Pahranagat Valley	209	Colorado River Basin	5.3	4.8	4.4	3.5	3.9	4.6	5.6
Pahroc Valley*	208	Colorado River Basin	4.9	4.4	4.1	3.4	3.9	4.1	5.2
Pahrump Valley	162	Central Region	5.7	5.4	4.8	4.0	4.1	5.5	6.0
Painter Flat*	18	Black Rock Desert Region	4.5	4.0	3.9	3.2	3.8	3.8	4.7
Panaca Valley	203	Colorado River Basin	4.9	4.5	4.2	3.5	4.0	4.1	5.2

Appendix 14 cont.

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Paradise Valley	69	Humboldt River Basin	4.6	3.8	3.6	3.0	3.5	3.4	4.8
Patterson Valley*	202	Colorado River Basin	4.9	4.1	3.9	3.2	3.7	3.7	5.1
Penoyer Valley	170	Central Region	5.1	4.4	4.4	3.6	4.2	4.3	5.4
Pilgrim Flat*	17	Black Rock Desert Region	4.4	3.9	3.8	3.2	3.7	3.8	4.7
Pilot Creek Valley	191	Great Salt Lake Basin	4.2	3.4	3.3	2.7	3.1	3.1	4.4
Pine Forest Valley*	29	Black Rock Desert Region	4.3	3.8	3.7	3.0	3.5	3.5	4.5
Pine Valley	53	Humboldt River Basin	4.4	3.2	3.1	2.5	2.9	2.9	4.6
Piute Valley*	214	Colorado River Basin	6.1	5.8	5.0	4.0	3.6	5.8	6.4
Pleasant Valley	130	Central Region	4.6	4.2	4.1	3.4	3.9	4.0	4.9
Pleasant Valley*	194	Great Salt Lake Basin	4.3	3.4	3.3	2.7	3.2	3.1	4.5
Pleasant Valley*	88	Truckee River Basin	4.7	4.1	3.9	3.2	3.8	3.8	5.0
Pueblo Valley	1	Northwest Region	4.3	3.7	3.6	3.0	3.5	3.5	4.5
Pumpernickel Valley*	65	Humboldt River Basin	4.5	3.9	3.8	3.1	3.6	3.7	4.7
Pyramid Lake Valley	81	Truckee River Basin	4.8	4.1	4.0	3.2	3.8	3.9	5.0
Queen Valley*	116	Central Region	5.1	4.4	4.2	3.4	4.0	4.1	5.4
Quinn River Valley	33B	Black Rock Desert Region	4.3	3.4	3.2	2.7	2.9	3.0	4.5
Quinn River Valley	33A	Black Rock Desert Region	4.4	3.9	3.8	3.1	3.6	3.6	4.6
Railroad Valley	173B	Central Region	4.6	4.1	4.1	3.3	3.9	4.0	4.9
Railroad Valley	173A	Central Region	4.8	4.2	4.1	3.4	4.0	4.1	5.0
Ralston Valley	141	Central Region	5.1	4.4	4.3	3.6	4.3	4.3	5.3
Rawhide Flats*	123	Central Region	4.4	3.8	3.7	3.0	3.6	3.7	4.7
Red Rock Valley	99	Western Region	4.0	3.1	2.9	2.4	2.9	2.7	4.2
Rhodes Salt Marsh Valley*	119	Central Region	5.0	4.4	4.1	3.3	4.0	4.1	5.3
Rock Creek Valley*	62	Humboldt River Basin	4.3	3.4	3.3	2.7	3.1	3.1	4.5
Rock Valley*	226	Death Valley Basin	5.8	5.4	4.8	3.9	3.9	5.4	6.1

Appendix 14 cont.

BASIN NAME	BASIN NUMBER	BASIN REGION	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
Rose Valley*	199	Colorado River Basin	4.9	4.0	3.8	3.1	3.6	3.6	5.2
Ruby Valley	176	Central Region	4.0	3.3	3.2	2.6	3.1	3.0	4.2
Sage Hen Valley*	5	Northwest Region	4.3	3.4	3.3	2.7	3.2	3.1	4.6
Salmon Falls Creek Area	40	Snake River Basin	4.1	3.3	3.1	2.6	3.0	2.9	4.3
San Emidio Desert	22	Black Rock Desert Region	4.2	3.8	3.7	3.1	3.6	3.7	4.4
Sano Valley*	20	Black Rock Desert Region	4.5	4.0	3.9	3.2	3.8	3.8	4.7
Sarcobatus Flat	146	Central Region	5.3	4.4	4.3	3.4	3.9	4.3	5.5
Silver State Valley*	32	Black Rock Desert Region	4.5	3.9	3.8	3.1	3.6	3.6	4.7
Skedaddle Creek Valley*	98	Western Region	4.5	4.0	3.9	3.2	3.8	3.8	4.7
Smith Creek*	134	Central Region	4.5	3.5	3.3	2.7	3.2	3.2	4.7
Smith Valley	107	Walker River Basin	4.3	3.6	3.5	2.9	3.4	3.5	4.5
Smoke Creek Desert	21	Black Rock Desert Region	4.4	4.0	3.9	3.2	3.8	3.8	4.6
Snake Valley*	195	Great Salt Lake Basin	4.4	3.6	3.5	2.9	3.4	3.3	4.7
Soda Spring Valley	121A	Central Region	4.9	4.3	4.1	3.3	3.9	4.1	5.1
Soda Spring Valley*	121B	Central Region	4.7	4.1	3.9	3.2	3.8	3.9	5.0
South Fork Area*	46	Humboldt River Basin	4.1	3.3	3.1	2.5	2.9	2.9	4.3
South Fork Owyhee River Area	35	Snake River Basin	4.2	3.0	2.9	2.4	2.8	2.7	4.4
Spanish Springs Valley*	85	Truckee River Basin	4.4	3.9	3.7	3.1	3.6	3.7	4.6
Spring Valley	184	Central Region	4.5	3.7	3.6	3.0	3.5	3.5	4.7
Spring Valley	201	Colorado River Basin	4.9	3.6	3.5	2.8	3.3	3.2	5.1
Starr Valley Area	43	Humboldt River Basin	4.1	3.3	2.9	2.4	2.8	2.7	4.3
Steptoe Valley	179	Central Region	4.4	3.5	3.4	2.8	3.2	3.2	4.6
Stevens Basin*	152	Central Region	4.3	3.2	3.2	2.6	3.0	3.0	4.5
Stingaree Valley*	125	Central Region	4.7	3.8	3.6	2.9	3.5	3.4	4.9
Stone Cabin Valley*	149	Central Region	4.9	4.1	4.1	3.3	3.9	3.9	5.1

Appendix 14 cont.

BASIN NAME	BASIN NUMBER	BASIN REGION	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
Stonewall Flat*	145	Central Region	5.2	4.5	4.3	3.5	4.1	4.4	5.5
Summit Lake Valley*	27	Black Rock Desert Region	4.3	3.7	3.6	3.0	3.5	3.5	4.5
Sun Valley*	86	Truckee River Basin	4.2	3.9	3.7	3.0	3.6	3.8	4.5
Surprise Valley*	14	Northwest Region	4.3	3.8	3.7	3.0	3.6	3.6	4.6
Susie Creek Area*	50	Humboldt River Basin	4.0	3.3	3.1	2.6	3.0	2.9	4.2
Swan Lake Valley*	7	Northwest Region	4.3	3.6	3.5	2.9	3.4	3.3	4.5
Teels Marsh Valley*	114	Central Region	5.0	4.3	4.1	3.3	3.9	4.1	5.2
Thousand Springs Valley	189D	Great Salt Lake Basin	4.4	3.5	3.4	2.7	3.2	3.1	4.6
Thousand Springs Valley	189A	Great Salt Lake Basin	4.3	2.9	2.8	2.3	2.7	2.5	4.5
Thousand Springs Valley*	189B	Great Salt Lake Basin	4.2	3.2	3.1	2.5	2.9	2.8	4.4
Thousand Springs Valley*	189C	Great Salt Lake Basin	4.2	3.3	3.1	2.6	3.0	2.9	4.4
Three Lakes Valley*	168	Central Region	5.7	5.3	4.7	3.8	4.0	5.2	6.0
Three Lakes Valley*	211	Colorado River Basin	6.0	5.6	5.0	4.0	4.0	5.5	6.3
Tikapoo Valley*	169A	Central Region	5.2	4.6	4.3	3.5	4.0	4.4	5.5
Tikapoo Valley*	169B	Central Region	5.5	5.0	4.5	3.7	3.9	4.9	5.7
Tippett Valley*	185	Central Region	4.3	3.4	3.3	2.7	3.2	3.1	4.5
Tracy Segment	83	Truckee River Basin	4.6	3.9	3.8	3.1	3.7	3.7	4.8
Truckee Canyon Segment*	91	Truckee River Basin	4.4	3.9	3.7	3.0	3.6	3.7	4.6
Truckee Meadows	87	Truckee River Basin	4.4	3.9	3.8	3.1	3.7	3.8	4.6
Tule Desert*	221	Colorado River Basin	5.0	4.7	4.1	3.4	3.5	4.6	5.3
Upper Reese River Valley	56	Humboldt River Basin	4.2	3.2	3.0	2.5	2.9	2.8	4.5
Virgin River Valley	222	Colorado River Basin	5.1	4.9	4.3	3.5	3.2	4.9	5.4
Virgin Valley	4	Northwest Region	4.4	3.3	3.1	2.6	3.0	2.9	4.6
Walker Lake Valley	110A	Walker River Basin	4.6	3.9	3.9	3.2	3.8	3.9	4.9
Walker Lake Valley	110C	Walker River Basin	4.7	4.1	3.9	3.2	3.8	3.9	4.9

Appendix 14 cont.

BASIN NAME	BASIN NUMBER	BASIN REGION	REFERENCE ET_{os} (ft)	ALFALFA ET_{act} (ft)	HIGHLY MANAGED PASTURE GRASS ET_{act} (ft)	LOW MANAGED PASTURE GRASS ET_{act} (ft)	GRASS HAY ET_{act} (ft)	TURF GRASS ET_{act} (ft)	SHALLOW OPEN WATER E_{act} (ft)
Walker Lake Valley*	110B	Walker River Basin	4.6	4.0	3.9	3.1	3.7	3.9	4.9
Warm Springs Valley*	84	Truckee River Basin	4.4	3.8	3.6	3.0	3.5	3.6	4.6
Warner Valley*	13	Northwest Region	4.3	3.7	3.6	2.9	3.5	3.5	4.5
Washoe Valley	89	Truckee River Basin	5.2	4.4	4.2	3.4	4.0	3.9	5.5
Whirlwind Valley*	60	Humboldt River Basin	4.3	3.7	3.6	3.0	3.5	3.5	4.5
White Plains*	74	Humboldt River Basin	4.5	4.0	3.9	3.2	3.7	3.8	4.8
White River Valley	207	Colorado River Basin	4.6	4.0	3.8	3.2	3.7	3.6	4.9
Willow Creek Valley	63	Humboldt River Basin	4.4	3.1	3.1	2.6	2.9	2.9	4.7
Winnemucca Lake Valley*	80	Truckee River Basin	4.5	3.9	3.8	3.1	3.7	3.7	4.7
Winnemucca Segment	70	Humboldt River Basin	4.6	4.0	3.8	3.2	3.7	3.7	4.8
Yucca Flat*	159	Central Region	5.5	4.9	4.5	3.7	4.1	4.8	5.7

Appendix 15. Mean annual Net Irrigation Water Requirement (NIWR) of alfalfa, grass hay, pasture grass, turf grass, and small shallow open water bodies for all HAs. Values of the NIWR for each HA were either assigned for HAs with single stations, computed using a valid period of record weighted average for HAs with multiple stations, or estimated from spatial interpolation for HAs with no stations. * indicates that the NIWR was estimated using spatial interpolation.

BASIN NAME	BASIN NUMBER	BASIN REGION	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
Adobe Valley*	115	Central Region	3.9	3.8	3.0	3.6	3.7	4.8
Alkali Spring Valley*	142	Central Region	4.2	4.0	3.2	3.9	4.0	5.1
Alkali Valley*	111A	Central Region	3.7	3.5	2.8	3.4	3.5	4.5
Alkali Valley*	111B	Central Region	3.7	3.5	2.8	3.4	3.5	4.5
Amargosa Desert	230	Death Valley Basin	5.3	4.5	3.6	3.6	5.3	5.8
Antelope Valley	57	Humboldt River Basin	3.0	3.1	2.4	3.0	3.0	3.9
Antelope Valley	106	Walker River Basin	3.3	3.2	2.5	3.1	3.2	4.0
Antelope Valley*	186B	Central Region	2.6	2.6	2.0	2.5	2.4	3.6
Antelope Valley*	186A	Central Region	2.7	2.7	2.1	2.6	2.5	3.7
Antelope Valley*	93	Western Region	3.1	3.1	2.5	3.0	3.1	3.7
Antelope Valley*	151	Central Region	2.8	2.8	2.2	2.7	2.6	4.0
Bedell Flat*	94	Western Region	2.9	2.9	2.3	2.8	2.8	3.6
Big Smoky Valley	137B	Central Region	3.6	3.5	2.8	3.5	3.4	4.5
Big Smoky Valley	137A	Central Region	3.7	3.6	2.9	3.6	3.4	4.7
Black Moutains Area	215	Colorado River Basin	4.7	4.0	3.1	2.7	4.7	5.2
Black Rock Desert	28	Black Rock Desert Region	3.2	3.2	2.6	3.2	3.2	3.8
Boulder Flat*	61	Humboldt River Basin	2.8	2.8	2.2	2.7	2.7	3.6
Boulder Valley*	15	Northwest Region	3.3	3.2	2.6	3.2	3.2	3.9
Bradys Hot Springs Area*	75	West Central Region	3.5	3.4	2.7	3.3	3.3	4.2
Bruneau River Area	38	Snake River Basin	1.6	1.5	1.1	1.2	1.3	3.3

Appendix 15 cont.

BASIN NAME	BASIN NUMBER	BASIN REGION	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
Buena Vista Valley*	129	Central Region	3.4	3.4	2.7	3.3	3.3	4.1
Buffalo Valley	131	Central Region	2.8	2.8	2.2	2.7	2.8	3.0
Butte Valley*	178A	Central Region	2.6	2.6	2.0	2.5	2.4	3.6
Butte Valley*	178B	Central Region	2.8	2.7	2.1	2.6	2.5	3.7
Cactus Flat*	148	Central Region	3.9	3.8	3.1	3.7	3.9	4.8
California Wash*	218	Colorado River Basin	4.8	4.1	3.3	3.1	4.9	5.3
Carico Lake Valley*	55	Humboldt River Basin	3.0	3.0	2.3	2.8	2.9	3.7
Carson Desert	101	Carson River Basin	3.3	3.2	2.6	3.1	3.3	3.9
Carson Desert*	101A	Carson River Basin	3.5	3.5	2.8	3.4	3.4	4.2
Carson Valley	105	Carson River Basin	3.0	3.0	2.4	2.9	3.0	3.7
Cave Valley*	180	Central Region	3.2	3.1	2.4	3.0	2.9	4.0
Churchill Valley	102	Carson River Basin	3.3	3.2	2.6	3.1	3.3	3.9
Clayton Valley	143	Central Region	4.4	4.3	3.4	3.9	4.4	5.3
Clover Valley	177	Central Region	2.5	2.6	2.1	2.5	2.5	3.1
Clover Valley	204	Colorado River Basin	3.8	3.7	2.9	3.4	3.6	4.4
Clovers Area	64	Humboldt River Basin	3.2	3.2	2.6	3.1	3.1	4.0
Coal Valley*	171	Central Region	3.8	3.7	2.9	3.5	3.7	4.6
Cold Spring Valley*	100A	Western Region	3.0	3.0	2.4	2.9	3.0	3.6
Cold Spring Valley*	100	Western Region	3.1	3.1	2.5	3.0	3.1	3.6
Coleman Valley*	11	Northwest Region	3.1	3.1	2.4	3.0	3.0	3.9
Colorado Valley	213	Colorado River Basin	5.8	5.0	3.9	3.6	5.8	6.4
Columbus Salt Marsh Valley	118	Central Region	4.4	4.2	3.3	4.1	4.1	5.4
Continental Lake Valley*	2	Northwest Region	3.0	3.0	2.4	2.9	2.9	3.8
Cowkick Valley	126	Central Region	3.4	3.2	2.5	3.1	3.0	4.5
Coyote spring Valley*	210	Colorado River Basin	4.6	4.1	3.2	3.4	4.6	5.1

Appendix 15 cont.

BASIN NAME	BASIN NUMBER	BASIN REGION	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
Crater Flat*	229	Death Valley Basin	4.8	4.2	3.4	3.8	4.8	5.4
Crescent Valley	54	Humboldt River Basin	2.9	3.0	2.4	2.9	2.9	3.7
Dayton Valley*	103	Carson River Basin	3.3	3.2	2.6	3.1	3.2	3.9
Deep Creek Valley*	193	Great Salt Lake Basin	2.7	2.7	2.1	2.6	2.5	3.6
Delamar Valley*	182	Central Region	4.1	3.7	2.9	3.4	3.9	4.6
Desert Valley	31	Black Rock Desert Region	3.1	3.2	2.5	3.1	3.1	3.8
Diamond Valley	153	Central Region	2.5	2.5	2.0	2.4	2.4	3.5
Dixie Creek-Tenmile Creek Area	48	Humboldt River Basin	2.8	2.7	2.1	2.4	2.6	3.7
Dixie Valley	128	Central Region	3.6	3.5	2.8	3.4	3.6	4.3
Dodge Flat	82	Truckee River Basin	3.5	3.4	2.7	3.3	3.3	4.3
Dry Lake Valley*	181	Central Region	3.7	3.5	2.7	3.3	3.5	4.3
Dry Valley*	19	Black Rock Desert Region	3.5	3.5	2.8	3.4	3.5	4.1
Dry Valley*	95	Western Region	2.9	2.9	2.3	2.7	2.7	3.6
Dry Valley*	198	Colorado River Basin	3.5	3.3	2.6	3.2	3.2	4.2
Duck Lake Valley*	16	Northwest Region	3.3	3.3	2.6	3.2	3.3	4.0
Eagle Valley	104	Carson River Basin	3.2	3.1	2.5	3.0	3.1	3.7
Eagle Valley*	200	Colorado River Basin	3.1	3.0	2.4	2.9	2.8	4.1
East Walker Area*	109	Walker River Basin	3.5	3.4	2.7	3.3	3.4	4.3
Eastgate Valley Area	127	Central Region	3.4	3.4	2.7	3.4	3.4	4.2
Edwards Creek Valley*	133	Central Region	3.2	3.1	2.4	3.0	3.0	4.0
Eldorado Valley	167	Central Region	4.6	3.9	3.1	2.9	4.6	5.1
Elko Segment	49	Humboldt River Basin	2.6	2.6	2.1	2.5	2.5	3.3
Emigrant Valley*	158A	Central Region	4.2	4.0	3.2	3.7	4.1	5.0
Emigrant Valley*	158B	Central Region	4.6	4.2	3.3	3.8	4.5	5.3
Escalante Desert*	197	Escalante Desert	3.6	3.4	2.7	3.2	3.4	4.3

Appendix 15 cont.

BASIN NAME	BASIN NUMBER	BASIN REGION	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
Fairview Valley*	124	Central Region	3.4	3.2	2.6	3.2	3.2	4.3
Fernley Area	76	West Central Region	3.5	3.4	2.7	3.3	3.3	4.3
Fireball Valley*	77	West Central Region	3.5	3.4	2.7	3.3	3.4	4.3
Fish Lake Valley	117	Central Region	4.2	4.1	3.2	4.1	4.0	5.4
Fortymile Canyon*	227B	Death Valley Basin	4.6	4.1	3.3	3.8	4.5	5.3
Fortymile Canyon*	227A	Death Valley Basin	4.9	4.3	3.4	3.8	4.9	5.5
Frenchman Flat*	160	Central Region	4.9	4.4	3.5	3.9	4.9	5.6
Gabbs Valley*	122	Central Region	3.5	3.4	2.7	3.3	3.3	4.4
Garden Valley*	172	Central Region	3.7	3.6	2.9	3.5	3.6	4.5
Garfield Flat*	120	Central Region	3.9	3.7	2.9	3.5	3.7	4.7
Garnet Valley*	216	Colorado River Basin	5.2	4.5	3.6	3.4	5.3	5.7
Gold Butte Area*	223	Colorado River Basin	4.7	4.0	3.2	2.9	4.7	5.2
Gold Flat*	147	Central Region	4.1	3.9	3.1	3.7	4.1	5.0
Goose Creek Area*	41	Snake River Basin	2.5	2.5	1.9	2.4	2.3	3.5
Goshute Valley	187	Central Region	2.8	2.7	2.1	2.6	2.5	3.7
Granite Basin*	23	Black Rock Desert Region	3.3	3.3	2.6	3.2	3.3	3.9
Granite Springs Valley*	78	West Central Region	3.5	3.5	2.8	3.4	3.4	4.2
Grapevine Canyon*	231	Death Valley Basin	4.4	4.1	3.3	3.8	4.3	5.3
Grass Valley	71	Humboldt River Basin	3.3	3.3	2.6	3.2	3.2	4.2
Grass Valley	138	Central Region	2.7	2.8	2.2	2.7	2.7	3.5
Greasewood Basin*	224	Colorado River Basin	4.6	4.0	3.2	2.9	4.7	5.1
Great Salt Lake Desert	192	Great Salt Lake Basin	2.3	2.4	1.9	2.3	2.2	3.1
Gridley Lake Valley*	3	Northwest Region	3.1	3.1	2.4	3.0	3.0	3.8
Grouse Creek Valley*	190	Great Salt Lake Basin	2.7	2.6	2.0	2.5	2.4	3.6
Guano Valley*	6	Northwest Region	3.0	3.0	2.4	2.9	2.9	3.9

Appendix 15 cont.

BASIN NAME	BASIN NUMBER	BASIN REGION	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
Hamlin Valley*	196	Great Salt Lake Basin	3.0	3.0	2.4	2.9	2.9	4.0
Hardscrabble Area*	68	Humboldt River Basin	3.1	3.0	2.4	2.9	2.9	3.8
Hidden Valley*	217	Colorado River Basin	5.2	4.5	3.6	3.4	5.3	5.8
Hidden Valley*	166	Central Region	5.2	4.5	3.6	3.4	5.3	5.7
High Rock Lake Valley*	25	Black Rock Desert Region	3.2	3.2	2.6	3.2	3.2	3.9
Honey Lake Valley*	97	Western Region	3.3	3.3	2.6	3.2	3.3	4.0
Hot Creek	156	Central Region	3.4	3.5	2.7	3.4	3.3	4.4
Hualapai Flat*	24	Black Rock Desert Region	3.3	3.3	2.6	3.3	3.3	3.9
Huntington Valley	47	Humboldt River Basin	2.4	2.4	1.8	2.2	2.2	3.0
Huntoon Valley*	113	Central Region	3.9	3.7	2.9	3.5	3.7	4.7
Imlay Area	72	Humboldt River Basin	3.5	3.4	2.7	3.3	3.4	4.2
Independence Valley	36	Snake River Basin	2.2	2.2	1.7	2.1	2.0	2.8
Independence Valley*	188	Central Region	2.5	2.5	2.0	2.4	2.4	3.4
Indian Springs Valley	161	Central Region	5.2	4.7	3.7	4.1	5.0	6.0
Ione Valley*	135	Central Region	3.4	3.2	2.6	3.2	3.1	4.4
Ivanpah Valley	164A	Central Region	5.2	4.4	3.5	3.7	5.1	5.6
Ivanpah Valley*	164B	Central Region	5.3	4.5	3.6	3.5	5.3	5.8
Jakes Valley	174	Central Region	2.7	2.6	2.0	2.5	2.4	3.7
Jarbidge River Area	39	Snake River Basin	2.3	2.3	1.7	2.2	2.1	2.7
Jean Lake Valley*	165	Central Region	5.2	4.5	3.6	3.5	5.3	5.7
Jersey Valley*	132	Central Region	3.3	3.2	2.6	3.1	3.2	3.8
Kane Springs Valley*	206	Colorado River Basin	4.0	3.6	2.8	3.2	4.0	4.4
Kawich Valley*	157	Central Region	4.1	3.9	3.1	3.7	4.0	4.9
Kelley Creek Area*	66	Humboldt River Basin	3.0	3.1	2.4	2.9	2.9	3.9
Kings River Valley*	30A	Black Rock Desert Region	3.1	3.1	2.4	2.9	3.0	3.8

Appendix 15 cont.

BASIN NAME	BASIN NUMBER	BASIN REGION	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
Kings River Valley*	30B	Black Rock Desert Region	3.1	3.1	2.5	3.0	3.0	3.8
Kobeh Valley*	139	Central Region	2.7	2.7	2.1	2.6	2.6	3.6
Kumiva Valley*	79	West Central Region	3.4	3.4	2.7	3.3	3.4	4.1
Lake Tahoe Basin	90	Truckee River Basin	2.3	2.3	1.8	2.1	2.2	2.4
Lake Valley	183	Central Region	3.0	2.9	2.3	2.7	2.7	4.0
Lamoille Valley	45	Humboldt River Basin	2.3	2.3	1.8	2.2	2.1	2.9
Las Vegas Valley	212	Colorado River Basin	5.6	4.8	3.9	3.7	5.7	6.1
Lemmon Valley	92B	Western Region	3.1	3.1	2.5	3.0	3.1	3.4
Lemmon Valley*	92A	Western Region	3.1	3.1	2.5	3.0	3.1	3.6
Lida Valley*	144	Central Region	4.3	4.1	3.3	3.8	4.2	5.2
Little Fish Lake Valley*	150	Central Region	3.2	3.2	2.5	3.1	3.1	4.2
Little Humboldt Valley*	67	Humboldt River Basin	2.8	2.8	2.2	2.6	2.6	3.7
Little Owyhee River Area*	34	Snake River Basin	2.5	2.5	2.0	2.4	2.4	3.5
Little Smoky Valley	155A	Central Region	2.8	2.8	2.2	2.6	2.6	4.4
Little Smoky Valley*	155C	Central Region	3.3	3.3	2.6	3.2	3.2	4.2
Little Smoky Valley*	155B	Central Region	3.2	3.2	2.5	3.1	3.1	4.2
Long Valley*	9	Northwest Region	3.2	3.2	2.5	3.1	3.1	3.9
Long Valley*	175	Central Region	2.7	2.7	2.1	2.6	2.5	3.7
Lovelock Valley	73	Humboldt River Basin	3.7	3.7	3.0	3.6	3.6	4.5
Lovelock Valley*	73A	Humboldt River Basin	3.5	3.4	2.8	3.3	3.4	4.2
Lower Meadow Valley Wash	205	Colorado River Basin	4.2	3.7	2.9	3.0	4.3	4.6
Lower Moapa Valley	220	Colorado River Basin	4.5	1.8	1.5	1.4	2.2	2.4
Lower Reese River Valley	59	Humboldt River Basin	3.2	3.2	2.6	3.1	3.1	4.0
Macy Flat*	10	Northwest Region	3.1	3.1	2.4	3.0	2.9	3.9
Maggie Creek Area*	51	Humboldt River Basin	2.4	2.4	1.9	2.3	2.3	3.3

Appendix 15 cont.

BASIN NAME	BASIN NUMBER	BASIN REGION	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
Marys Creek Area*	52	Humboldt River Basin	2.7	2.7	2.2	2.6	2.6	3.6
Marys River Area	42	Humboldt River Basin	2.4	2.4	1.8	2.3	2.2	3.2
Mason Valley	108	Walker River Basin	3.1	3.0	2.4	2.9	3.0	3.9
Massacre Lake Valley*	8	Northwest Region	3.1	3.1	2.5	3.0	3.0	3.9
Mercury Valley*	225	Death Valley Basin	5.2	4.6	3.6	3.8	5.2	5.8
Mesquite Valley*	163	Central Region	5.3	4.5	3.6	3.7	5.3	5.7
Middle Reese River Valley*	58	Humboldt River Basin	3.1	3.1	2.4	2.9	3.0	3.8
Monitor Valley*	140A	Central Region	2.9	2.9	2.3	2.8	2.7	4.0
Monitor Valley*	140B	Central Region	3.3	3.3	2.6	3.2	3.1	4.3
Mono Valley*	112	Central Region	3.8	3.6	2.8	3.5	3.6	4.5
Monte Cristo Valley*	136	Central Region	4.0	3.8	3.0	3.7	3.7	4.9
Mosquito Valley*	12	Northwest Region	3.1	3.1	2.5	3.0	3.0	3.9
Mud Meadow*	26	Black Rock Desert Region	3.2	3.2	2.6	3.2	3.2	3.9
Muddy River Springs Area*	219	Colorado River Basin	4.7	4.0	3.2	3.1	4.7	5.1
Newark Valley*	154	Central Region	2.7	2.7	2.1	2.6	2.6	3.8
Newcomb Lake Valley*	96	Western Region	3.0	3.0	2.4	2.9	2.9	3.7
North Fork Area	44	Humboldt River Basin	2.2	2.2	1.7	2.1	2.0	3.2
Oasis Valley	228	Death Valley Basin	4.7	4.1	3.3	3.9	4.7	5.3
Oriental Wash*	232	Death Valley Basin	4.3	4.1	3.3	3.8	4.2	5.2
Owyhee River Area	37	Snake River Basin	2.1	2.1	1.6	2.0	1.9	3.1
Pahranagat Valley	209	Colorado River Basin	4.4	4.0	3.1	3.6	4.2	5.0
Pahroc Valley*	208	Colorado River Basin	3.8	3.6	2.8	3.4	3.6	4.4
Pahrump Valley	162	Central Region	5.0	4.4	3.6	3.8	5.1	5.6
Painter Flat*	18	Black Rock Desert Region	3.5	3.4	2.7	3.4	3.4	4.1
Panaca Valley	203	Colorado River Basin	3.8	3.6	2.9	3.4	3.6	4.4

Appendix 15 cont.

BASIN NAME	BASIN NUMBER	BASIN REGION	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
Paradise Valley	69	Humboldt River Basin	3.2	3.2	2.5	3.0	3.0	4.0
Patterson Valley*	202	Colorado River Basin	3.4	3.3	2.6	3.1	3.1	4.2
Penoyer Valley	170	Central Region	3.9	3.9	3.1	3.8	3.8	4.8
Pilgrim Flat*	17	Black Rock Desert Region	3.4	3.4	2.7	3.3	3.4	4.0
Pilot Creek Valley	191	Great Salt Lake Basin	2.9	2.8	2.2	2.7	2.6	3.6
Pine Forest Valley*	29	Black Rock Desert Region	3.1	3.1	2.5	3.0	3.1	3.8
Pine Valley	53	Humboldt River Basin	2.5	2.4	1.9	2.3	2.3	3.8
Piute Valley*	214	Colorado River Basin	5.4	4.6	3.7	3.5	5.4	6.0
Pleasant Valley	130	Central Region	3.5	3.4	2.8	3.3	3.4	4.1
Pleasant Valley*	194	Great Salt Lake Basin	2.8	2.8	2.2	2.7	2.6	3.8
Pleasant Valley*	88	Truckee River Basin	3.5	3.5	2.7	3.3	3.3	4.2
Pueblo Valley	1	Northwest Region	3.1	3.1	2.5	3.0	3.0	3.7
Pumpernickel Valley*	65	Humboldt River Basin	3.3	3.3	2.6	3.1	3.2	4.0
Pyramid Lake Valley	81	Truckee River Basin	3.6	3.5	2.8	3.4	3.5	4.4
Queen Valley*	116	Central Region	4.1	3.9	3.1	3.8	3.8	5.0
Quinn River Valley	33B	Black Rock Desert Region	2.8	2.7	2.1	2.3	2.5	3.8
Quinn River Valley	33A	Black Rock Desert Region	3.1	3.1	2.5	3.0	3.1	3.7
Railroad Valley	173B	Central Region	3.5	3.5	2.8	3.4	3.4	4.2
Railroad Valley	173A	Central Region	3.7	3.7	3.0	3.5	3.7	4.5
Ralston Valley	141	Central Region	4.0	3.9	3.1	3.9	3.9	4.8
Rawhide Flats*	123	Central Region	3.4	3.3	2.6	3.2	3.3	4.2
Red Rock Valley	99	Western Region	2.6	2.6	2.0	2.5	2.4	3.4
Rhodes Salt Marsh Valley*	119	Central Region	4.0	3.8	3.0	3.7	3.8	4.8
Rock Creek Valley*	62	Humboldt River Basin	2.7	2.7	2.1	2.6	2.6	3.7
Rock Valley*	226	Death Valley Basin	5.1	4.5	3.5	3.8	5.1	5.7

Appendix 15 cont.

BASIN NAME	BASIN NUMBER	BASIN REGION	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
Rose Valley*	199	Colorado River Basin	3.3	3.2	2.5	3.0	3.0	4.2
Ruby Valley	176	Central Region	2.5	2.6	2.0	2.5	2.4	3.0
Sage Hen Valley*	5	Northwest Region	2.9	2.8	2.2	2.7	2.7	3.9
Salmon Falls Creek Area	40	Snake River Basin	2.6	2.5	1.9	2.3	2.3	3.5
San Emidio Desert	22	Black Rock Desert Region	3.2	3.2	2.6	3.2	3.2	3.8
Sano Valley*	20	Black Rock Desert Region	3.5	3.5	2.8	3.4	3.5	4.1
Sarcobatus Flat	146	Central Region	4.2	4.0	3.2	3.7	4.2	5.2
Silver State Valley*	32	Black Rock Desert Region	3.3	3.3	2.6	3.1	3.2	4.0
Skedaddle Creek Valley*	98	Western Region	3.5	3.5	2.8	3.4	3.5	4.1
Smith Creek*	134	Central Region	3.0	2.9	2.3	2.8	2.7	4.1
Smith Valley	107	Walker River Basin	3.1	3.0	2.4	2.9	3.0	3.9
Smoke Creek Desert	21	Black Rock Desert Region	3.4	3.4	2.7	3.3	3.4	4.0
Snake Valley*	195	Great Salt Lake Basin	3.0	2.9	2.3	2.8	2.8	3.9
Soda Spring Valley	121A	Central Region	3.9	3.7	2.9	3.6	3.7	4.6
Soda Spring Valley*	121B	Central Region	3.8	3.6	2.8	3.5	3.6	4.6
South Fork Area*	46	Humboldt River Basin	2.5	2.5	1.9	2.3	2.3	3.2
South Fork Owyhee River Area	35	Snake River Basin	1.8	1.9	1.5	2.0	1.8	3.1
Spanish Springs Valley*	85	Truckee River Basin	3.3	3.3	2.6	3.2	3.3	3.9
Spring Valley	184	Central Region	3.0	3.0	2.4	2.9	2.9	3.9
Spring Valley	201	Colorado River Basin	3.0	2.9	2.3	2.8	2.6	4.1
Starr Valley Area	43	Humboldt River Basin	2.4	2.3	1.8	2.2	2.2	3.3
Steptoe Valley	179	Central Region	2.9	2.8	2.2	2.7	2.6	3.9
Stevens Basin*	152	Central Region	2.7	2.7	2.1	2.6	2.5	3.9
Stingaree Valley*	125	Central Region	3.4	3.2	2.5	3.1	3.0	4.4
Stone Cabin Valley*	149	Central Region	3.7	3.7	2.9	3.6	3.6	4.6

Appendix 15 cont.

BASIN NAME	BASIN NUMBER	BASIN REGION	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
Stonewall Flat*	145	Central Region	4.2	4.0	3.2	3.8	4.0	5.0
Summit Lake Valley*	27	Black Rock Desert Region	3.1	3.1	2.5	3.1	3.1	3.8
Sun Valley*	86	Truckee River Basin	3.3	3.2	2.6	3.2	3.3	3.7
Surprise Valley*	14	Northwest Region	3.2	3.2	2.6	3.1	3.2	3.9
Susie Creek Area*	50	Humboldt River Basin	2.5	2.5	2.0	2.4	2.4	3.3
Swan Lake Valley*	7	Northwest Region	3.1	3.0	2.4	2.9	2.9	3.9
Teels Marsh Valley*	114	Central Region	4.0	3.8	3.0	3.7	3.8	4.8
Thousand Springs Valley	189D	Great Salt Lake Basin	2.9	2.9	2.2	2.8	2.6	4.0
Thousand Springs Valley	189A	Great Salt Lake Basin	2.2	2.2	1.7	2.1	2.0	3.6
Thousand Springs Valley*	189B	Great Salt Lake Basin	2.5	2.5	1.9	2.4	2.3	3.5
Thousand Springs Valley*	189C	Great Salt Lake Basin	2.6	2.6	2.0	2.5	2.4	3.6
Three Lakes Valley*	168	Central Region	4.9	4.4	3.5	3.8	4.9	5.6
Three Lakes Valley*	211	Colorado River Basin	5.3	4.7	3.7	3.9	5.2	6.0
Tikapoo Valley*	169A	Central Region	4.2	3.9	3.1	3.7	4.0	4.9
Tikapoo Valley*	169B	Central Region	4.6	4.1	3.3	3.6	4.5	5.2
Tippett Valley*	185	Central Region	2.8	2.8	2.2	2.7	2.6	3.8
Tracy Segment	83	Truckee River Basin	3.5	3.4	2.7	3.2	3.3	4.3
Truckee Canyon Segment*	91	Truckee River Basin	3.3	3.2	2.6	3.1	3.2	3.8
Truckee Meadows	87	Truckee River Basin	3.4	3.4	2.7	3.3	3.5	4.0
Tule Desert*	221	Colorado River Basin	4.0	3.5	2.8	3.1	4.0	4.4
Upper Reese River Valley	56	Humboldt River Basin	2.6	2.5	2.0	2.4	2.3	3.6
Virgin River Valley	222	Colorado River Basin	4.4	3.8	3.0	2.9	4.5	4.8
Virgin Valley	4	Northwest Region	2.8	2.7	2.1	2.6	2.5	4.0
Walker Lake Valley	110A	Walker River Basin	3.5	3.5	2.8	3.4	3.5	4.4
Walker Lake Valley	110C	Walker River Basin	3.8	3.6	2.9	3.5	3.7	4.6

Appendix 15 cont.

BASIN NAME	BASIN NUMBER	BASIN REGION	ALFALFA NIWR (ft)	HIGHLY MANAGED PASTURE GRASS NIWR (ft)	LOW MANAGED PASTURE GRASS NIWR (ft)	GRASS HAY NIWR (ft)	TURF GRASS NIWR (ft)	SHALLOW OPEN WATER NIWR (ft)
Walker Lake Valley*	110B	Walker River Basin	3.7	3.5	2.8	3.4	3.5	4.5
Warm Springs Valley*	84	Truckee River Basin	3.3	3.2	2.6	3.1	3.2	4.0
Warner Valley*	13	Northwest Region	3.1	3.1	2.5	3.0	3.0	3.9
Washoe Valley	89	Truckee River Basin	3.7	3.8	2.9	3.5	3.5	4.7
Whirlwind Valley*	60	Humboldt River Basin	3.0	3.0	2.4	2.9	2.9	3.7
White Plains*	74	Humboldt River Basin	3.5	3.4	2.8	3.3	3.4	4.3
White River Valley	207	Colorado River Basin	3.2	3.2	2.5	3.0	3.0	4.0
Willow Creek Valley	63	Humboldt River Basin	2.4	2.5	2.0	2.4	2.4	3.9
Winnemucca Lake Valley*	80	Truckee River Basin	3.5	3.4	2.7	3.3	3.4	4.2
Winnemucca Segment	70	Humboldt River Basin	3.4	3.4	2.7	3.2	3.3	4.2
Yucca Flat*	159	Central Region	4.6	4.2	3.3	3.8	4.5	5.3

Appendix 16. Mean annual Net Irrigation Water Requirement (NIWR) for selected HAs and crops. Values of the NIWR were either assigned or averaged for HAs with multiple stations according to the number of valid years used in computing the station annual average NIWR. The NIWR for corn is the average of silage, field, and sweet corn crops. For other areas and crops of interest, see electronic statistical summaries. Descriptions of the electronic statistical summaries are given in Appendix 9.

Basin Name	Basin Number	Garden Vegetables (general) NIWR (ft)	Corn NIWR(ft)	Spring Wheat NIWR (ft)	Winter Wheat NIWR (ft)	Garlic NIWR (ft)	Onion NIWR (ft)	Potatoes (baking-late harvest) NIWR (ft)	Potatoes (processing -early harvest) NIWR (ft)	Grapes NIWR (ft)	Melons NIWR (ft)
Carson Desert	101	2.8	2.6	2.0	2.1					2.4	1.7
Carson Valley	105	2.7	2.5	1.9	2.2						
Diamond Valley	153	2.2	2.2	2.0	2.1						
Lovelock Valley	73	3.4	3.1	2.3	2.5			2.9	2.5		
Mason Valley	108	2.7	2.4	1.9	2.0	2.3	2.4				
Paradise Valley	69	2.6	2.8	2.3	2.5	2.5	2.6	2.7	2.4		
Smith Valley	107	2.6	2.5	2.0	2.2	2.4	2.5				
Lake Valley	183	2.3	2.4	2.2	2.5	2.5	2.5	2.6	2.4		

Annex 1.

FAO-56 Dual Crop Coefficient Method for Estimating Evaporation from Soil and Application Extensions

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Abstract: Crop coefficient curves provide simple, reproducible means to estimate crop evapotranspiration (ET) from weather-based reference ET values. The dual crop coefficient (K_c) method of the Food and Agricultural Organization of the United States (FAO) Irrigation and Drainage Paper No. 56 (*FAO-56*) is intended to improve daily simulation of crop ET by considering separately the contribution of evaporation from soil. The dual method utilizes "basal" crop coefficients representing ET from crops having a dry soil surface and separately predicts evaporation from bare soil based on a water balance of the soil surface layer. Three extensions to the evaporation calculation procedure are described here that are intended to improve accuracy when applications warrant the extra complexity. The first extension uses parallel water balances representing the portion of the soil surface wetted by irrigation and precipitation together and the portion wetted by precipitation alone. The second extension uses three "stages" for surface drying and provides for application to deep cracking soils. The third extension predicts the extraction of the transpiration component from the soil surface layer. Sensitivity and analyses and illustrations indicate moderate sensitivity of daily calculated ET to application of the extensions. The dual K_c procedure, although relatively simple computationally and structurally, estimates daily ET as measured by lysimeter relatively well for periods of bare soil and partial and full vegetation cover.

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CE Database subject headings: Evapotranspiration; Evaporation; Crops; Crop moisture index; Soil water.

Introduction

A commonly used approach for estimating consumptive use of water by irrigated crops is the crop coefficient—reference evapotranspiration (K_c ET_0) procedure. Reference evapotranspiration (ET_0) is computed for a grass or alfalfa reference crop and is then multiplied by an empirical crop coefficient (K_c) to estimate crop evapotranspiration (ET_c) (Jensen et al. 1971; Doorenbos and Pruitt 1977; Wright 1981, 1982). In general, three primary characteristics distinguish ET from a crop from ET from the reference surface: aerodynamic roughness of the crop; general resistance within the crop canopy and soil to the flow of heat and water vapor; and reflectance of the crop and soil surface to short wave radiation. Because ET_0 represents nearly all effects of weather, K_c varies predominately with specific crop characteristics and only a small amount with climate. This enables the transfer of standard values and curves for K_c between locations and climates. This transfer has led to the widespread acceptance and usefulness of the K_c approach.

In situations where K_c has not been derived by ET measurement, it can be estimated from fraction of ground cover or leaf area index (Allen et al. 1998). K_c varies during the growing season as plants develop, as the fraction of ground covered by vegetation changes, and as plants age and mature (Fig. 1). K_c varies according to the wetness of the soil surface, especially when there is little vegetation cover. Under bare soil conditions, K_c has a high value when soil is wet and its value steadily decreases as the soil dries.

This paper describes the dual K_c procedure of FAO published as *FAO Irrigation and Drainage Paper No. 56* (Allen et al. 1998) and provides a brief rationale for various components of the procedure along with selected sensitivity analyses. Extensions to the original procedure are introduced that may improve accuracy of applications for special situations.

FAO-56 K_c Procedure

The *FAO-56* crop coefficients are intended for use with grass reference ET_0 similar to that predicted by the *FAO-56* Penman–Monteith method (Allen et al. 1998). The *FAO-56* Penman–Monteith equation predicts ET_0 from a hypothetical grass reference surface that is 0.12 m in height having a surface resistance of 70 s m^{-1} for 24 h time steps and albedo of 0.23. Standardized equations for computing parameters in the *FAO-56* Penman–Monteith equation are given in Allen et al. (1998, 1994) as well

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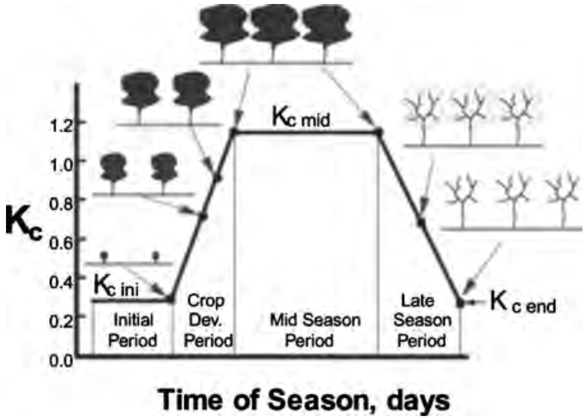

Fig. 1. Schematic showing generalized shape of Food and Agricultural Organization (FAO) K_c curve with four crop stages and three K_c (or K_{cb}) values and relative development of vegetation

as in Smith et al. (1991), Pereira et al. (1998), Pereira and Allen (1999), and ASCE (2002).

Crop Coefficient

Fundamentally, the crop coefficient is defined as the ratio of ET from any specific crop or soil surface to some reference ET as defined by weather data. In *FAO-56* nomenclature

$$K_c = \frac{ET_c}{ET_0} \tag{1}$$

In *FAO-56*, values listed for K_c represent ET under growing conditions having a high level of management and with little or no water or other ET reducing stresses and thus represent what are referred to as potential levels for crop ET

$$ET_c = K_c ET_0 \tag{2}$$

Actual ET_c can be less than the potential ET_c for a crop under nonideal growing conditions including those having water stress or high soil salinity. In this paper, ET_c representing ET under any condition, ideal or nonideal, is termed "actual ET_c" and is denoted as $ET_{c\ act}$. The $ET_{c\ act}$ was termed "adjusted ET_c" ($ET_{c\ adj}$) in *FAO-56*. The terms are synonymous and

$$ET_{c\ act} = K_{c\ act} ET_0 \tag{3}$$

where $K_{c\ act}$ = "actual" crop coefficient that includes any effects of environmental stresses.

A linearized form for mean K_c and basal K_c curves in *FAO-56* was introduced in *FAO-24* (Doorenbos and Pruitt 1977) where the FAO K_c curve is comprised of four straight line segments representing the initial period, the development period, the midseason period, and the late season period (Fig. 1). These segments are defined by three primary K_c values: K_c during the initial period ($K_{c\ ini}$), K_c during the midseason (full cover) period ($K_{c\ mid}$), and K_c at harvest (or at the end of the late season) ($K_{c\ end}$). The $K_{c\ ini}$ defines the horizontal portion of the K_c curve during the initial period until approximately 10% of the ground is covered by vegetation. The $K_{c\ mid}$ defines the value for K_c during the peak period for the crop, which is normally when the crop is at "effective full cover." This period is described by a horizontal line extending through $K_{c\ mid}$. The development period is defined by a sloping line that connects the initial and midseason periods. The late season has a sloping line that connects the end of the midseason period with the harvest (end) date.

In *FAO-56*, two forms for K_c are presented: the "singular" K_c form used in *FAO-24* and the "dual" $K_c = K_{cb} + K_e$ form introduced in *FAO-56*, where K_{cb} is the basal crop coefficient and K_e is the soil evaporation coefficient. In the dual form, K_{cb} represents the ratio of ET_c to ET_0 under conditions when the soil surface layer is dry, but where the average soil water content of the root zone is adequate to sustain full plant transpiration. Under basal conditions, small amounts of evaporation from the surface soil layer occur by diffusion and are included in K_{cb} (and thus $K_{cb\ ini}$ is usually not set to zero during the growing cycle). The majority of evaporation from soil following wetting by precipitation or irrigation is represented by the separate K_e. The total, actual $K_{c\ act}$ is the sum of K_{cb} and K_e, reduced by any occurrence of soil water stress

$$K_{c\ act} = K_s K_{cb} + K_e \tag{4}$$

where K_{cb} and K_e range from [0 to $\sim$1.4]. The stress reduction coefficient K_s [0–1], reduces K_{cb} when the average soil water content or salinity level of the root zone are not conducive to sustain full plant transpiration. K_s for soil water stress is described later and the function for salinity induced stress is described in Allen et al. (1998). The sum of K_{cb} and K_e cannot exceed some maximum value for a crop–soil complex (generally $\sim$1.4 for *FAO-56* based ET_0), based on energy limitations. The form and principle of Eq. (4) was developed by Jensen et al. (1971), Wright and Jensen (1978), and Wright (1981, 1982).

The K_{cb} curve has the same shape as in Fig. 1 and three benchmark values for K_{cb} are used to construct the curve, namely $K_{cb\ ini}$, $K_{cb\ mid}$, and $K_{cb\ end}$. Because K_{cb} can include "diffusive" or residual evaporation from soil for potentially long periods following wetting, $K_{cb\ ini}$ is generally set to 0.15 in *FAO-56* for annual crops for the period from planting to before 10% ground cover. However, under dry conditions with long periods between wetting events or during the nongrowing season, $K_{cb\ ini}$ can be set equal to 0. This is illustrated later.

FAO-56 describes the procedure for applying the dual method on a daily basis, with specific estimation of evaporation from wet soil. The dual approach is well suited for predicting the effects of day to day variation in soil water evaporation and the effectiveness of precipitation.

Adjustment for Climate

FAO-24 (Doorenbos and Pruitt 1977) presented, for each crop listing, four values for singular midseason and end-of-season crop coefficients, termed in *FAO-56* as $K_{c\ mid}$ and $K_{c\ end}$. The four values represented four climatic cases of wind and humidity that impact the value for K_c. In contrast, *FAO-56* includes only single entries for $K_{c\ mid}$ and for $K_{c\ end}$, or, in the case of K_{cb}, for $K_{cb\ mid}$ and for $K_{cb\ end}$. The single entries correspond to K_c or K_{cb} values associated with a standard subhumid climate having average daytime minimum relative humidity (RH_{min}) of about 45% and having calm to moderate wind speeds of 1–3 m s^{-1}, averaging 2 m s^{-1}. K_c and K_{cb} values are listed for about 80 crops in *FAO-56*. These can be accessed on the FAO web site (FAO 1998).

For climates where mean RH_{min} is different from 45% or where wind speed at 2 m (u_2) is different from 2.0 m s^{-1}, $K_{cb\ mid}$ values from *FAO-56* are adjusted as

$$K_{\text{cb mid}} = K_{\text{cb mid (standard climate)}} + [0.04(u_2 - 2) - 0.004(\text{RH}_{\min} - 45)]\left(\frac{h}{3}\right)^{0.3} \quad (5)$$

where $K_{\text{cb mid(standard climate)}}$ = value for $K_{\text{cb mid}}$ from Table 17 of *FAO-56*; u_2 = mean daily wind speed at 2 m height (m s^{-1}); $\text{RH}_{\min}$ = mean daily minimum relative humidity (%) during the midseason period; and h = mean plant height during the midseason period (m). The adjustment in Eq. (5) accounts for impacts of differences in aerodynamic roughness between crops and the grass reference with changing climate and closely replicates the range in K_c values for the four climatic classes of *FAO-24*. Justification for Eq. (5) is given in Allen et al. (1998). Similar adjustment is made to $K_{\text{cb end}}$ when values for $K_{\text{cb end}} > 0.45$. Eq. (5) can be applied daily using daily values for u_2 and $\text{RH}_{\min}$ or can be applied for the midseason in total using averages for u_2 and $\text{RH}_{\min}$ for the period with relatively small loss in accuracy. When only mean daily dewpoint temperature or vapor pressure is known, $\text{RH}_{\min}$ can be approximated as $\text{RH}_{\min} \sim 100 e_a / e^0(T_{\max})$, where e_a is actual vapor pressure and $e^0(T_{\max})$ is saturation vapor at daily maximum air temperature. The crop height adjustment in Eq. (5) is applied to both the wind and the $\text{RH}_{\min}$ terms because both terms appear in the aerodynamic term of the Penman–Monteith equation and both factors influence ET in some proportion to aerodynamic roughness.

Evaporation from Soil

The approach of *FAO-56* is similar to that of Ritchie (1972), Saxton et al. (1974), and Wright (1982) where evaporation from soil beneath a canopy or inbetween plants is predicted by estimating the amount of energy at the soil surface in conjunction with energy consumed by transpiration. When the soil is wet, evaporation is predicted to occur at some maximum rate and the sum $K_c = K_{\text{cb}} + K_e$ is limited by some maximum value $K_{c\,\max}$.

As the surface soil layer dries, a reduction in evaporation occurs, and K_e is simulated as

$$K_e = K_r(K_{c\,\max} - K_{\text{cb}}) \leq f_{\text{ew}} K_{c\,\max} \quad (6)$$

where $K_{c\,\max}$ = maximum value of K_c following rain or irrigation; K_r = dimensionless evaporation reduction coefficient and is dependent on the cumulative depth of water depleted (evaporated); and f_{ew} = fraction of the soil that is both exposed to solar radiation and that is wetted. Evaporation is restricted by the energy available at the exposed soil fraction, i.e., K_e cannot exceed $f_{\text{ew}} K_{c\,\max}$. The *FAO-56* dual procedure differs from Ritchie (1972) and Saxton et al. (1974) in that the FAO procedure gives K_e (as limited by $f_{\text{ew}} K_{c\,\max}$) equal priority to transpiration (as represented by K_{cb}) in regard to energy consumption, whereas the Ritchie and Saxton approaches give transpiration priority over evaporation.

$K_{c\,\max}$ represents an upper limit on evaporation and transpiration from the cropped surface and is introduced to reflect the natural constraints on available energy. $K_{c\,\max}$ ranges from about 1.05 to 1.30 when using the grass reference ET_0

$$K_{c\,\max} = \max\left(\left\{1.2 + [0.04(u_2 - 2) - 0.004(\text{RH}_{\min} - 45)]\left(\frac{h}{3}\right)^{0.3}\right\}, \{K_{\text{cb}} + 0.05\}\right) \quad (7)$$

where h = mean plant height during the period of calculation (initial, development, mid-season, or late-season) (m), and the max () function indicates the selection of the maximum of values separated by the comma. Eq. (7) ensures that $K_{c\,\max}$ is always greater than or equal to the sum $K_{\text{cb}} + 0.05$, suggesting that wet soil always increases the K_c value above K_{cb} by 0.05 following complete wetting of the soil surface, even during periods of full ground cover. The value 1.2 represents the impact of reduced albedo of wet soil and the contribution of heat stored in dry soil prior to wetting events that are separated by more than 3 or 4 days. The value also considers the effect of increased aerodynamic roughness of surrounding crops during development, midseason, and late season growth stages which can increase the turbulent transfer of vapor from the exposed soil surface. Bonachela et al. (2001) noted $K_{c\,\max}$ of over 1.5 for soil evaporation from a drip-irrigated olive orchard caused by microadvection of heat from dry surface areas to wet surface areas. Under complete surface wetting, $K_{c\,\max}$ would be expected to be lower, for example ranging from 1.0 to 1.2. In addition, if irrigation or precipitation events are more frequent than 3 days each, for example daily or 2 days each, then the soil has less opportunity to absorb heat between wetting events, and the 1.2 value can be reduced to about 1.1.

The surface soil layer is presumed to dry to an air dry water content approximated as halfway between wilting point θ_{WP} and oven dry. The amount of water that can be removed by evaporation during a complete drying cycle is estimated as

$$\text{TEW} = 1000(\theta_{\text{FC}} - 0.5\theta_{\text{WP}})Z_e \quad (8)$$

where (total evaporable water) (TEW) = maximum depth of water that can be evaporated from the surface soil layer when the layer has been initially completely wetted (mm). Field capacity θ_{FC} and θ_{WP} are expressed in ($\text{m}^3\,\text{m}^{-3}$) and Z_e(m) = effective depth of the surface soil subject to drying to 0.5 θ_{WP} by way of evaporation. Typical values for θ_{FC}, θ_{WP}, and TEW are given in Table 1 for various soil types. Z_e is an empirical value based on observation. *FAO-56* recommended values for Z_e of 0.10–0.15 m, with 0.1 m recommended for coarse soils and 0.15 m recommended for fine textured soils. However, the user should select the value for Z_e, or even TEW, that represents evaporation amounts observed over complete drying cycles via gravimetric or other measurement. Some evaporation or soil drying will be observed to occur below the Z_e depth.

Evaporation from exposed soil is presumed to take place in two stages: an energy limiting stage (Stage 1), and a falling rate stage (Stage 2) (Philip 1957 and Ritchie 1972). During Stage 1, the soil surface remains wet and evaporation is predicted to occur at the maximum rate limited only by energy availability at the soil surface and therefore, $K_r = 1$. As the soil surface dries, the evaporation rate decreases below the potential evaporation rate (defined as $K_{c\,\max} - K_{\text{cb}}$), and K_r becomes less than one. K_r becomes zero when no water is left for evaporation in the evaporation layer.

Stage 1 holds until the cumulative depth of evaporation D_e is such that the hydraulic properties of the upper soil become limiting and water cannot be transported to near the soil surface at a rate to supply the demand. At the end of Stage 1 drying, D_e is equal to readily evaporable water (REW). Readily evaporable water normally ranges from 5 to 12 mm and is highest for medium and fine textured soils (Ritchie 1972; Ritchie et al. 1989).

The second stage, where K_r is decreasing, begins when D_e exceeds REW. At this point, the soil surface is visibly dry, and evaporation from the exposed soil decreases in proportion to the amount of water remaining in the surface soil layer. Most early Stage 2 models (Philip 1957; Ritchie 1972) proportion the evaporation rate according to the square root of time since the begin-

Table 1. Typical Soil Water Characteristics for Different Soil Types (from *FAO-56*)

				Evaporation parameters		
	Soil water characteristics			Amount of water that can be depleted by evaporation		
Soil type (USDA soiltexture classification)	θ_{FC} $m^3\,m^{-3}$	θ_{WP} $m^3\,m^{-3}$	(θ_{FC}-θ_{WP}) $m^3\,m^{-3}$	Stage 1 REW (mm)	Stages 1 and 2 TEW[a] (Z_e=0.10 m) (mm)	Stages 1 and 2 TEW[a] (Z_e=0.15 m) (mm)
Sand	0.07–0.17	0.02–0.07	0.05–0.11	2–7	6–12	9–13
Loamy sand	0.11–0.19	0.03–0.10	0.06–0.12	4–8	9–14	13–21
Sandy loam	0.18–0.28	0.06–0.16	0.11–0.15	6–10	15–20	22–30
Loam	0.20–0.30	0.07–0.17	0.13–0.18	8–10	16–22	24–33
Silt loam	0.22–0.36	0.09–0.21	0.13–0.19	8–11	18–25	27–37
Silt	0.28–0.36	0.12–0.22	0.16–0.20	8–11	22–26	33–39
Silt clay loam	0.30–0.37	0.17–0.24	0.13–0.18	8–11	22–27	33–40
Silty clay	0.30–0.42	0.17–0.29	0.13–0.19	8–12	22–28	33–42
Clay	0.32–0.40	0.20–0.24	0.12–0.20	8–12	22–29	33–43

Note: USDA=United States Department of Agriculture; REW=readily evaporated water; and TEW=totally evaporated water.
[a]TEW=$(\theta_{FC}-0.5\theta_{WP})Z_e$.

ning of Stage 2. This requires manipulation of time terms as new water enters the system. Moreover, the proportionality factor changes with ET_0 demand and therefore requires frequent recalibration (Snyder et al. 2000). In the *FAO-56* model, the reduction in evaporation during Stage 2 is proportional to the cumulative evaporation from the surface soil layer, resulting in a more simple, easily managed computation procedure that is based on a soil–water balance and that does not require recalibration

$$K_r = \frac{\text{TEW} - D_{e,j-1}}{\text{TEW} - \text{REW}} \quad (9)$$

for $D_{e,j-1} > \text{REW}$, where $D_{e,j-1}$=cumulative depletion from the soil surface layer at the end of day $j-1$ (the previous day) (mm); and TEW and REW are in millimeters (REW<TEW). The general form for the K_r function is illustrated in Fig. 2. The prediction by Eq. (9) is similar to that predicted by a square-root-of-time Stage 2 model, and differences are in general smaller than the uncertainties caused by the continuously changing effects of soil hydraulic properties, tillage, soil temperature, wetting characteristics, and root extraction. Saxton et al. (1974) used a nonlinear proportionality based on water content of the surface layer that had similar behavior as Eq. (9). A three-stage drying process can be applied to cracking soils as described in a following section. Mutziger et al. (2001) found good agreement between K_r predicted using the *FAO-56* dual method using REW and TEW from Table 1 (with Z_e=0.1 m) and relative evaporation measurements published by Chanzy and Bruckler (1993) for loam, silty clay loam, and clay soils.

In crops having partial ground cover, evaporation from the soil usually occurs nonuniformly over the surface, and is greater between plants having dense canopies near the ground where exposure to sunlight occurs and where more air ventilation is able to transport vapor from the soil surface to above the canopy. This is especially true where only part of the soil surface is wetted by irrigation. While it is recognized that both the locations and the fractions of the soil surface exposed to sunlight and ventilation may change with the time of day and depend on row orientation and near surface canopy density, the procedure of *FAO-56* predicts a general, averaged fraction of soil surface from which the majority of evaporation is expected to occur. Most evaporation from the soil beneath the crop canopy, occurring at a slower rate, is in many situations included in the basal K_{cb} coefficient.

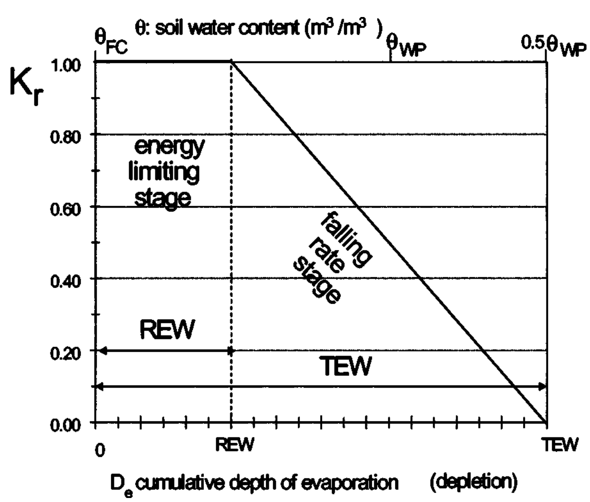

Fig. 2. General function for soil evaporation reduction coefficient K_r for two-stage *FAO-56* model (from *FAO-56*)

Table 2. Common Values for Fraction of Soil Surface Wetted by Irrigation or Precipitation (after *FAO-56*)

Wetting event	f_w
Precipitation	1.0
Sprinkler irrigation, field crops	1.0
Sprinkler irrigation, orchards	0.7–1.0
Basin irrigation	1.0
Border irrigation	1.0
Furrow irrigation (every furrow), narrow bed	0.6–1.0
Furrow irrigation (every furrow), wide bed	0.4–0.6
Furrow irrigation (alternated furrows)	0.3–0.5
Microspray irrigation, orchards	0.5–0.8
Trickle (drip) irrigation	0.3–0.4

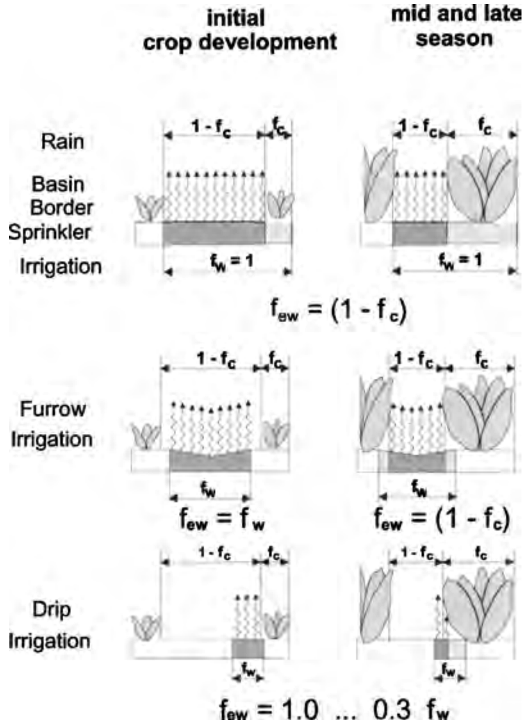

Fig. 3. Determination of f_{ew} (greyed areas) as function of fraction of ground surface coverage (f_c) and fraction of surface wetted (f_w) (from *FAO-56*)

In the *FAO-56* model, the term f_w is defined as the fraction of the surface wetted by irrigation and/or precipitation. This term defines the potential spatial extent of evaporation. Common values for f_w are listed in Table 2. An extension to Eq. (10) is described later.

When the soil surface is completely wetted, as by precipitation or sprinkler, f_{ew} of Eq. (6) is set equal to $(1-f_c)$, where f_c is the fraction of soil surface effectively covered by vegetation and $(1-f_c)$ represents the approximate fraction of soil surface that is effectively exposed to evaporation energy. For irrigation systems where only a fraction of the ground surface (f_w) is wetted, f_{ew} is limited to f_w

$$f_{ew} = \min(1 - f_c, f_w) \tag{10}$$

Both $1-f_c$ and f_w, for numerical stability, have limits of [0.01–1]. The limitation imposed by Eq. (10) presumes the fraction of soil wetted by irrigation occurs within the primary fraction of soil exposed to sunlight and ventilation. This is generally the case, except with some drip irrigation (Fig. 3). In the case of drip irrigation, Allen et al. (1998) recommended multiplying f_w by $[1-(2/3)f_c]$. Pruitt et al. (1984) and Bonachela et al. (2001) have described evaporation patterns and extent under drip irrigation.

Predicting Fraction of Surface Cover

The difference $(1-f_c)$ represents the fraction of the soil effectively exposed to sunlight and air ventilation and serves as the site where the majority of evaporation is expected to occur. The value for f_c is limited to <0.99 for numerical stability and is generally determined by visual observation. For purposes of estimating f_{ew}, f_c can be estimated from K_{cb} as

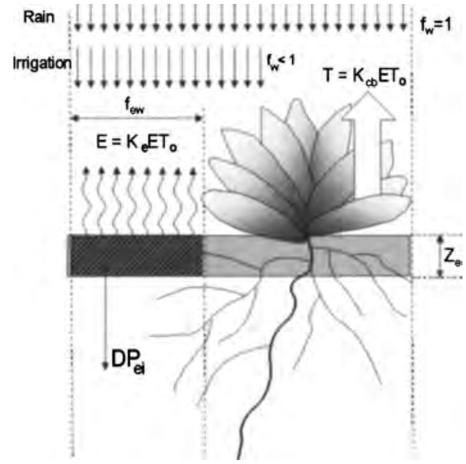

Fig. 4. Water balance of soil surface layer (from *FAO-56*)

$$f_c = \left(\frac{K_{cb} - K_{c\,\min}}{K_{c\,\max} - K_{c\,\min}}\right)^{(1+0.5h)} \tag{11}$$

where f_c is limited to [0–0.99] and $K_{c\,\min}$ = minimum K_c for dry bare soil with no ground cover. Eq. (11) assumes that the value for K_{cb} is largely governed by the fraction of vegetation cover. The $1+0.5h$ exponent in Eq. (11) represents the impact of plant height on shading of the soil surface and in increasing the value for K_{cb} given a specific value for f_c. The difference $K_{cb}-K_{c\,\min}$ is limited to $\geqslant 0.01$ for numerical stability. The value for f_c will change daily as K_{cb} changes. $K_{c\,\min}$ ordinarily has the same value as $K_{cb\,ini}$ used for annual crops under nearly bare soil conditions (i.e., $K_{c\,\min} \sim 0.15$). The value for f_c decreases during the late season period in proportion to K_{cb} to account for local transport of sensible heat from senescing leaves to the soil surface.

Under vegetation having an open canopy near the ground surface, for example some types of orchards, a large proportion, if not all, of the ground surface is effectively exposed to evaporative energy (Bonachela et al. 2001). In these situations, $1-f_c$ does not have large impact on f_{ew}, and $f_{ew}=f_w$ can be applied. The decision in assigning values for f_c and f_{ew} should be based on field observation of drying patterns.

Water Balance of Soil Surface Layer

Calculation of K_e requires a daily water balance for the f_{ew} fraction of the surface soil layer. The daily soil water balance equation is (Fig. 4)

$$D_{e,j} = D_{e,j-1} - (P_j - \mathrm{RO}_j) - \frac{I_j}{f_w} + \frac{E_j}{f_{ew}} + T_{ei,j} + \mathrm{DP}_{ei,j} \tag{12}$$

where $D_{e,j-1}$ and $D_{e,j}$ = cumulative depletion depth at the ends of days $j-1$ and j (mm); P_j and RO_j = precipitation and precipitation runoff from the soil surface on day j (mm); I_j = irrigation depth on day j that infiltrates the soil (mm); E_j = evaporation on day j (i.e., $E_j = K_e \mathrm{ET}_0$) (mm); $T_{ei,j}$ = depth of transpiration from the exposed and wetted fraction of the soil surface layer on day j (mm); and $\mathrm{DP}_{ei,j}$ = deep percolation from the soil surface layer on day j if soil water content exceeds field capacity (mm). Assuming that the surface layer is at field capacity following heavy rain or irrigation, the minimum value for $D_{e,j}$ is zero and limits imposed are $0 \leqslant D_{e,j} \leqslant \mathrm{TEW}$. It is recognized that water content of the soil surface layer can exceed TEW for short periods of time while drainage is occurring. However, because the length of time that this occurs varies with soil texture, wetting depth, and tillage, $D_{e,j} \geqslant 0$ is assumed. Additionally, it is recognized that some drainage in soil occurs at very small rates at water contents below field capacity. To some extent, impacts of these simple assumptions can be compensated for, if needed, in setting the value for Z_e or TEW.

RO_j can be computed using the USDA curve number procedure (Hawkins et al. 1985). The irrigation depth I_j is divided by f_w to approximate the infiltration depth to the f_w portion of the soil surface. Similarly, E_j is divided by f_{ew} because it is assumed that all E_j (other than residual evaporation implicit to the K_{cb} coefficient) is taken from the f_{ew} fraction of the surface layer.

Except for shallow rooted crops, where the depth of the maximum rooting is less than 0.5–0.6 m, the amount of transpiration extracted from the f_{ew} portion of the surface soil layer is small and can be ignored (i.e., $T_{ei}=0$). Where transpiration is known to extract water from the f_{ew} fraction of the surface layer, but is not considered in Eq. (12), *FAO-56* advises that the depth of the surface layer Z_e be decreased to compensate for the quicker drying. Estimation of T from the f_{ew} fraction of the surface layer is described in a following section.

Following heavy rain or irrigation, the soil water content in the surface layer (Z_e layer) might exceed field capacity for short time periods until excess water moves into the root zone and perhaps even deeper. In the simple water balance procedure used in *FAO-56,* however, it is assumed that the soil water content is limited to $\leqslant \theta_{FC}$ on the day of a complete wetting event. This is a reasonable assumption considering the shallowness of the surface layer. Downward drainage (percolation) of water from the surface layer is calculated as

$$DP_{e,j} = (P_j - RO_j) + \frac{I_j}{f_w} - D_{e,j-1} \geqslant 0 \qquad (13)$$

As long as the soil water content in the evaporation layer is below field capacity (i.e., $D_{e,j} > 0$), the surface layer is assumed to not drain, and $DP_{e,j}=0$.

Initialization of Water Balance

To initiate the water balance for the evaporating layer, the user can assume that the soil surface layer is near θ_{FC} following a heavy rain or irrigation so that $D_{e,j-1}=0$. Where a long period of time has elapsed since the last wetting, the user can assume that all evaporable water has been depleted from the evaporation layer at the beginning of calculations so that $D_{e,j-1} = TEW = 1{,}000(\theta_{FC} - 0.5\,\theta_{WP})\,Z_e$.

Order of Calculation

Calculations for the *FAO-56* dual $K_{cb}+K_e$ procedure, for example when using a spreadsheet, proceed in the following order: K_{cb}, h, $K_{c\,max}$, f_c, f_w, f_{ew}, K_r, K_e, E, DP_e, D_e, I, K_c, and ET_c.

Extensions to FAO-56 Procedure

The evaporation component of the *FAO-56* dual K_c procedure was intended for routine application under a wide range of conditions. The procedure constitutes a balance between simplicity, understandability, and completeness and is recommended for most applications. The following three extensions to the *FAO-56* procedure may increase accuracy and definition of the total evaporation and drying process under special conditions.

Separate Prediction of Evaporation from Soil Wetted by Precipitation Only

The evaporation component is assumed to be fully concentrated in the exposed and wetted fraction of the surface layer. The slower rate of evaporation occurring from beneath the vegetation canopy is generally included in K_{cb} and is therefore not explicitly quantified. E is computed as $K_e\,ET_0$. The quotient E/f_{ew} in Eq. (12) describes the concentration of evaporation over the fraction of the soil that is both exposed and wetted.

Parameter $f_w=1$ for precipitation but is often <1 for some types of surface irrigation and micro irrigation. *FAO-56* recommended a procedure for calculating f_w according to the type of last wetting event and its extent. However, this determination can be subjective and uncertain. This section describes an extension to *FAO-56* that incorporates a separate water balance and procedure for K_r for the fraction of soil that is wetted by precipitation only (i.e., not by irrigation). The extension reduces uncertainty in determining the value for f_w and has been applied by Mutziger et al. (2005) in estimating annual evaporation losses from agricultural areas in California.

In the extension to the *FAO-56* procedure, the evaporation calculation is divided into two separate calculations. One calculation is made for the exposed fraction of soil wetted by both irrigation and precipitation and one calculation is made for the exposed fraction of soil wetted by precipitation only. The coefficient K_e is calculated as

$$K_e = K_{ei} + K_{ep} \qquad (14)$$

where K_{ei}=evaporation coefficient for the exposed fraction of the soil wetted by both irrigation and by precipitation and K_{ep} =evaporation coefficient for the exposed fraction of the soil wetted by precipitation only.

The modification to Eq. (6) that applies to the fraction wetted by both irrigation and by precipitation is

$$K_{ei} = K_{ri}W(K_{c\,max} - K_{cb}) \leqslant f_{ewi}K_{c\,max} \qquad (15)$$

and the application of Eq. (6) to the fraction of soil that is exposed and wetted by precipitation only is

$$K_{ep} = K_{rp}(1 - W)(K_{c\,max} - K_{cb}) \leqslant f_{ewp}K_{c\,max} \qquad (16)$$

where f_{ewi}=fraction of soil wetted by both irrigation and precpitation and is exposed to rapid drying due to exposure to solar radiation and/or ventilation; f_{ewp}=fraction of soil exposed to rapid drying and is wetted by precipitation only; W=weighting coefficient for partitioning the energy available for evaporation into the f_{ewi} and f_{ewp} soil fractions, depending on water availability; K_{ri} and K_{rp}=evaporation reduction coefficients for the f_{ewi} and f_{ewp} fractions; and f_{ewp} is calculated as

$$f_{ewp} = 1 - f_c - f_{ewi} \qquad (17)$$

and f_{ewp} and f_{ewi} are limited to 0.001–1.0. Eq. (10) is reexpressed for f_{ewi} as

$$f_{ewi} = \min(1 - f_c, f_w) \qquad (18)$$

where $1-f_c$ has limits of [0.01–1] and f_w=average fraction of soil surface wetted by irrigation, only [0.01–1].

The weighting factor W is calculated according to water availability in the two wetted, exposed fractions of the surface layer

$$W = \frac{1}{1 + \frac{f_{ewp}}{f_{ewi}} \frac{(\text{TEW} - D_{ep})}{(\text{TEW} - D_e)}} \quad (19)$$

where D_e = cumulative depletion depth (mm) from the evaporating layer for the f_{ewi} fraction of soil; and D_{ep} = cumulative depletion depth (mm) from the evaporating layer for the f_{ewp} fraction of soil. The limits D_e and $D_{ep} < \text{TEW}$; D_e and $D_{ep} \geqslant 0$; and $f_{ewi}(\text{TEW} - D_e) > 0.001$ are imposed for numerical stability.

An associated water balance is computed for the fraction of the evaporation layer wetted by precipitation, but not by irrigation, and is in the exposed portion of the soil

$$D_{ep,j} = D_{ep,j-1} - (P_j - \text{RO}_j) + \frac{E_{p,j}}{f_{ewp}} + T_{ep,j} + \text{DP}_{ep,j} \quad (20)$$

where $D_{ep,j-1}$ and $D_{ep,j}$ = cumulative depletion depths at the ends of days $j-1$ and j in the f_{ewp} fraction of the surface (mm); $E_{p,j}$ = evaporation from f_{ewp} fraction on day j ($E_{p,j} = K_{ep}$ ET_0) (mm); $T_{ep,j} = T_e$ from f_{ewp} fraction of the evaporation layer on day j (mm); ($T_{ep,j}$ can be set equal to zero for simplification); and $\text{DP}_{ep,j}$ = deep percolation from the f_{ewp} fraction of the evaporation layer on day j if soil water content exceeds θ_{FC} (mm). The limits on $D_{ep,j}$ are $0 \leqslant D_{ep,j} \leqslant \text{TEW}$. The $E_{p,j}$ is divided by f_{ewp} because it is assumed that all E_p is taken from the f_{ewp} fraction of the surface layer.

Eq. (12) is expressed for the f_{ewi} fraction as

$$D_{e,j} = D_{e,j-1} - (P_j - \text{RO}_j) - \frac{I_j}{f_w} + \frac{E_j}{f_{ewi}} + T_{ei,j} + \text{DP}_{ei,j} \quad (21)$$

where f_w = fraction of soil surface wetted by irrigation.

Eq. (9) is expressed for the f_{ewi} and f_{ewp} fractions as

$$K_{ri} = \frac{\text{TEW} - D_{e,j-1}}{\text{TEW} - \text{REW}} \quad (22)$$

and

$$K_{rp} = \frac{\text{TEW} - D_{ep,j-1}}{\text{TEW} - \text{REW}} \quad (23)$$

for $D_{e,j-1}$ and $D_{ep,j-1} \geqslant 0$.

The total evaporation rate from the exposed fraction of the surface is $E = K_e$ $\text{ET}_0 = (K_{ei} + K_{ep})$ ET_0. K_{ei} and K_{ep} are both constrained so that $K_{ei} \geqslant 0$ and $K_{ep} \geqslant 0$

Eq. (13) is expressed for the f_{ewi} fraction of the surface layer as

$$\text{DP}_{ei,j} = (P_j - \text{RO}_j) + \frac{I_j}{f_w} - D_{ei,j-1} \geqslant 0 \quad (24)$$

As long as the soil water content in the evaporation layer is below field capacity (i.e., $D_{ei,j} > 0$), the soil will not drain and $\text{DP}_{ei,j} = 0$. For the fraction of exposed soil that is wetted by precipitation but not by irrigation

$$\text{DP}_{ep,j} = (P_j - \text{RO}_j) - D_{ep,j-1} \geqslant 0 \quad (25)$$

Transpiration from Surface Layer

The amount of transpiration extracted from the f_{ew} fraction of the evaporating soil layer is generally small and can be ignored. However, for shallow-rooted annual crops where the depth of the maximum rooting is less than about 0.5 m, T_e may have significant effect on the water balance of the surface layer and therefore on prediction of the evaporation component, especially for the period midway through the development period.

Under conditions of uniform water availability within the soil profile, the ratio of T extracted from the evaporation layer to total T is presumed proportional to $(Z_e/Z_r)^{0.6}$ (Allen et al. 1996), where Z_e is the depth of the surface evaporation layer and Z_r is the effective depth of the root zone ($Z_e \leqslant Z_r$ and Z_e is contained in Z_r). This relationship is based on the commonly used 40–30–20–10% root extraction pattern for quartile rooting depths (top to bottom) of the root zone for moist soils.

In this extension, it is assumed that the previous extension using f_{ewi} and f_{ewp} is applied. If this is not the case, then only T_{ei} is used and all occurrences of f_{ewi} are set to f_{ew}. The equation for T_e from the f_{ewi} fraction of the evaporation layer T_{ei} is

$$T_{ei} = K_{ti} K_{cb} K_s \text{ET}_0 \quad (26)$$

where K_{ti}, [0–1] = proportion of basal ET(= $K_{cb}\text{ET}_0$) extracted as transpiration from the f_{ewi} fraction of the surface soil layer, and K_s = soil water stress factor computed for the root zone [0–1]. K_{ti} is determined by comparing relative water availability in the Z_e and Z_r layers along with the presumed rooting distribution. For the f_{ewi} fraction

$$K_{ti} = \left(\frac{1 - \frac{D_e}{\text{TEW}}}{1 - \frac{D_r}{\text{TAW}}} \right) \left(\frac{Z_e}{Z_r} \right)^{0.6} \quad (27)$$

where the numerator and denominator of the first expression of Eq. (27) are limited to $\geqslant 0.001$ and TAW is total available water in the root zone [see Eq. (33) introduced later]. In addition, the value for K_{ti} is limited to $\leqslant 1.0$ to limit T_{ei} to $\leqslant \text{ET}_c$. A value of $K_{ti} \sim 1.0$ would represent conditions where the soil profile is near wilting point, but the shallow surface layer is partially or fully rehydrated by a light precipitation or irrigation event, or where the root zone is very shallow.

Transpiration from the f_{ewp} fraction of the soil T_{ep} is calculated as

$$T_{ep} = K_{tp} K_{cb} K_s \text{ET}_0 \quad (28)$$

where

$$K_{tp} = \left(\frac{1 - \frac{D_{ep}}{\text{TEW}}}{1 - \frac{D_r}{\text{TAW}}} \right) \left(\frac{Z_e}{Z_r} \right)^{0.6} \quad (29)$$

where K_{tp}, [0–1] = proportion of basal ET(= $K_{cb}\text{ET}_0$) extracted as transpiration from the f_{ewp} fraction of the surface soil layer. The same limitations apply as for Eq. (27).

When there is Stage 3 evaporation, as defined in the next section, TEW in Eqs. (27) and (29) is set equal to TEW_3, the upper limit for evaporable water.

Stage Three Evaporation

The third extension to the *FAO-56* procedure applies to soils that crack substantially upon drying, thereby exposing progressively deeper depths of soil to drying by evaporation. This progressive drying continues at a low rate for an extended period of time. Drying to depths as deep as 0.5 m is possible for severely cracking soils containing large amounts of montmorillinite clay where cracks can extend as deep as 1 m (Pettry and Switzer 1996).

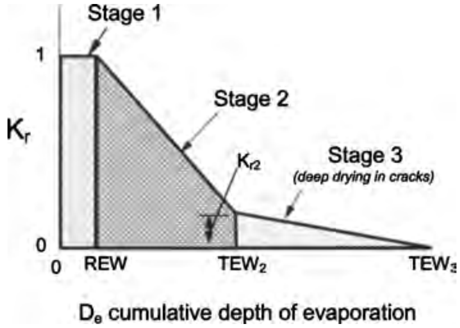

Fig. 5. General schematic showing evaporation reduction coefficient K_r as function of depth of water evaporated (depleted) from surface soil layer for cracking soil having three-stage evaporation.

In the extension for cracking soils, the evaporation process is expanded from two to three stages. The three stages are illustrated in Fig. 5. For normal agricultural soils that do not crack or only mildly crack, only Stage 1 and Stage 2 drying is applied. For cracking soils that have Stage 3 drying, Stage 3 is presumed to begin when K_r reduces to a threshold value labeled K_{r2}.

For three-stage drying, K_r is calculated for the second stage as

$$K_r = K_{r2} + (1 - K_{r2})\frac{\mathrm{TEW}_2 - D_{e,j-1}}{\mathrm{TEW}_2 - \mathrm{REW}}$$

$$\text{for REW} < D_{e,j-1} < \mathrm{TEW}_2 \qquad (30)$$

where TEW_2 = maximum cumulative depth of evaporation (depletion) from the soil surface layer when $K_r = K_{r2}$ (point at which evaporation transitions into stage three drying) (mm), and K_{r2} = value for K_r at the junction of Stage 2 and Stage 3 drying. Generally, the value for K_{r2} should be some relatively low value between about 0.1 and 0.4, depending on the nature and degree of cracking as the soil dries. Allen et al. (1998) recommended K_{r2} ~ 0.2. Mutziger et al. (2001) found best fit values for K_{r2} for two cracking soils in Texas to be 0.3 and 0.2 when comparing against lysimeter measurements of evaporation for a black clay and clay loam.

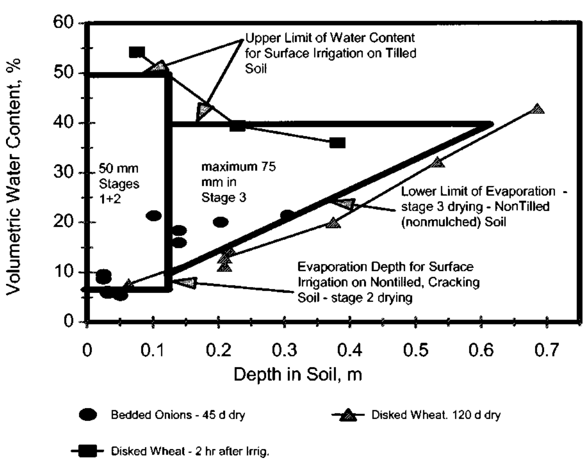

Fig. 6. Field measurements of volumetric water content for cracking soils in Imperial Irrigation District when wet (square symbols) and after 45 and 120 days of drying (circles and triangles). Superimposed on data are abstracted water content profiles associated with Stages 1 and 2 and with Stage 3 evaporation components

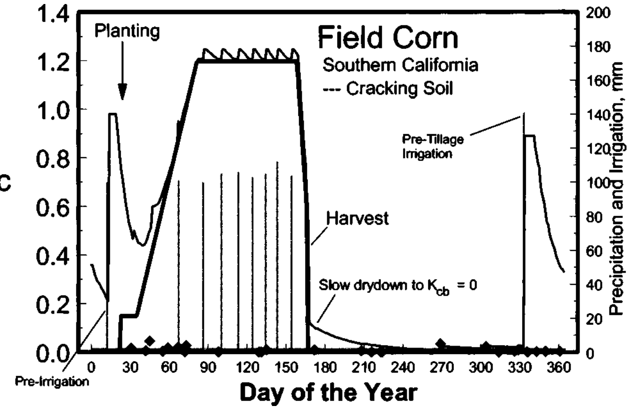

Fig. 7. Simulated K_{cb} (heavy line) and $K_{cb}+K_e$ (light line) curves for crop of field corn planted in late January in southern California on cracking soil having REW = 8 mm, TEW_2 = 50 mm, TEW_3 = 100 mm, K_{r2} = 0.2, and f_w = 0.7 for growing period irrigations and f_w = 1.0 for preirrigations. Bars denote predicted timing and depths of irrigation and diamonds denote rainfall

K_r is calculated for the third stage as

$$K_r = K_{r2}\frac{\mathrm{TEW}_3 - D_{e,j-1}}{\mathrm{TEW}_3 - \mathrm{TEW}_2}$$

$$\text{for } \mathrm{TEW}_2 \leqslant D_{e,j-1} \qquad (31)$$

where TEW_3 = maximum cumulative depth of evaporation (depletion) from the soil surface layer when the soil is dry and no further evaporation occurs ($K_r = 0$) (mm). The value TEW_3 includes REW and TEW_2. For application of the three-stage drying extension with the first extension, Eqs. (22) and (23) are expanded using Eqs. (30) and (31), with each application ($\mathrm{I}+P$) and (P) having its own water balance.

The three stage drying extension has been applied to cracking heavy clay soils in the Imperial Irrigation District of California (Allen et al. 2005) and to two cracking or partially cracking soils in Texas (Mutziger et al. 2001). Values used for the Imperial soils were REW = 8 mm, TEW_2 = 50 mm, TEW_3 = 100 mm, and K_{r2}

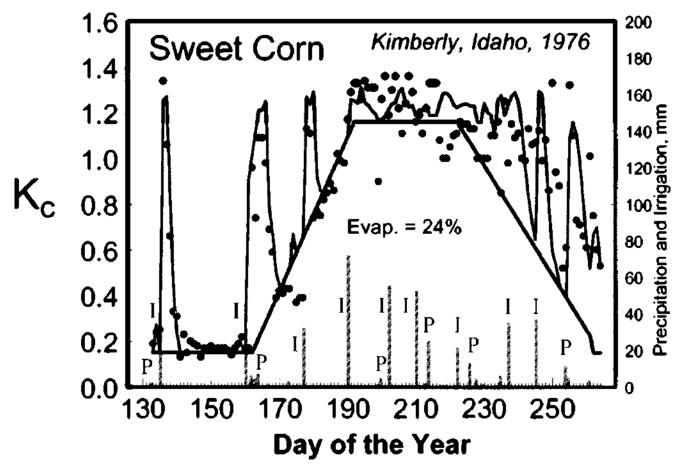

Fig. 8. Daily crop coefficients based on measured evapotranspiration and simulated using *FAO-56* dual K_c approach at Kimberly, Id. for a crop of sweet corn (lysimeter data from Wright 1982, personal communication 1990).

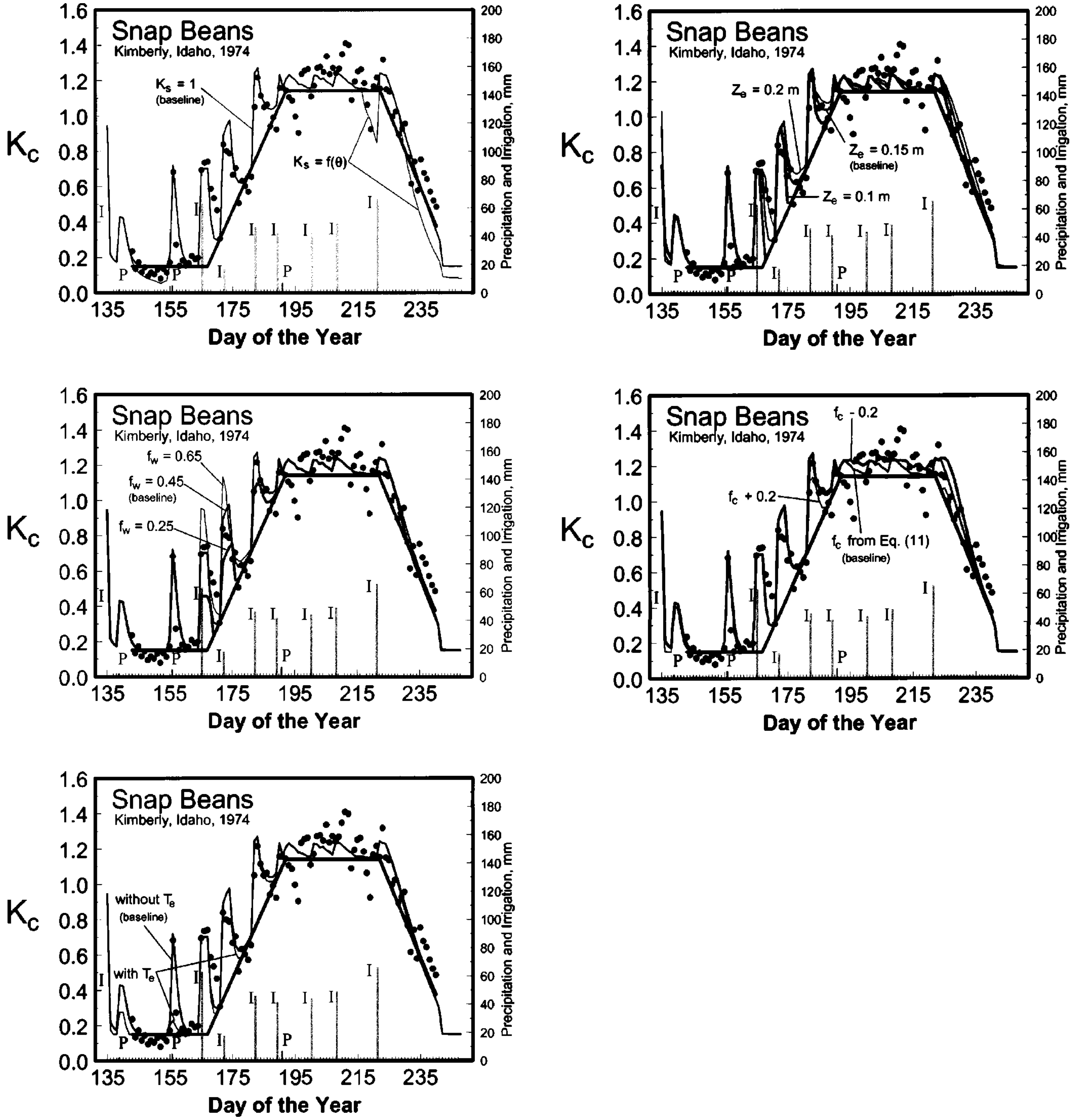

Fig. 9. Sensitivity of daily $K_{c\ \mathrm{act}}$ estimation for snap bean crop near Kimberly, Id. (lysimeter data from J. L. Wright, unpublished) to: (a) application of water stress function [Eq. (32)] (thin line) with comparison to K_c predicted using $K_s=1$ (medium line), K_{cb} (thick line), and measured K_c (symbols); (b) value for f_w; (c) application of T_e in Eq. (12); (d) value for Z_e; and (e) value for f_c

=0.2. Best fit values (to lysimeter evaporation measurements) for the Houston black clay and Pullman clay loam soils evaluated by Mutziger were REW=7 mm; TEW_2=30 and 22 mm; and TEW_3 =50 and 45 mm.

TEW_2 and TEW_3 for the Imperial Valley soils were estimated from sampled soil water contents at the beginning and end of drying cycles in fallow fields as shown in Fig. 6. The sampling sites were in an area of mixed Imperial silty clay and Imperial-Glenbar silty clay loam soil. Cracks penetrated to about 1 m on drying on an approximately 0.5 to 2 m grid and average crack width was 10 mm. Moisture was gravimetrically determined from cored samples. In the case of sampling the dry profile where the soil was deeply cracked, samples were taken approximately 0.3 m in from the face of cracks. The areas between the upper horizontal and the lower horizontal or diagonal lines in the figure suggest the equivalent depth of water evaporated during Stages 1 and 2 and during Stage 3 from the cracking soil. The sampling indicated drying to a depth of more than 0.5 m due to cracking. Even though the apparent depletable depth from 0.12 to 0.6 m shown in Fig. 6 was about 75 mm, a value of 50 mm for Stage 3 drying

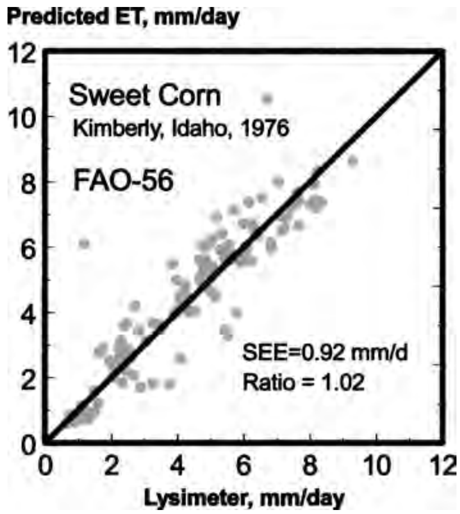

Fig. 10. Daily measured and estimated evapotranspiration for sweet corn near Kimberly, Id. using *FAO-56* dual K_c procedure (data from Wright 1982, personal communication 1990).

(so that $TEW_3 = 50 + 50 = 100$ mm) was selected for routine application in the Imperial Valley to account for dampening effects of disking and other tillage on creating a surface soil mulch and any effects of water extraction by roots (Allen et al. 2005).

The net impact of Stage 3 drying is to prolong the time for K_r to decrease to zero, thereby creating a prolonged "base-line" evaporation rate. As shown in Fig. 7, where the *FAO-56* $K_{cb} + K_e$ method was applied with Stage 3 drying, base-line evaporation was prolonged following harvest for more than 60 days, even when time between wetting events was large. Without the Stage 3 drying, $K_{c\ act}$ reduced to zero within 5–10 days following harvest. The K_{cb} prior to planting and following harvest was set to zero to allow evaporation (and total ET) to approach zero during extended dry periods.

Impacts of Water Stress

The final component in Eq. (4) is the water stress coefficient K_s used to reduce K_{cb} under conditions of water stress or salinity stress. Allen et al. (1998) describes the salinity stress function and computation. The water stress function is described here and is illustrated later. Mean water content of the root zone in the *FAO-56* procedure is expressed by root zone depletion, D_r, i.e., water shortage relative to field capacity. At field capacity, $D_r = 0$. Stress is presumed to initiate when D_r exceeds RAW, the depth of readily available water in the root zone. For $D_r > \mathrm{RAW}$, K_s is

$$K_s = \frac{\mathrm{TAW} - D_r}{\mathrm{TAW} - \mathrm{RAW}} = \frac{\mathrm{TAW} - D_r}{(1-p)\mathrm{TAW}} \quad (32)$$

where TAW = total available soil water in the root zone (mm), and p = fraction of TAW that a crop can extract from the root zone without suffering water stress. When $D_r \leq \mathrm{RAW}$, $K_s = 1$. The total available water in the root zone is estimated as the difference between the water content at field capacity and wilting point

$$\mathrm{TAW} = 1000(\theta_{FC} - \theta_{WP})Z_r \quad (33)$$

where Z_r = effective rooting depth (m) and Z_r contains Z_e. RAW is estimated as

$$\mathrm{RAW} = p\mathrm{TAW} \quad (34)$$

where RAW has units of TAW (mm). *FAO-56* contains recommended values for p for 60 crops and describes several means to model the development (increase) in Z_r with time for annual crops including in proportion to development of K_{cb} and in proportion to time. Other methods for Z_r development include a sine function of time (Borg and Grimes 1986), an exponential function of time dampened by soil temperature and soil moisture (Danuso et al. 1995), and a full root growth simulation model by Jones et al. (1991).

Example Applications and Sensitivity Analyses

Illustrative applications of the *FAO-56* procedure are given in Fig. 8 for a sweet corn crop and in Fig. 9 for a snap bean crop grown near Kimberly, Id. during 1976 and 1974 by Wright (1982). Daily ET was measured using a precision weighing lysimeter planted to and immediately surrounded by a specific crop. Fetch of the lysimeter was at least 50 m in all directions for the specific crop and resolution of the lysimeter system was about 0.05 mm (Wright 1982). The daily measured K_c values in the figures were calculated by dividing daily lysimeter measurements by ET_0 as computed by Eq. (1). Weather data were assembled from a grassed weather station located about 1 km north of the lysimeter site. Dates for planting and harvest and for precipitation and irrigation were based on field notes (Wright, personal communication 1990; Vanderkimpen 1991). Values for K_{cb} were taken from *FAO-56*. Dates for beginning of development, midseason and late season periods for the *FAO-56* procedure were selected to fit the lysimeter data.

The application used the original *FAO-56* procedure with extension for T_e. The Portneuf silt loam soil at Kimberly was modeled using two-stage drying with Z_e set to 0.15 m and REW = 8 mm and TEW = 34 mm. The value for f_w was 0.6 for the furrow-irrigated sweet corn and 0.45 for alternate furrow-irrigated beans.

For the application to beans, ranges in values for parameters K_s, f_w, T_e, Z_e, and f_c were applied to illustrate the sensitivity of the *FAO-56* model predictions to these parameters. In the case of K_s and T_e, the sensitivity was with and without the inclusion of functions for these parameters.

Results

Simulated daily K_{cb} and $K_{c\ act}$ and measured $K_{c\ act}$ for the growing period for the sweet corn crop shown in Fig. 8 indicate relatively

Table 3. Standard Error of Estimate (SEE) and Ratio of Estimated to Measured Daily Evapotranspiration for Full Season of Snap Beans in 1974 near Kimberly, Id. (n = 98 days), where Baseline Conditions were $f_w = 0.45$, $T_e = 0$, $K_s = 1$, $Z_e = 0.15$ m, and f_c from Eq. (11)

	Baseline	$f_w = 0.25$	$f_w = 0.65$	with T_e	with K_s	$Z_e = 0.10$ m	$Z_e = 0.20$ m	$f_c - 0.2$	$f_c + 0.2$
SEE (mm day^{-1})	0.63	0.74	0.68	0.67	0.78	0.76	0.61	0.66	0.68
Ratio to measured	1.00	0.96	1.03	0.98	0.96	0.96	1.04	1.03	0.95

good agreement between simulated and measured values. The peak spikes in $K_{c\ \mathrm{act}}$ following wetting agreed well with measurements as did the rate of decay of the K_e curve. There was some underestimation of $K_{c\ \mathrm{act}}$ during the midseason period which may have been caused by underestimation of ET_0 by Eq. (1) or underestimation of the midseason K_{cb} for corn by *FAO-56*. The $K_{c\ \mathrm{act}}$ predicted during the late season overestimated measured $K_{c\ \mathrm{act}}$ for some days and underestimated over two 5 day periods. Much of the under- and overestimation during the senescence period was probably caused by uncertainty in the estimation of f_c during that period and the impact of ground shading on the wetted portion of the soil surface.

The unadjusted standard error of estimate (SEE) between the estimated and lysimeter-measured daily ET (Fig. 10) was $0.92\ \mathrm{mm\,day}^{-1}$ and the seasonal ratio of predicted ET to measured ET was 1.02. Total seasonal evaporation for the sweet corn crop was estimated to be 24% of the total seasonal ET. Because the lysimeter measurements provide only integrated values of ET, the separate estimation of evaporation cannot be evaluated for accuracy. Estimates of soil evaporation do not include the evaporation from soil that occurs as a diffusive component of K_{cb} over time.

Sensitivity of the $K_{\mathrm{cb}}+K_e$ procedure of *FAO-56* to invocation of a K_s soil moisture stress function under conditions where mild stress may have occurred is shown in Fig. 9(a) for the 1974 snap bean crop. Without the K_s function (thus $K_s=1.0$), the $K_{c\ \mathrm{act}}$ curve (medium gage line) "bottomed" against the K_{cb} curve (heavy line). With the K_s function [Eq. (32)], drying below the p level of the root zone was predicted during the development period, late midseason, and latter part of the late season. These predictions were based on actual irrigation dates and values for soil water holding properties from Table 1 ($\mathrm{AW}=160\ \mathrm{mm\,m}^{-1}$), and $p=70\%$ during the initial period and $p=55\%$ for the other three periods, and maximum rooting depth of 1.6 m, based on measurements by Wright (unpublished data, 2000). The application of the K_s function improved estimation of $K_{c,\mathrm{act}}$ for some dates and caused underestimation for others. No visual or measured stress by the lysimeter crop in 1974 was noted by Wright (1982).

Figure 9(b) illustrates the impact that f_w, the fraction of soil surface wetted by irrigation, has on the $K_{c\ \mathrm{act}}$ estimate. Higher values for f_w extended the magnitudes and time lengths of drydown for K_e "spikes" during the development period when the value $1-f_c$ in Eq. (10) was large. During midseason period, $1-f_c$ in Eq. (10) limited the value for f_{ew} regardless of range in f_w. Thus, sensitivity to f_w is generally prominent only during the initial and development periods.

The inclusion of the T_e function for extraction for transpiration from the Z_e layer impacted the estimation for K_c during the initial and development periods and had no impact during the mid and late season periods when the evaporation layer was largely shaded. The T_e function reduced the prediction of K_e for the precipitation event on Day 156 [Fig. 9(b)] because T_e extraction during prior days increased D_e so that the 6 mm precipitation depth was absorbed into the Stage 2 depletion reservoir, rather than adding to Stage 1 drying. This illustrates a weakness of the *FAO-56* model in that any light precipitation event is subtracted from the total D_e for the Z_e depth, rather than left on the soil skin for immediate evaporation. D_e was increased during the initial period with the application of the T_e function because all of the K_{cb} value [0.15 in Fig. 9(b)] is assigned to basal transpiration in the dual procedure, even though the 0.15 value may contain significant amounts of diffusive evaporation. There is danger in assigning too large a value for K_{cb} in the dual method, including the method of Wright (1982), since no limit is placed on K_{cb} extraction from a shallow, initial root depth unless the K_s function is invoked. The fact that inclusion of the T_e function did not improve predictions for the snap beans may reflect the tillage practices for beans, where open spaces between rows are cultivated two to three times during the growing season, thus reducing root activity there and thus extraction by transpiration. The $1-f_c$ parameter in Eq. (10) represents these open spaces.

The impact of the value assigned to Z_e, the effective depth of the evaporating layer, is illustrated in Fig. 9(d). With all other parameters fixed, the impact of greater Z_e is to extend the lengths of drydown periods and to increase the estimated evaporation component of ET. The impact of Z_e was pronounced during all periods.

Sensitivity to the estimation of fraction of surface covered by vegetation is illustrated in Fig. 9(e), where 0.2 was added and subtracted from the value for f_c predicted by Eq. (11). The impact of value for f_c was negligible for the initial and most of the development period when $1-f_c$ exceeded the value assigned to f_w. In this case, f_w controlled the estimate of evaporation. As f_c increased, its value began to control f_{ew} from Eq. (10) and impact on K_e and K_c increased. The smaller value for f_c (i.e., $f_c-0.2$) during late development and mid season tended to improve estimates during those periods.

Table 3 lists summary statistics for the five sensitivity tests. The smallest SEE ($0.61\ \mathrm{mm\,day}^{-1}$) occurred when Z_e was increased from 0.15 to 0.20 m, however, the reduction in SEE over the baseline was very small. The impact by the individual ranges in the parameters on the ratio of estimated seasonal ET to measured ET ranged from -5 to $+4\%$.

Summary and Conclusions

The *FAO-56* dual K_c procedure was established to provide daily estimates of evaporation from wet soil in conjunction with crop transpiration. The procedure uses a daily water balance of the soil surface layer and accounts for the fraction of soil surface wetted by irrigation or by precipitation and exposed to radiation and ventilation. Three optional extensions to the original method are described. The first is the establishment of a separate water balance for the fraction of the surface wetted by precipitation, only, and for the fraction wetted by both irrigation and precipitation. The second extension is a procedure to approximate the drying of the surface layer by transpiration in addition to evaporation. The third extension provides for the application to deep cracking soils. The dual K_c procedure is useful when short term estimates of evapotranspiration are needed, for example in research and in irrigation scheduling for individual fields as well as in estimation of total consumption of water where impacts of wetting frequency are important.

The sensitivity analysis indicates that inclusion of a function to estimate transpiration from the evaporating layer may not substantially impact or improve estimates, especially for crops having periodic cultivation. Calculations are moderately sensitive to values specified for the depth of the evaporation layer and fraction of surface wetted by irrigation, and to the estimation of fraction of ground cover.

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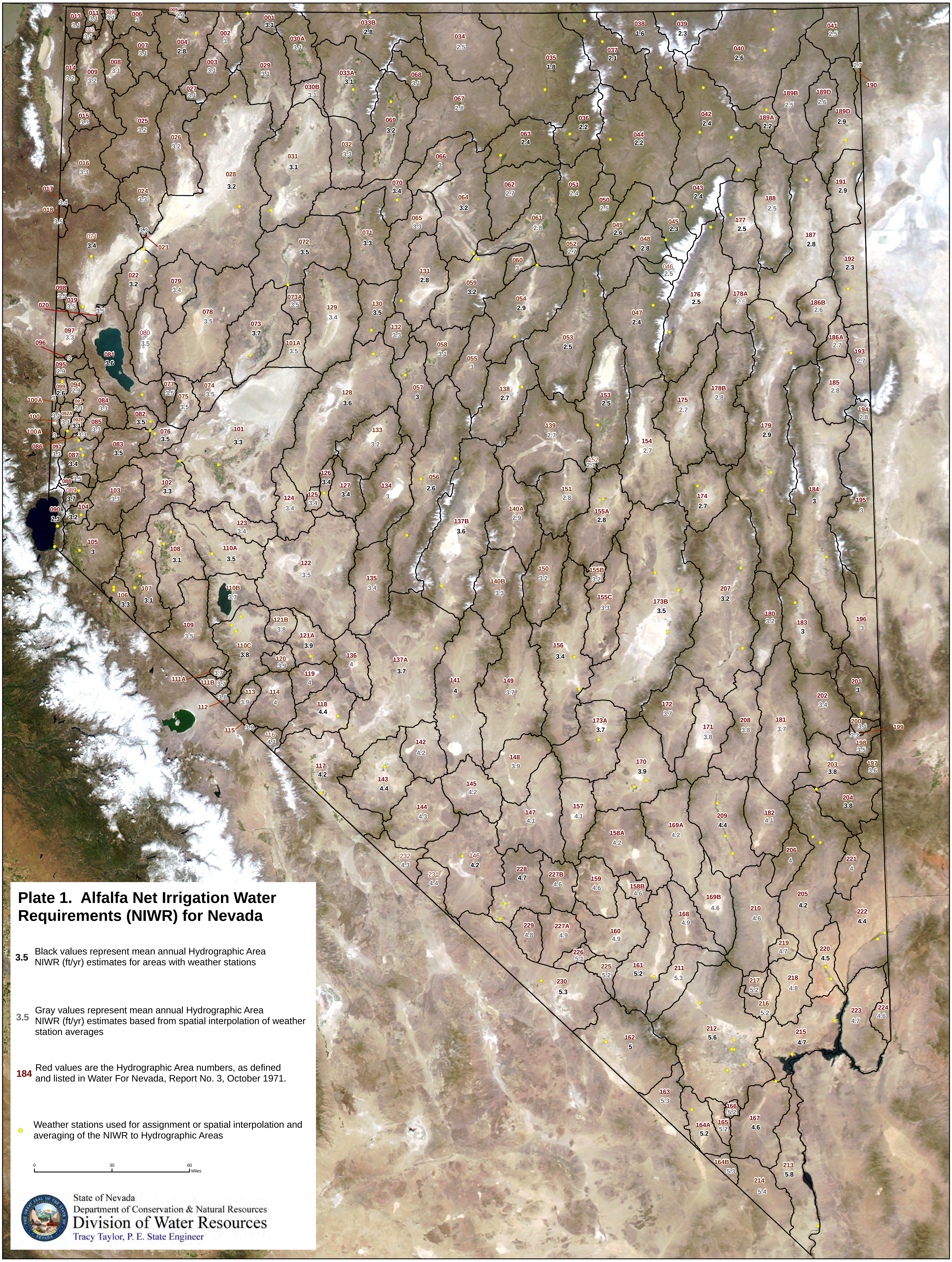

Plate 1. Alfalfa Net Irrigation Water Requirements (NIWR) for Nevada