Evapotranspiration and Consumptive Irrigation Requirements for Washington

R. Troy Peters; Extension Irrigation Engineer/Assistant Professor, WSU, Prosser, WA
Leigh Nelson; WA State Irrigation Engineer, USDA-NRCS, Ephrata, WA
Richard Allen; Irrigation Engineer/Professor, University of Idaho, Kimberly, ID

Background

The competition and demand for Washington's already limited water resources will increase steadily over time due to the following emerging issues:

- The water demand to produce food to feed a *growing population*,
- Summer water shortages predicted as a result of *climate change*,
- The water demand to produce *biofuel crops*, and
- The desire to maintain our *environment* and aquatic wildlife habitat.

Good data is required to manage these water resources. The Washington evapotranspiration (ET) and consumptive irrigation water requirements tables (crop-water-use tables) are used extensively throughout the state for irrigation system design and planning, irrigation scheduling and management, water rights discussions, water rights transfers, and hydrologic studies. The crop-water-use estimates currently being used were created in the early 1980's and 1990's. With the changes in climate, crops, and irrigation systems, the foundation information which was then best available data, has become old and out-dated. These tables are not available in electronic format and are therefore difficult for the public to access and use for improved irrigation planning and management.

Objectives and Significance

It is proposed that the crop water use tables be updated using current weather data, and more current and accurate methods, equations and parameters. Additional locations and crops will be added to expand the existing tables. This data will be compiled into a database and published on the internet. It will also be made available through the NRCS Washington Irrigation Guide (WIG). A report on the results and the methods and procedures used will be produced so that the data compilation and analysis will be transparent and reproducible. The improved data quality, quantity and transparency will help make planning, design and water rights users of the WIG make better decisions.

This new database will be subsequently used for creating simple irrigation scheduling and planning tools, and tools that demonstrate the economic benefits to producers for improved irrigation management. These improvements in irrigation management will result in better yields with less water and lower pumping energy use. This is a formula for improved farmer profitability, but is also important for improved environmental water quality.

Design and Procedure

The creation of these crop-water-use tables needs to be done by a reputable entity in order to ensure accuracy and unbiased results. The two investigators of this project are unique in the state of Washington in their experience, training and their ability to oversee this work. Their positions also make them disinterested third parties which also uniquely qualifies them for this work in the state of Washington.

Their goal is to develop accurate, unbiased numbers that can be used for good water planning and management, and fair and equitable water allocations that will both increase grower profitability, the state's economic vitality, and environmental water quality.

ET Estimation

A committee of leading researchers in evapotranspiration within the American Society of Civil Engineers recently updated and standardized the method for calculating evapotranspiration. This updated equation (the ASCE standardized Penman Monteith equation) will be used to calculate ET on a daily time step instead of a monthly time step to give improved within-month accuracy. Reference ET rates over the whole year, including winter months, will be calculated. All of the assumptions about which evaporative losses are included in the calculations will be explicitly stated. Accuracy of ET calculations will be estimated and documented. Guidance for modifying these calculations for non-standard conditions and/or deficit irrigation will also be provided. Since these will be estimates based on historical averages, measurements of the variability in this data will also be reported, namely standard deviation and different return intervals (2, 5, 10, 20, and 100 years).

Weather Data

There are multiple sources of historical weather information for calculating crop water use: 1) national weather service (NWS) stations, 2) Agrimet, and 3) Washington AgWeatherNet. Additional areas of local crop water use expertise also exist, such as the Wenatchee Tree Fruit Research Laboratory, the USDA-ARS Moxee Farm, WSU Puyallup Research and Extension Center, and information through watershed planning units. Currently the Washington Irrigation Guide (WIG) contains 76 selected NWS stations. All of these will be included in the new report, the Agrimet stations will be included and select AgWeatherNet stations will also be included. Information from areas of local crop water use expertise will also be considered. The general goal is to include all data possible to accurately represent the diverse climates from the important urban and agricultural regions of the state. Which additional stations will be chosen for inclusion depend on the station siting, which weather parameters are measured at that site, the data quality from that station, and the historical period of record. It is anticipated that the new report will contain over 100 total stations and an effort will be made to bridge geographic data gaps where possible (e.g. Asotin County, Tucannon, North Central Washington, etc.).

Crops

All of the crops that are currently in the WIG will be included in the new report. Crops that have recently become economically important and traditional crops that are emerging in new geographic areas will be added. This includes winegrapes, canola, blueberries, cranberries, cherry w/o cover, cherry w/cover, bluegrass seed, alfalfa seed, and cottonwood. Water use of native sagebrush, cheatgrass, pine trees and ET rates from wetlands, evaporation ponds, and open and deep water will also be included for use by hydrologists and other water management professionals. All assumptions about spacing or density will be stated.

Procedure

The steps required to update the Washington water use tables are as follows:

1. Identify and collect historical weather data sources from wide and diverse areas of the state. Weather stations should be located in green and growing fields. Those located in town, or whose readings are influenced by dry fields, buildings, or concrete should not be used if possible. In order to use the ASCE standardized reference ET equation the following data are required for each station: station location, elevation, latitude. The daily data required from each station are: day of year, minimum and maximum daily temperature, precipitation, dew point temperature, wind speed, and the total received shortwave solar radiation. National Weather Service stations, which usually have the longest histories typically only consist of temperature and precipitation data. Methods similar to Allen and Robison (2007) will be used to calculate solar radiation, wind speed, and dewpoint temperature for these stations.

2. Develop protocols for data cleaning and review with Ecology's technical committee[1].

3. Graph, review, and clean the weather data to fill in missing spots and check for anomalies (such as unrealistic numbers). Make a best effort to fill in holes or make good estimates of missing data.

4. Collect appropriate crop coefficients for economically important crops in Washington from published research data.

5. For every weather data location calculate evapotranspiration using the ASCE standardized reference ET equation on a daily time step for every year of record.

6. Sanitize data by graphing and looking for outliers and other anomalies. Chase these down and correct any errors. QA/QC data cleaning efforts.

7. Total the daily values into monthly and yearly values for each year. Statistics on these values will be performed to show year-to-year variability, the means, and 20% and 80% exceedence values. Chart these and compare these with nearby stations.

8. Apply the crop coefficients to get estimated average water use for the economically significant crops in each area. Compare these values with the existing (old) data set. Be able to include information on these comparisons between the old and new data in the final report.

9. Create tables of these values, and put them together in a relational database that can be accessed on the web, published in the Washington Irrigation Guide and used in later applications. Publish this data on the web.

10. Write up procedures and results in a draft report. The draft report shall be formatted consistent with the newly reprinted 2005 Washington State Irrigation Guide and serve as an addendum thereto.

11. Circulate draft report for internal Ecology and technical committee review. Incorporate comments and circulate for external public comment. Incorporate comments and finalize report.

[1] Ecology assembled a technical committee of professionals who use the Washington Irrigation Guide, including Ecology staff, Conservation Commission, river conservancies, Washington Dept. of Ag., NRCS, and the Farm Bureau.

Responsibilities

WSU will oversee and direct the tasks in this scope of work unless otherwise noted. NRCS will assist in Tasks 2 and 6 and provide technical assistance to WSU upon request on other tasks. WSU will rely on advice and input from Richard Allen on development of the consumptive use model. Ecology staff will work on Tasks 3, 9 and 11 based on direction and QA/QC from WSU. Ecology and WSU will rely on advice from the technical committee.

Timeline

It is estimated that the steps 1-8 can be completed within one year from the date of funding. Publishing the tables to the web and creating the final report will take an additional 6 months. The total time to complete this project is 1½ years.

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AMENDMENT NO. 4 TO

INTERAGENCY AGREEMENT NO. C0900112

BETWEEN THE

STATE OF WASHINGTON DEPARTMENT OF ECOLOGY

AND WASHINGTON STATE UNIVERSITY

It is mutually agreed that:

1. The scope of the project is amended by adding the following tasks to the existing contract (as further set forth in Attachment A to this Amendment):

   Crop Coefficients

   - The investigators in the project will perform a comprehensive literature review to compile all of the relevant research and find the most reliable and scientifically sound sources for crop coefficients.
   - All evapo-transpiration (*ET*)-based coefficients will be converted using the more accurate methods described in Attachment A to work correctly with ET_r.
   - Whenever possible day-of-the-year (*DOY*) based crop coefficients will be converted to be growing-degree-days (*GDD*) based. Otherwise the crop coefficients will be modified to apply to specific geographic areas of the state.
   - The developed crop coefficients will be checked by validating the planting, plant development stage, and harvest dates from interviews with county extension agents, farmers, irrigation designers, irrigation and crop consultants, and/or commodity commission personnel. These dates and their sources will be noted and reported.
   - These crop coefficients and their sources, modification, and methods will be published as a part of the deliverable, the revised Washington Irrigation Guide.

2. The period of performance is extended from June 30, 2011 to December 31, 2011.