CONSUMPTIVE USE ANALYSIS: WHAT IT IS AND HOW IT IS QUANTIFIED

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PRESENTED TO:
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AGRICULTURAL CONSUMPTIVE USE ANALYSIS: WHAT DO WE USE?

- Water Court Decrees
- Water Right - Proof of Ownership
- Diversion Records
- Irrigated Acreage Through Time
- Representative Climate Data
- Soil Information
- Irrigation Method
WATER COURT DECREES

• Original decrees are utilized to understand the water right.
  • Were specific lands identified in the decree (statement maps)?
  • Was there a duty of water defined in the decree?
    • i.e. 1 cfs for the irrigation of 50 acres
  • Any other limitations included in the decree that should be considered?

• Understand the relative seniority of priorities decreed to a structure.
WATER RIGHT PROOF OF OWNERSHIP

• Sometimes, there are multiple users and multiple priorities decreed for a structure.
  • Which Priority is your ownership included in?

• How to find changes associated with the water right?
  • Track changes in Title
  • Research Special Warranty Deeds
  • Interviews (ranchers, water commissioners, etc.)
  • Other records indicating ownership in the water rights?

• Unless a change of water right has been decreed, the water must be utilized on the lands and for the uses originally specified in the decree.
DIVERSION RECORDS

- Diversion records maintained through Division of Water Resources
  - Available through CDSS (Colorado Decision Support System)
    - https://www.colorado.gov/cdss
  - Research Water Commissioner Notebooks for Older Records.
    - Laserfiche archives of records
    - http://water.state.co.us/DWRDocs/ImagedDocs/Pages/default.aspx
- Total Diversions can be pro-rated by ownership when only considering a portion of the water right.
IRRIGATED ACREAGE AND CROP TYPE

• Historic aerial imagery is examined to quantify the irrigated acreage on subject parcels.

• Any acreage beyond the originally decreed area or duty of water does NOT count toward the historical consumptive use.

• The crop type (or mix) is also required as water usage varies by crop type.
- Aerial imagery provides information into irrigated area and irrigation methods.
- Older aerials can still be ordered online (USGS Earth Explorer)
Representative Climate Data

- **Reference Evapotranspiration (ET)**
  - The amount of water utilized by a well watered alfalfa (tall) or grass (short) crop.
  - No stress to the plant; water is not limited.
  - Crop Coefficients are then applied to the Reference values to obtain Crop Potential ET (PET).
  - Multiple stations or adjustments to data can be made to make the measurements more representative of the location being quantified.
    - Orographic elevation adjustment to temperature = 3.6 F/1,000 feet
    - Blaney-Criddle increase 10%/1,000 meters above sea level (accounts for low overnight temperatures which decreases mean temperature)

Typical CoAgMet Station: Temperature, Humidity, Solar Radiation, Wind Speed/Direction and Precipitation.
Several methods to estimate Reference Evapotranspiration (will discuss 2 major)

Blaney-Criddle (SCS TR-21) – widely accepted by Water Court

- Utilizes long-term climate temperature records from NOAA Cooperative Stations
- Inputs include:
  - % of sunshine hours (latitudinally based)
  - Monthly Mean Temperature
- Requires locally calibrated Crop Coefficients which are not always available
Standardized ASCE Penman

A physically-based approach to estimate Reference ET using daily or hourly:
- Temperature
- Solar Radiation
- Wind Speed
- Vapor Pressure (humidity)

This method requires more data parameters than the long term NOAA stations collect. This is where CoAgMet data comes in!
- State efforts are being made to incorporate CoAgMet data in State Tools (Lease-Fallow Tool).
- ASCE has developed methodology to simulate CoAgMet data back in time using NOAA temperature data.

Equation 1 - ASCE Standardized Reference ET Equation: (ASCE/EWRI 2005)

\[
ET_{ref} = \frac{0.408\Delta (Rn - G) + \gamma \frac{Cn}{T + \frac{273}{u2}} (es - ea)}{\Delta + \gamma (1 - Cd u2)}
\]

\(ET_{ref}\) = standardized reference ET for short (ETos) or tall (ETrs) surfaces
\(Rn\) = calculated net radiation at the crop surface MJ/m2/d (function of solar data)
\(G\) = soil heat flux density at the soil surface (0 for daily timestep)
\(T\) = mean air temperature, °C
\(u2\) = mean wind speed at 2-m height, m/s
\(es\) = saturation vapor pressure, kPa (function of temperature data)
\(ea\) = mean actual vapor pressure, kPa (function of humidity and temperature data)
\(\Delta\) = slope of the saturation vapor pressure-temperature curve, kPa/°C (function of temperature data)
\(\gamma\) = the psychrometric constant, kPa/°C
\(Cn\) = a numerator constant that changes with reference type and timestep
\(Cd\) = a denominator constant that changes with reference type and timestep

Note: Coefficients and additional calculations are explained in detail in ASCE/EWRI 2005
IRRIGATION WATER REQUIREMENT

• PET allows us to understand the amount of water a certain crop would use if water was not limited.

• IWR (Irrigation Water Requirement) or CIR (Crop Irrigation Requirement) represents PET – Effective Precipitation.
  • In other words, after considering precipitation, what amount of water was required for the crop of interest to be fully watered.
SOIL INFORMATION

- NRCS Web Soil Survey
  - Detailed soil type with soil properties available online:

- Soil properties are used to determine:
  - Available soil moisture reservoir over the root zone
    - Available water capacity
  - Tendency of runoff to determine the likelihood of irrigation to go to surface runoff vs. deep percolation
    - Soil Hydrologic Group
IRRIGATION METHOD

- Type of Irrigation Determines the Efficiency

- What percentage of the water applied makes it to the field?

<table>
<thead>
<tr>
<th>Type</th>
<th>Range</th>
<th>Avg (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Irrigation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level Basin</td>
<td>80-95</td>
<td>85</td>
</tr>
<tr>
<td>Graded Border</td>
<td>50-80</td>
<td>65</td>
</tr>
<tr>
<td>Furrow or Corrugations</td>
<td>50-80</td>
<td>65</td>
</tr>
<tr>
<td>Surge</td>
<td>60-90</td>
<td>75</td>
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<tr>
<td>Micro Irrigation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Point Source Emmitter</td>
<td>70-95</td>
<td>88</td>
</tr>
<tr>
<td>Line Source Emitter</td>
<td>75-95</td>
<td>90</td>
</tr>
<tr>
<td>Spray Emitter</td>
<td>70-95</td>
<td>85</td>
</tr>
<tr>
<td>Sprinkler Irrigation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Handline/Wheelline</td>
<td>60-85</td>
<td>75</td>
</tr>
<tr>
<td>Traveling Big Gun</td>
<td>55-75</td>
<td>65</td>
</tr>
<tr>
<td>Solid Set (Above Canopy)</td>
<td>60-75</td>
<td>60</td>
</tr>
<tr>
<td>Solid Set (Below Canopy)</td>
<td>70-85</td>
<td>75</td>
</tr>
<tr>
<td>Center Pivot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact Sprinkler w/ end gun</td>
<td>75-90</td>
<td>80</td>
</tr>
<tr>
<td>Drops, spray heads w/o end gun</td>
<td>75-95</td>
<td>85</td>
</tr>
<tr>
<td>Lateral Move</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spray heads w/ hose feed</td>
<td>75-95</td>
<td>90</td>
</tr>
<tr>
<td>w/ canal feed</td>
<td>75-95</td>
<td>85</td>
</tr>
</tbody>
</table>

Typical Values from the NRCS National Engineering Handbook: Irrigation Guide
HCU ANALYSIS

- A water balance approach to determine what was historically consumed by the crops on a given acreage over a time period representing wet, average and dry conditions.

- The IWR is calculated for the entire season; however, quantified consumptive use only takes into account what was consumed given the water applied using diversion records.
  - Also called “Water Supply Limited Consumptive Use”
HCU ANALYSIS

• As part of the analysis, the following are quantified:
  • Consumptive Use – Amount of applied irrigation water consumed by the crops
  • Surface Runoff
  • Deep Percolation/Delayed Return Flows (the amount that goes to deep percolation taking into account the lagged nature of these returns to the river).
    • This can get pretty complex.
  • Conveyance Losses
Example Outcome (Annual Values)

Headgate Diversion = 424 AF; 1 cfs: 50 acres with full supply

Ditch Loss = 15% = 64 AF

Surface Runoff = 126 AF

Deep Percolation = 126 AF

CU = 97 AF = 1.94 AF/ac

Irrigation Spray Loss = 3% = 11 AF

Irrigated Acreage = 50 ac
BASIN-WIDE ESTIMATES – SWSI (SURFACE WATER SUPPLY INITIATIVE)

• StateCU and StateMOD allow the consumptive use analysis to be expanded over larger regions using the available data in CDSS.
  • They are NOT verifying every decree to ensure duty of water, etc.

• The 2018 SWSI Update uses the following methodology:
  • Use Crop Type, Acreage and Climate Data to Quantify the IWR
  • On-farm irrigation and conveyance efficiencies are utilized to estimate the total agricultural DIVERSION needed.
  • The Diversion amount is entered into the water allocation model to determine amount of water available to meet these demands under various planning scenarios.
  • This method is more consistent with Municipal quantification.
MUNICIPAL DEMANDS

- Demand = Population * Water Usage (gpcd)
- CU = Metered Water Use – Return Flows
- Current and future demands rely on population and associated projections.
  - Quantify Future Population and Urban Growth
  - Apply Climate Impacts to Outdoor Usage
  - Adjust future gpcd rates and delivery loss assumptions
  - Calculate Future Municipal Water Demands