The Origin of GUID-1210:
Irrigation Efficiency and Consumptive Use (CU)

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SUMMARY

1. Background / Timeline
2. Litigation
3. Time-out for some science fun
4. 2004 Experts Workshop
5. Resolution and adoption of GUID 1210
6. Updates to GUID 1210

In the Beginning . . . The Legislature created the Water Code

- **1917 to 1997 → Acres was a "fixed" water right attribute like quantity and priority date.**

  When a permit or certificate limits irrigation to a specific number of acres within a larger legal description, irrigation of no more than that specific number of acres may occur during any irrigation season. Moving the water over the entire described acreage during any crop year is an unauthorized expansion of the right. Kummer v. Ecology, PCHB No. 85-188 (1987); Benningfield v. Ecology, PCHB No. 87-106 (1987).

- **After 1997 → "Spreading" and "adding new uses" became legal subject to a new statutory "consumptive use" test.**

Where am I in the statute? Why do I care?

- **The Legislature put ACQ in the "no impairment" section of RCW 90.03.380. The test is focused therefore on what will diminish another's right not, for example, other tests like public interest.**

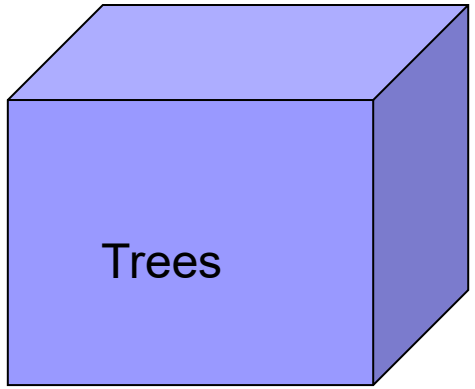
RCW 90.03.380. Right to water attaches to land—Transfer or change in point of diversion

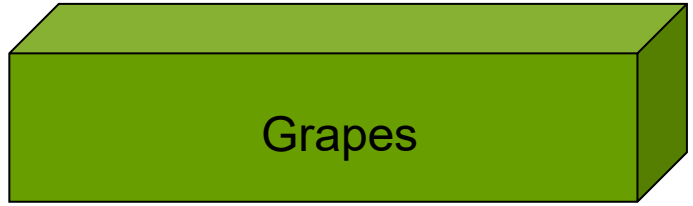
- (1) The right to the use of water which has been applied to a beneficial use in the state shall be and remain appurtenant to the land or place upon which the same is used: PROVIDED, HOWEVER, That the right may be transferred to another or to others and become appurtenant to any other land or place of use without loss of priority of right theretofore established if such change can be made without detriment or injury to existing rights. The point of diversion of water for beneficial use or the purpose of use may be changed, if such change can be made without detriment or injury to existing rights.
  - (a) A change in the place of use, point of diversion, and/or purpose of use of a water right to enable irrigation of additional acreage or the addition of new uses may be permitted if such change results in no increase in the annual consumptive quantity of water used under the water right.
  - (c) For purposes of this section, "annual consumptive quantity" means the estimated or actual annual amount of water diverted pursuant to the water right, reduced by the estimated annual amount of return flows, averaged over the two years of greatest use within the most recent five-year period of continuous beneficial use of the water right.

Background / Timeline (1997 to 2002)



- During this time period, Ecology's processing of ACQ changes were primarily related to crop change. → For example, I want to convert 50 acres of apples trees to 100 acres of grapes.
- 50 acres of trees x 4 feet = 200 ac-ft
- 100 acres of grapes x 2 feet = 200 ac-ft





Then in 2002, the Benton Board approved CG4-23101C

The applicant is making this request based on recent (within past 5-years) water application system efficiencies, where an older generation, center pivot system (high pressure, overhead impact sprinklers, with end gun) was upgraded (low pressure, drop-tubes with efficiency application emitters), resulting in less consumptive water-use per crop acre. The new efficiency measure costs were paid for by the applicant. The applicant proposes to use the "water savings" gained through the efficiency measures for application to a residential home development. As such, the water right would reflect an added purpose of use, place of use, and time of use.

- Before = 140 acres
- After = 140 acres, no crop change, and a subdivision of houses
- How is there no increase in CU?



Savings were based on conservation only

Relying on the pre-and post-change water application efficiency rates (minus return flows) of 75% and 87.5%, the water "savings" gained through efficiency improvements would be about 89 acre-ft. (622 acre-ft. minus 533 acre-ft., at 140 acres).

- Can consumptive use be saved only through sprinkler changes?
- Is the magnitude right?
- Ecology approved the decision, but . . . began studying CU science in earnest because similar changes followed.



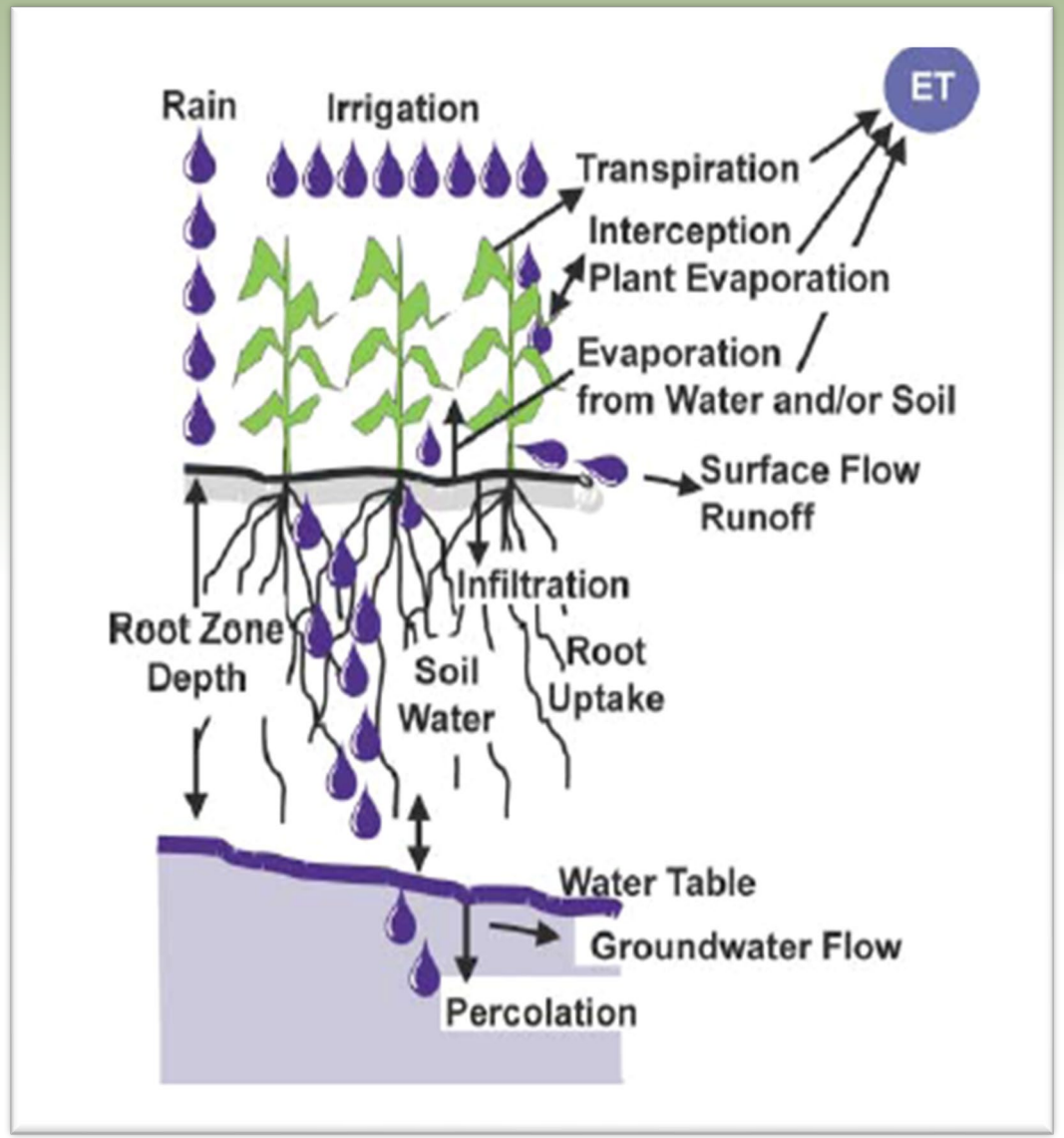
How did we investigate CU?

- **First, we reviewed the literature and contacted the authors of the research referenced in the Board decision.**

Saved Water Discussion. In 2001, Wiser Farms converted the irrigation system for the subject water right to high-efficiency low-pressure center pivot technology. The prior system was an old-generation high-pressure center pivot, with overhead impact sprinklers. The new system reduces the required water application for a given crop, primarily by reducing spray evaporative and water drift losses. Spray evaporative water losses are highest for high-angle, high-pressure, overhead sprinklers, which were used prior to 2001. The literature reports a value of 12% for spray evaporative losses using this old-generation technology, under calm wind conditions (Kincaid et al, 1986). These evaporative losses increase with wind speed, and at an exponential rate when wind speeds exceed 10 miles per hour (Frost and Schwalen, 1955; Inoue, 1963; Yazar, 1984). Under extreme conditions (high radiation, high temperature, low humidity) spray evaporative losses as high as 42% and 45% have been reported (Christiansen, 1942; Frost and Schwalen, 1955). With respect to the newly installed center pivot to be used by Wiser Farms, the literature reports that spray evaporation is reduced with lower nozzle pressure and lower nozzle elevation. Low elevation spray nozzles were shown to have a mean spray evaporation loss of 2% (Kincaid et al, 1986).

Wiser Farms Water Use Report, Reierson, 2002

And now, a time-out for science



Can't calculate CU without knowing how irrigation water budget works

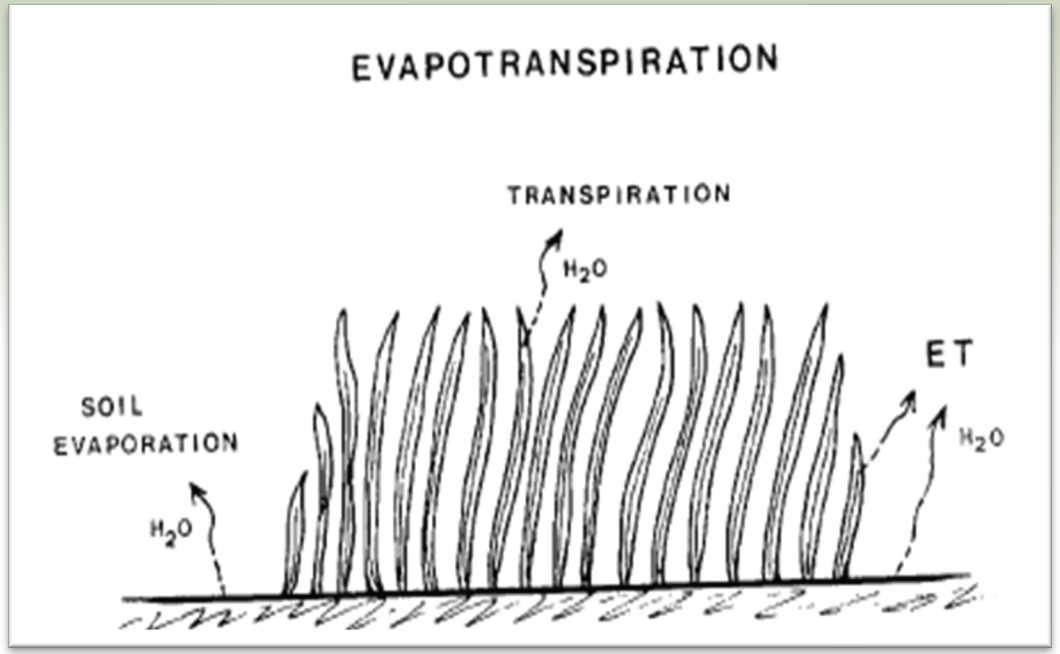
- ET
- Rainfall
- Irrigation
- Soil "Reservoir"
- Irrigation Efficiency
  - Canopy Loss
  - Spray Evaporative Loss
  - Wind Drift
  - Deep Percolation
  - Runoff
  - Leaks
  - Non-Uniform Application

Evapotranspiration (ET)





- **Evapotranspiration (ET) is the loss of water from a vegetated surface through soil evaporation and plant transpiration.**
- **Sources of ET data**
  - **Washington Irrigation Guide**
    - 60 crops; 1951 – 1980
  - **WSU Irrigation Bulletin**
    - 39 crops; 1948 – 1973
  - **WSU PAWS**
    - 42 crops; 1989 – present
  - **ET Derivation Methods (> 50 methods)**
    - Modified Blanney-Criddle (Temperature-Based, WIG)
    - Penman-Montieth (Energy-Based, ASCE, New Standard Adopted by USDA)
    - FAO Radiation (Radiation)
    - Pan Evaporation



Difference Between Plant Need and Plant Use

WSU Research: Measuring Whole-Canopy Net Transpiration

(Dr. Matthew Whiting, WSU Prosser)










ZIMMATIC





How Consumptive is Application Efficiency?

- Washington Irrigation Guide gave Ea values
- Other similar ranges existed in the literature for new technology
- The debate was about how much of these terms was consumed vs. return flow

Table WA684.20.4 - Expected Irrigation Method Efficiencies in Washington 1/

Method	Efficiency
Level Border	75
Graded Border	70
Flood Irrigation	50
Contour Ditch	50
Level Furrow	65
Graded Straight Furrow	60
Graded Contour Furrow	60
Corrugations	60
Subirrigation-Water Table Control	65
Subirrigation-Trickle	70
Trickle-Point Source Emitter	90
Trickle-Spray Emitter	85
Trickle-Continuous Tape	90
Handline/Wheel line	65
Big Gun (Fixed Place)	60
Traveling Gun	65
Solid Set (Above Canopy)	65
Solid Set (Below Canopy)	70
Center Pivot	70
Linear Move	70

We started reading some *fascinating* papers

- Relative performance of sprinkler and drip irrigation in Southern Idaho (1999)
- Spray losses and uniformity with low pressure center pivots (1986)
- Drop size distributions for irrigation sprinklers (1996)
- Spraydrop kinetic energy from irrigation sprinklers (1996)
- A water droplet evaporation and temperature model (1989)
- Evaporation and drift losses from sprinklers irrigation systems under various operating conditions (1984)
- A sprinkler water droplet evaporation and plant canopy model(1993)
- Yikes.

Spray Evaporative Loss

High and Low Elevation Sprays on a Center-Pivot



Where were we headed between 2002-2004?

- **Seemed like . . .**
  - New literature suggested spray evaporative losses were small.
  - Big drops have low consumption (e.g. big gun sprinklers, end guns, wheel lines with large spacing).
  - Small drops have high consumption (e.g. microspray, smaller sprinklers with closer spacing)
  - The higher off the ground water was applied, higher consumption.
  - The consumptive portion of Ea in many non-windy settings would be low (a few percent)
- **We started policy work on this issue, but the workflow of change applications kept coming.**
- **As "technical assistance" on the topic was requested and provided, tension ensued until . . .**

Benton and Franklin Boards sued Ecology

- Did Ecology's technical assistance amount to an illegal rule?
- Was Ecology wrong on its consumptive use position?
- Injunction prevented Ecology from issuing ACQ decisions until court ruled.

SUPERIOR COURT OF THE STATE OF WASHINGTON
FOR BENTON COUNTY

BENTON COUNTY WATER CONSERVANCY BOARD and FRANKLIN COUNTY WATER CONSERVANCY BOARD,

Plaintiffs,

vs.

DEPARTMENT OF ECOLOGY, a department of the State of Washington; LINDA HOFFMAN, Director, Department of Ecology; JOSEPH STOHR, Program Manager, Water Resources Program,

Defendants.

No. 24 – 2

COMPLAINT

The case settled fairly quickly under these terms

- Two-day experts' technical workshop convened.
- Experts invited from institutions with expertise on these topics, plus appointed by conservancy boards and one appointed by Ecology.
- Ecology had to timely produce a policy informed by the experts.

Irrigation Experts Workshop

- Tom Spofford, P.E., USDA National Engineer
- Leigh Nelson, P.E., USDA State Engineer (WA)
- Dr. Robert Stevens, WSU Prosser
- Dr. Allan Thompson, University of Missouri
- Dr. Dennis Kincaid, USDA-ARS Idaho
- Mark Nielson, Franklin County Conservation District
- Robert Montgomery, P.E., Montgomery Water Group
- Paul Wattenburger, P.E., IRZ Consulting
- Dan Haller, P.E., Department of Ecology
- Dr. Darryll Olsen, Benton Co. Water Conservancy Board

*Selected slides adapted from presenters listed above and from WSU Prosser.

Conference Agenda and Goals

Tuesday, November 30th, 2004

8:30 – 10:30 a.m.	From current understanding and information, which factors should be considered when determining irrigation efficiency, and how are those factors defined and bounded? (Facilitated Discussion for All) 1. What ET values should be used? 2. What efficiency values should be used? 3. What are the consumptive and nonconsumptive portions of irrigation efficiency for different irrigation systems? 4. What is the accuracy of our estimation methods? 5. How sensitive is the outcome to different assumptions?
10:30 – 10:45 a.m.	Break
10:45 – 12:00 p.m.	Recommendations on a Practical Approach. (Facilitated Discussion for All) For the task of estimating the consumptive use of water in a given irrigation water rights case, how can irrigation efficiency be determined in a practical manner?

Came down to key papers and recommendations tied to height of irrigation application

- **Dr. Blaine Hansen, University of California, Davis, 1995 measured efficiencies of nearly 1000 different irrigation systems (below).**
- **Dr. Terry Howell, USDA-ARS Texas, 2002, collected and summarized existing irrigation efficiency research.**
- **Experts Workshop recommendation was to use this data and include ranges to allow adjustment for site-specific conditions.**
  - If high off the ground, 15% additional water consu
  - If medium height, 10% consumed.
  - If low elevation, 5% consumed

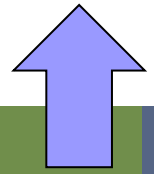
Irrigation Method	Sample Size	Average DU (%)	Standard Deviation (%)
Sprinklers			
Continuous-move	57	75a	10
Portable Solid-set	56	64b	11
Periodic-move	109	61b	17
Under-tree	28	79ade	16
Micro-irrigation			
Microsprinklers	276	71c	14
Drip emitters	163	77ae	14
Surface			
Furrow	157	81d	15
Border	72	84d	14

DU Range	CM	SS	PM	MS	D	F	B
0-10	0	0	1.8	0	0	0	0
11-20	0	0	0.9	0	0	0	0
21-30	0	0	2.8	1.4	1.2	0	0
31-40	1.8	0	7.3	2.5	1.8	2.0	2.9
41-50	1.8	12.5	14.6	4.3	2.4	2.6	1.4
51-60	1.8	21.4	13.8	14.5	6.1	9.2	1.4
61-70	22.8	39.2	29.3	21.3	14.7	5.9	12.9
71-80	38.6	21.4	20.2	27.2	27.0	20.4	10.0
81-90	33.3	5.4	8.2	25	35.0	27.3	35.7
91-100	0	0	0.9	3.6	11.6	32.9	35.7

CM = continuous-move sprinklers, SS = solid-set sprinklers, PM = periodic-move sprinklers, MS = microsprinklers, D = drip emitters, F = furrow, B = border.

GUID 1210 Table for Estimating CU

Method		Application Efficiency, Ea (%)[2]		%Total Evaporated	% Total Use Consumed	Return Flow
		Range	Average, Ea_{avg}	%Evap	%CU, Average[3]	%RF, Average[4]
Surface:	Graded Furrow	50 – 80	65	5	70	30
	w/ tailwater reuse	60 – 90	75	5	80	20
	Level Furrow	65 – 95	80	5	85	15
	Graded Border	50 – 80	65	5	70	30
	Level Basins	80 – 95	85	5	90	10
	Flood	35 – 60	50	5	55	45
Sprinkler:	Periodic Move (Handline)	60 – 85	75	10	85	15
	Side Roll (Wheelline)	60 – 85	75	10	85	15
	Moving Big Gun	55 – 75	65	10	75	25
	Solid-Set—Overtree	55 – 80	70	15	85	15
	Solid Set--Undertree	60 – 85	75	10	85	15
	Pop-Up Impact	60 – 85	75	10	85	15
Center-Pivot	Impact heads w/end gun	75 – 90	80	15	95	5
	Spray heads w/o end gun	75 – 95	90	10	100	0
	LEPA[5] w/o end gun	80 – 98	92	5	97	3
Lateral-Move	Spray heads w/hose feed	75 – 95	90	10	100	0
	Spray heads w/canal feed	70 – 95	85	10	95	5
Microirrigation:	Trickle/Drip	70 – 95	88	5	93	7
	Subsurface Drip	75 – 95	90	0	90	10
	Microspray	70 – 95	85	10	95	5



Under what conditions is CU test applied?

- **From 2004 to 2023, the guidance said:**

2. Ecology must determine the consumptive use of an irrigation right:

   a. When a change in purpose is proposed that could increase the consumptive use of a water right and such increase could result in impairment of existing water rights; and
   b. When a change to enable irrigation of additional acres or an additional purpose of use is proposed, requiring application of the Annual Consumptive Quantity (ACQ) test[1].

[1] See RCW 90.03.380. While an ACQ change requires averaging of the two highest years of consumptive use, consumptive increases that could lead to impairment may be evaluated using the highest year of consumptive use.

Under what new conditions is CU test applied?

- **In 2023, Ecology "reformatted" GUID 1210 and omitted the page with this guidance.**
- **The ACQ language is still in statute, but there is no official guidance on the time period to consider when CU is calculated for impairment review.**

[1] See RCW 90.03.380. While an ACQ change requires averaging of the two highest years of consumptive use, consumptive increases that could lead to impairment may be evaluated using the highest year of consumptive use.

  - The impairment position is grounded in case law (e.g. Big Creek Water Users v. Ecology and Trendwest), literature (R. Beck, Waters and Water Rights, 1991), and Ecology decisions (e.g. Sullivan Lake ROE (S3-30635).
- **When asked about whether the page was omitted in error I was told:**
  - "We looked into this and determined that there is no missing page or information. The current version reflects our current guidance on consumptive use."
- **Since impairment CU reviews are often triggered, the deletion of impairment guidance with no replacement could lead one to many conclusions about its implications.**

Questions?

