

# USE OF SATELLITE DATA TO ESTIMATE WATER USE FOR WHATCOM IRRIGATION<sup>1</sup>

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Agricultural irrigation is the single largest water user in Whatcom County. And its use peaks during the summer months, when streamflows are lowest and fish most need abundant, cold, clean water.

Because water-meter data on agricultural irrigation are not publicly available, various approximations have been developed to estimate this water use. Recently, “a new online platform that uses satellites to estimate water used by crops ...” has become available.<sup>2</sup> This OpenET system estimates crop evapotranspiration (ET) for individual fields, along with the crop type and field size, for 17 western states by month from January 2016 to the present.<sup>3</sup> Given the absence of water-meter data for Whatcom farms, these ET data offer a new way to estimate agricultural water use at a detailed level.

This paper presents these ET data, scales them up to estimate field-specific and county-wide water use, and presents these results by month, year, and crop type. I also compare these results with other estimation methods and show how month-to-month variations in water use are related to rainfall and air temperatures. Finally, I offer my personal interpretation of these data and, once again, strongly recommend use of water meters to measure and improve our understanding of water use by Whatcom farms. The Appendix provides additional detail on water use by crop and explains how I developed these results.

## RESULTS

I downloaded ET data for 31 farms throughout Whatcom County, focusing on the major crops grown locally: corn, grass/hay, blueberries, raspberries, and potatoes. Fig. 1 is a screen shot from the OpenETData.org website that shows results for a field east of Lynden.

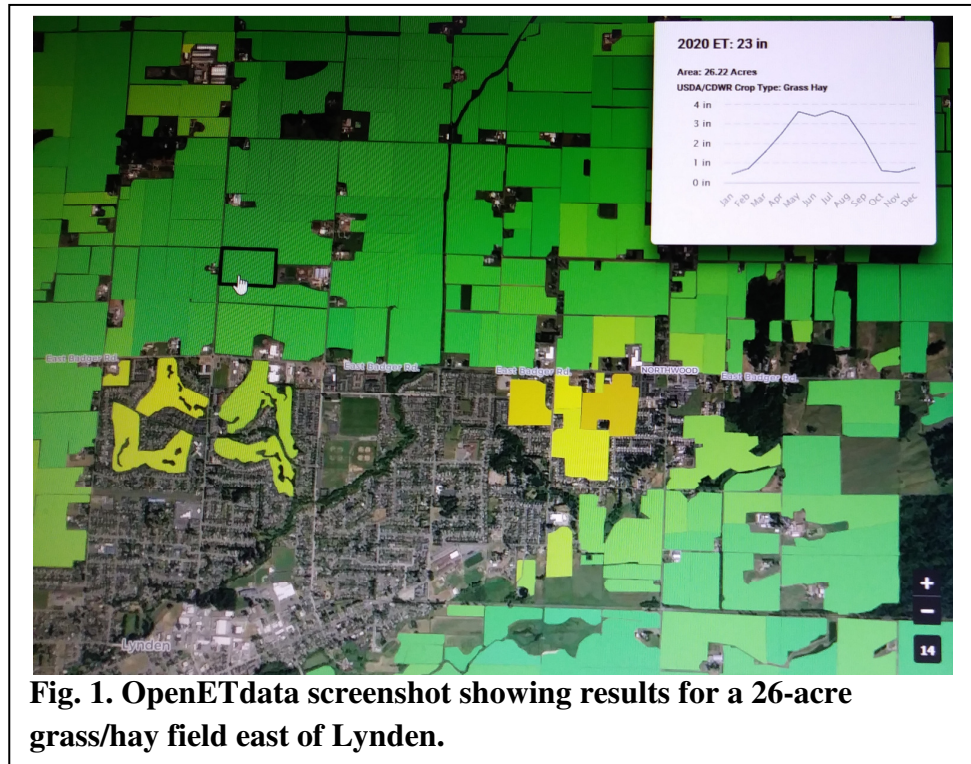
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<sup>1</sup> I thank Larry Davis, Atul Deshmane, Dan Eisses, Chris Elder, Kara Kuhlman, Troy Peters and Ander Russell for their helpful comments on a draft of this paper.

<sup>2</sup> Environmental Defense Fund et al., “Consortium Launches New Online Water Data Platform to Transform Water Management in the Western United States as Droughts Intensify,” October 21, 2021. <https://openetdata.org/press-release-10-2021/>

<sup>3</sup> ET is the sum of plant transpiration, evaporation from the soil surface, and water used for plant growth.

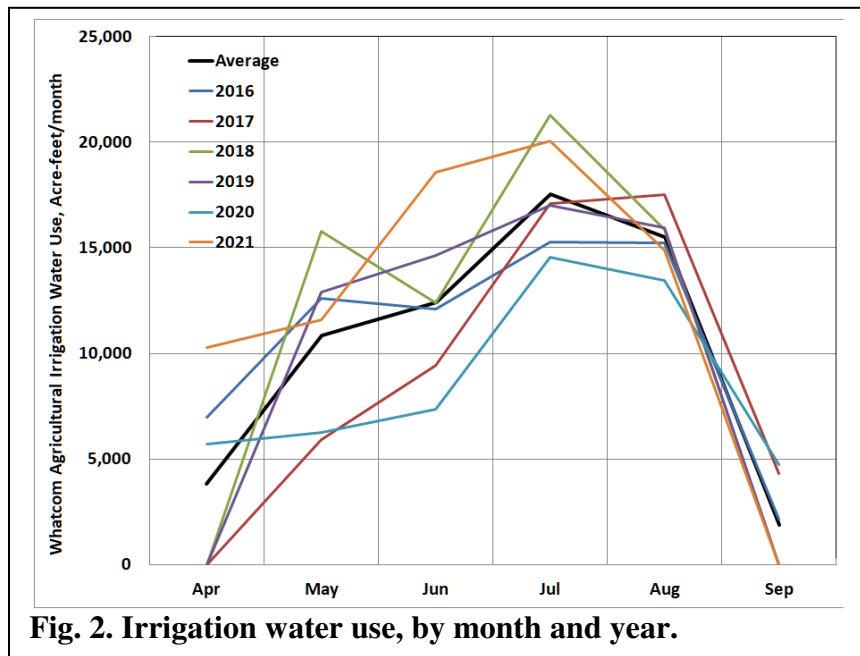
The amount of irrigated land in Whatcom County was 46,000 acres in 2019.<sup>4</sup> Fig. 2 shows total irrigation water use by month and year from 2016 through 2021. On average, water use for corn, grass/hay, and potatoes is almost 40% more than for blueberries and raspberries; see Figs. 7-11 in the Appendix. This



**Fig. 1. OpenETdata screenshot showing results for a 26-acre grass/hay field east of Lynden.**

difference among crops is attributable primarily to differences in the assumed efficiency of irrigation, 65% for corn, grass/hay, and potatoes; and 85% for berries.<sup>5</sup> Absent equipment efficiencies, corn, grass/hay, and potatoes would require only a little more water than berries.

Averaged over all months and years, grass/hay is the dominant water use, accounting for 34% of the total. Corn accounts for 31%, raspberries for 14%, blueberries for 10%, potatoes for 6%, and other crops for the remainder.<sup>6</sup>



**Fig. 2. Irrigation water use, by month and year.**

<sup>4</sup> <https://nrsig.org/projects/washington-state-agland-database>. See appendix for more on the amount of irrigated farmland in Whatcom County.

<sup>5</sup> Washington State Dept. of Ecology, GUID-1210, *Water Resources Program Guidance: Determining Irrigation Efficiency and Consumptive Use*, Oct. 11, 2005.

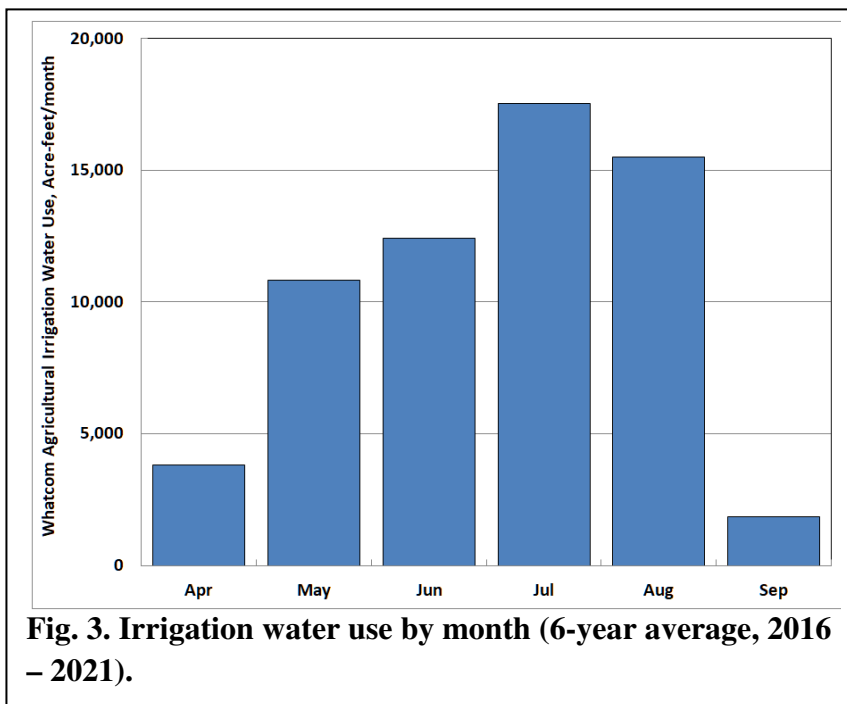
<sup>6</sup> The percentages of irrigated acres are: grass/hay 32%, corn 30%, raspberries 19%, blueberries 13%, and potatoes 6%.

For all five crops, water use is greatest during the 3-month period of June, July and August, accounting for more than 70% of the annual totals.<sup>7</sup>

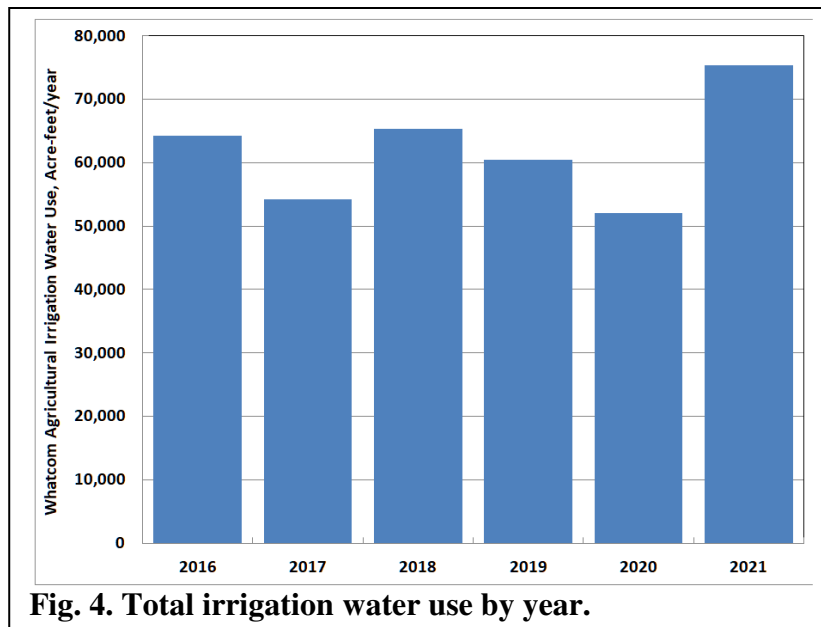
Fig. 3 shows total water use (averaged over the 6-year period) by month; water use is highest in July and August, with May and June also high-water-use months. Water use varies from year to year, ranging from 82% to 129% of average use across these six years (Fig. 4).

Much of that year-to-year variation is related to rainfall and air temperature. Regression analysis of total water use as a function of rainfall suggests that one additional inch of rain reduces annual water requirements by about 3,400 acre-feet. A 1°F increase in air temperature increases water use by about 900 acre-feet.

Five years ago, I compared different methods to estimate irrigation water use.<sup>8</sup> Fig. 5 adds the current OpenET results (adjusted for differences in the number of acres irrigated) to the earlier comparison. The estimates of annual water use range from 53,000



**Fig. 3. Irrigation water use by month (6-year average, 2016 – 2021).**



**Fig. 4. Total irrigation water use by year.**

<sup>7</sup> In prior analyses, the key months were July, August and September, one month later than these results; see E. Hirst, *How Much Water Does Whatcom Irrigation Actually Use*, April 2017.

<sup>8</sup> E. Hirst, *How Much Water Does Whatcom Irrigation Actually Use?* April 2017.

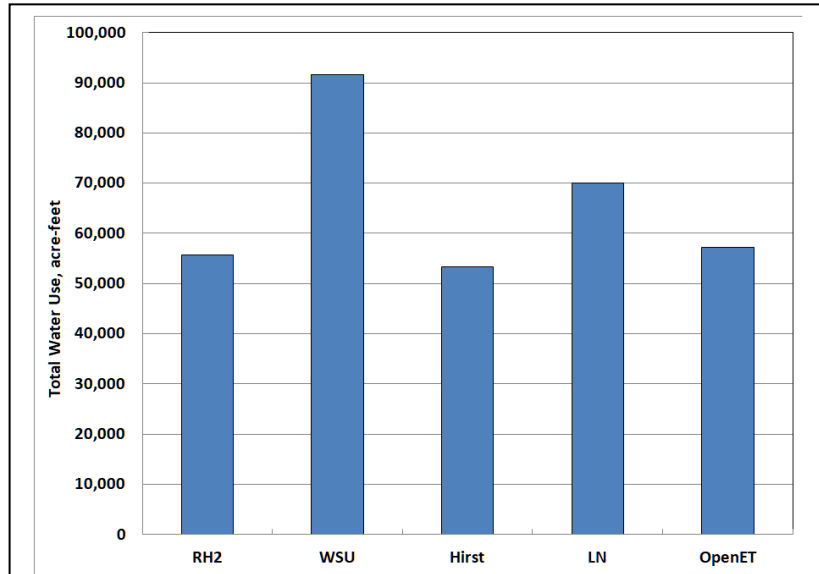
to 70,000 acre-feet, with the OpenET estimate near the low end. The OpenET estimates of month-to-month variation in water use are roughly consistent with those for the four other methods (Fig. 6).

**INTERPRETATION**

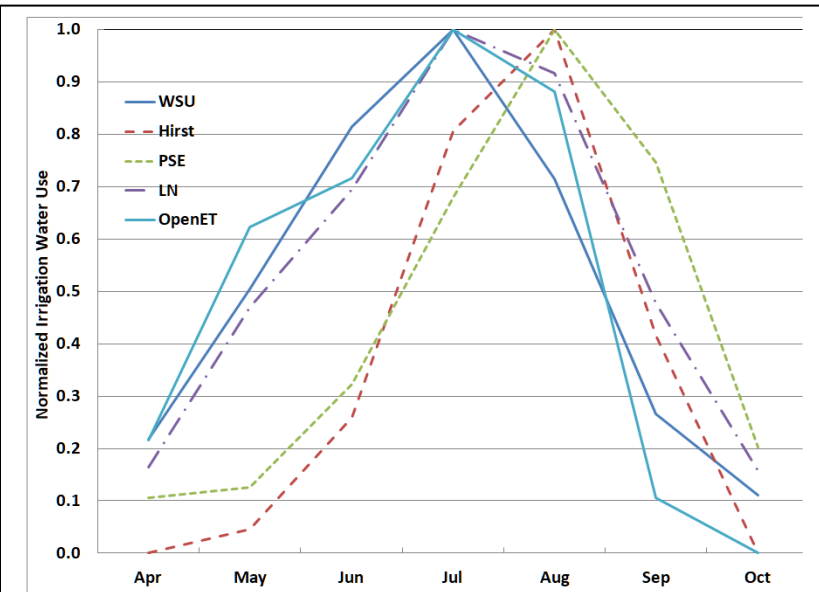
How do these results relate to the key issues that currently confront Whatcom County water users and those responsible for water-resource management?

The forthcoming adjudication of water rights in the Nooksack River basin is a major process, the outcome of which will determine who has the right to use water, where and when.<sup>9</sup> The two key elements of this process, set to begin in July 2023, are Tribal treaty rights and farmer rights to irrigation water. The two local tribes, Lummi Nation and Nooksack Indian Tribe, hold two sets of rights reserved by the 1855 Treaty of Point Elliott: the right to sufficient instream flows to support salmon and other wildlife, and the right to on-reservation water to support tribal economies and lifestyles.

To date, neither Tribe has indicated the amounts of water they think they are entitled to.



**Fig. 5. Comparison of estimation methods on annual agricultural irrigation water use. (RH2, WSU, Hirst, and LN refer to the other estimation methods studied.)**



**Fig. 6. Comparison of estimation methods on month-to-month variations in water use.**

<sup>9</sup>Ecology, *Water Resources Adjudication Assessment Legislative Report, Watersheds Proposed for Urgent Adjudication and Future Assessment*, Pub. 20-11-084, Sept. 2020.

The only official estimates are the minimum flows established by Ecology in its 1985 instream flow rule;<sup>10</sup> these minimum flows are often not met, especially during the summer months.<sup>11</sup> My guess is that the superior court will grant the Tribes the right to maintain instream flows equal to or greater than those specified by Ecology more than 25 years ago. The court might rely on the more recent work done by Utah State University to identify instream flows optimal for fish.<sup>12</sup>

As noted above, agricultural irrigation is the dominant use of water in Whatcom County, especially during the summer when instream flows are lowest and often fall below Ecology's minima. In addition, much of the water now used by farmers lacks authorization from Ecology – as much as half, according to the farmers themselves.<sup>13</sup>

This background suggests that the farmers will receive the right to use less water than they now use for two reasons. First, they are not entitled to much of the water they now use. Second, their use of water likely reduces streamflows, potentially cutting into Tribal water rights.

This discussion has dealt with water *rights*, not water *use* (*paper* and *wet* water).<sup>14</sup> The only way to know how much water farmers actually use, and the only way to know whether their water use adversely affects streamflows is to measure that use. And the only way to measure that use is with water meters. As the results presented here clearly show, the methods used to *estimate* agricultural irrigation water use vary substantially. Therefore, they cannot be relied upon to ensure that farmers use no more water than they are legally entitled to use.

A second major process likely to occur in Whatcom County is settlement discussions, more recently called a Solutions Table.<sup>15</sup> The county hired consultants to develop and help implement such a process to ensure that settlement discussions are productive. The idea is that adjudication, while important, addresses only some of the many outstanding local water issues. Other issues – water quality, habitat, land-use planning and zoning, climate change, and the types of resources

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<sup>10</sup> Washington State Dept. of Ecology, *Instream Resources Protection Program—Nooksack Water Resource Inventory Area (WRIA) I*, Chapter 173-501 WAC, June 9, 1988.

<sup>11</sup> Ecology's rule in no way limits water use for those with water rights that are senior to (i.e., issued before) Ecology's rule. The rule's only regulatory effects are to limit the issuance of subsequent, more junior water rights and to interrupt water use for those who hold water rights junior to the instream flow rule's establishment. That is, Ecology lacks authority to use its instream flow rule to require that more water be left in (or put back into) the river.

<sup>12</sup> C. Bandaragoda and J. Greenberg, *Data Integration of WRIA 1 Hydraulic, Fish Habitat, and Hydrology Models*, WRIA 1 Joint Board, June 2013.

<sup>13</sup> *Whatcom Ag Water Board Position Paper on Water Right Adjudication in the Nooksack Basin*, April 2020.

<sup>14</sup> A water right, issued by Ecology, grants the recipient the right to use a set amount of water, for a certain time period, taken from a specific location, and used for particular purposes. Given the lack of water-meter data for farms, Ecology has no way to know whether a particular farmer's water use is consistent with that farmer's water right.

<sup>15</sup> M. Bellon and J. Manning, "Nooksack Watershed Readiness Assessment Process and Recommendations," presentation to WRIA 1 Watershed Management Board, Cascadia Policy Solutions, Oct. 21, 2021.

(supply, storage, and efficiency) to fill the growing gap between out-of-stream water uses and available resources – will be addressed in a Solutions Table.

Here, too, data on irrigation water use will be essential. When farmers are called upon to improve their management of irrigation systems (maintenance and scheduling practices), how will we know whether these improvements reduce water use unless we have meter data? If farmers install new, more efficient irrigation equipment, how will we know how much water they actually save and whether these changes are cost effective? If farmers improve soil quality and water retention, how will we know the effects on water use?

Climate change will play an important role in water-resource planning, because it will reduce streamflows (glacier loss, less winter snow, earlier snowmelt, less summer rainfall) and increase the need for irrigation water (higher summer air temperatures and less summer rainfall). Here, too, meter data are needed to document the effects of climate change on irrigation water use. And here, too, estimates cannot do this job.

Given the forgoing, I urge the Watershed Management Board and Dept. of Ecology to promote and require installation of water meters at local farms to address a critical data gap and improve our understanding of agricultural water use. If this analysis and my thinking are flawed, I would appreciate hearing from local experts where and how I am wrong. I am especially interested in explanations of how we can resolve local water issues absent water-meter data for agricultural irrigation.<sup>16</sup>

## **CONCLUSIONS**

The detailed, field-specific ET data provided by this new online source should help us better understand the details of irrigation water use in Whatcom County. The results on water use derived from these ET data are roughly consistent with other methods used to estimate agricultural irrigation water use (Figs. 5 and 6).

Irrigation of 46,000 acres uses about 70,000 acre-feet of water a year, equivalent to 1.5 acre-feet/acre. Water use varies from year to year (from almost 60,000 to 90,000 acre-feet/year), depending on rainfall and air temperatures (and perhaps other factors not considered here), by about +30% to -20% (Fig. 4).

Irrigation water use varies substantially from month to month, with water use greatest in June, July and August (Figs. 3 and 6). Some estimation methods show water use peaking in July, others peaking in August.

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<sup>16</sup> I sent a draft of this paper to three members of the local agricultural community, but they all declined to comment on the draft.

My interpretation of these new ET data, as well as other estimation methods, is that they are helpful but not sufficient for understanding the details of agricultural water use. Specifically, water-meter data are necessary to:

- understand how irrigators can and should prepare for and respond to droughts,
- assess the costs and benefits of higher-efficiency irrigation equipment,
- assess the costs and benefits of improved maintenance and scheduling practices, and
- compare the costs and benefits of new supply, storage, and water-use efficiency projects.

The age-old maxim, “you can’t manage what you don’t measure,” applies as well to water use.

## APPENDIX

I created an Excel workbook to organize and analyze the OpenET data.<sup>17</sup> I arbitrarily selected a sample of 31 fields throughout Whatcom County to roughly represent the primary crops grown in the county (Table 1). These fields encompass a total of 1,688 irrigated acres, 4% of the actual total.

	Blueberries	Raspberries	Grass Hay	Corn	Potato	Other	Total
# fields	7	5	8	8	2	1	31
Average acres	57	62	58	49	30	66	54

I obtained irrigated acres for each crop from a 2019 survey conducted by the Whatcom Conservation District (WCD) for the Washington State Dept. of Agriculture (WSDA), 54,200 acres in total.<sup>18</sup> This survey also identified the types of equipment (big gun, sprinkler, drip) used to irrigate each crop. I combined these equipment types with estimates of irrigation efficiencies (88% for drip, 75% for sprinkler, and 65% for big gun) to estimate irrigation efficiency for each crop.<sup>19</sup>

This 2019 survey’s estimate of total irrigated acreage in Whatcom County is much higher than prior estimates: 41,000 for 2014 and 47,300 for 2017 from the comparable WCD/WSDA surveys, 36,500 for 2017 from the U.S. Dept. of agriculture Census of Agriculture, and 46,000 for 2019 from the University of Washington Agland database. I used the 46,000 acres for 2019 from the Agland database as the control total and the shares from the latest (2019) WCD/WSDA survey. Table 2 shows these inputs to the calculations.

<sup>17</sup> I am glad to share this workbook with others who want to verify my analysis and results or test different inputs.

<sup>18</sup> <https://agr.wa.gov/departments/land-and-water/natural-resources/agricultural-land-use> Golf courses account for more than 1,000 acres of this total; other uses that might not be considered agriculture are also included in the total.

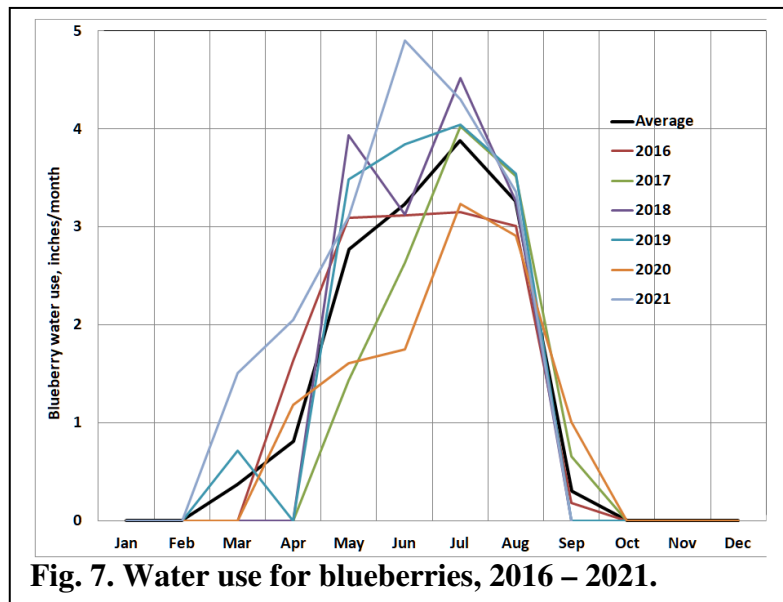
<sup>19</sup> See footnote 5.

**Table 2. Estimates of irrigated agricultural land in Whatcom County and associated efficiencies by crop**

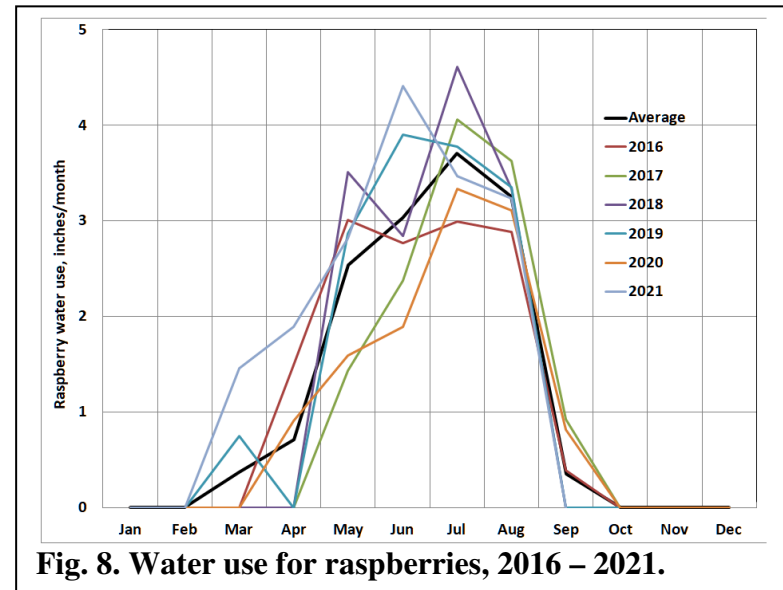
	Blueberries	Raspberries	Grass Hay	Corn	Potato	Total
Irrigated acres	6,100	8,600	14,800	13,900	2,700	46,000
Irrigation efficiency, %	86%	85%	65%	65%	65%	72%
Water use, acre-feet/acre	1.2	1.2	1.7	1.6	1.6	1.5

The Agland Database also classifies the irrigation equipment used in the county: 63% big gun, 29% drip, 7% sprinkler, and 1% wheel line, which yields an average irrigation efficiency of 72%. (The WCD/WSDA database yields a slightly different mix of irrigation equipment: 67% big gun, 26% drip, 3% sprinkler, and 4% other.)

The OpenET values show how much water the plants need. I adjusted these numbers down to account for the effects of rainfall and up to account for equipment, maintenance, and scheduling inefficiencies. I used data on monthly rainfall and air temperatures for Clearbrook<sup>20</sup> and the efficiency of rain from the Natural Resources Conservation Service.<sup>21</sup> Overall, almost two-thirds of the rainfall displaces irrigation water, with rainfall more efficient during the summer months and less so during the shoulder seasons.



**Fig. 7. Water use for blueberries, 2016 – 2021.**



**Fig. 8. Water use for raspberries, 2016 – 2021.**

<sup>20</sup> <http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?wa1484>

<sup>21</sup> U.S. Dept. of agriculture, Natural Resources Conservation Service, National Engineering Handbook, Sept. 1993, chapter 2 Table 2-43, p 2-148: <ftp://ftp.wcc.nrcs.usda.gov/wntsc/waterMgt/irrigation/NEH15/ch2.pdf>

Figs. 7-11 show monthly water use for the five major Whatcom crops for the six years covered here. Table 2 summarizes average annual water use intensity for each crop, ranging from 1.2 to 1.7 acre-feet/acre.

