UNPERMITTED IRRIGATION WATER USE IN WHATCOM COUNTY

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INTRODUCTION

With rare exceptions, everyone in Washington must have a water right before taking water from streams, rivers, and lakes or from groundwater wells. However, some farmers in Whatcom County are using water without state authorization; estimates of unpermitted agricultural water use include "up to 70%", "30 to 60%", and "20 to 30%".[2] The degree of noncompliance with state law likely varies greatly, with some water uses differing from their rights only in the locations of withdrawal/diversion or application, but some water uses lack any right at all. As a report for the Bertrand Watershed Improvement District (WID) noted: "… there are conflicting records on the status of water rights within the WID. Land is irrigated under a mosaic of permits, certificates, claims, and non-permitted use."[3]

The purposes of this project are to (1) develop a methodology to identify the extent and locations of unpermitted water use in the Whatcom County agricultural sector, (2) roughly quantify permitted and unpermitted water use, and (3) suggest policies to bring farmers into compliance with state water law.

We used data on water rights and land-use patterns along with GIS (Geographical Information Systems) software to identify the locations and extent of lands that *might* be using water without the right to do so. Because of limitations and deficiencies in the various datasets (discussed below and in the Appendix), it is not possible to make definitive statements about who is and is not using water legally. Indeed, there are three sets of errors that complicate interpretation of the results presented here:

- Errors in the data themselves. In particular, the Washington State Department of Ecology (Ecology) database contains many errors and omissions, which are difficult for a nonexpert to identify and correct.[4]

[1] Rio Digby, Daniel Ashley, and Benjamin Larson conducted the technical GIS work reported here. They are all former undergraduates with Western Washington University. I especially thank Ben Larson for his thorough review of a draft of this paper. Thanks also to Doug Allen, Henry Bierlink, Jim Bucknell, Hart Hodges, Hank Kastner, and an anonymous reviewer for their very helpful comments on a draft of this paper.
[2] These informal estimates are from personnel with Whatcom Farm Friends, the Dept. of Ecology, and Nooksack Indian Tribe; none is documented.
[3] Economic and Engineering Services, Inc., *Final Report for Bertrand Watershed Improvement District Comprehensive Irrigation District Management Plan*, Nov. 2004.
[4] RH2 Engineering, *Quantification of Agricultural Water Use and Water Rights*, prepared for Whatcom County PUD#1, Dec. 2016; E. Hirst, *Whatcom Water Rights and Applications: Insights from Ecology's Data*, Feb. 2016; A. Atkeson and P. Gill, *WRIA 1 Water Rights Summary By Delineated Area, Water Rights Review Stage I Report Final Version*, Whatcom County PUD #1, Feb. 2001.

- The three WWU students who conducted the GIS analyses presented here know a lot about GIS software but little about Whatcom County water issues or agriculture. Therefore, they lacked the ability to assess the reasonableness of their decisions, assumptions and results.
- I know something about local water issues, but nothing about GIS. Therefore, I lacked the ability to assess (or in some cases understand) the validity of the students' decisions.

Given these caveats, does it makes sense to read the rest of this paper? I think it does because unpermitted water use is a major issue in Whatcom County, and addressing and resolving this issue is feasible. More than one-third of irrigated crop acreage is using water without authorization from Ecology, accounting for over 40% of the total water used for agricultural irrigation. And the six WIDs are ideally suited to address and resolve this issue.

BACKGROUND

The issue of unpermitted water use may have no villains. The farmers using water without authorization have been trying to get permits for 30 years. Ecology notes that water in the Nooksack River basin is over appropriated, so that state law does not allow the department to issue new water rights. And the state legislature has been unwilling or unable to deal with the issue.[5]

Unfortunately, the current situation, while understandable, creates serious environmental and legal problems. Summer flows in the Nooksack River and many of its tributaries are below the requirements set by Ecology:[6] "From 1986 to 2009, flows in the Nooksack River failed to meet instream flow-rule requirements 72% of the time during the July-September flow period,"[7] [8] which limits Ecology's ability to issue water rights. "Most water in the Nooksack watershed is already legally spoken for. Increasing demands for water from ongoing population growth, diminishing surface water supplies, declining groundwater levels in some areas during peak use periods, and the impacts of climate change limit Ecology's ability to issue new water rights in this watershed."[9] In part because of these low flows, the numbers of salmon and steelhead in our

[5] Long before the mid-1980s, the state paid little attention to groundwater use in Whatcom County because of its perceived abundance. Obtaining groundwater rights in the 1950s and 1960s was largely a formality that well drillers provided for farmers. Some drillers completed these applications but many did not, leading to a checkerboard of water rights coverage. When the local Native American tribes sought to quantify their water rights in the early 1990s, farmers became aware of their lack of water rights and flooded Ecology with more than 400 applications. By then, Ecology better understood hydraulic continuity (the connections between groundwater and surface water) and was therefore unable to approve most of these applications. Thus many farms that have been irrigated for decades lack formal water rights. (H Bierlink, Administrator, Ag Water Board, personal communication, Aug. 2017),

[6] Ecology, *Instream Resource Protection Program—Nooksack Water Resource Inventory Area (WRIA) 1*, Chapter 173-501 WAC, June 9, 1988.

[7] Northwest Indian Fisheries Commission, *2012 State of our Watersheds*, p. 73, August 2012.

[8] Low flows affect the mechanical, thermal, and chemical environment in which fish swim, i.e., slower currents, warmer temperatures, less dissolved oxygen, and higher concentrations of pollutants.

[9] Ecology, *Focus on Water Availability: Nooksack Watershed WRIA 1*, August 2012.

waters are very low relative to historical levels, leading to their listing as threatened under the federal Endangered Species Act.

The Lummi Nation and Nooksack Indian Tribe have treaty rights dating to 1855 and perhaps to "time immemorial" that guarantee them the right to harvest salmon. These treaty rights are meaningless unless salmon populations can support a harvestable surplus of salmon. And these rights are not yet quantified.

Because agriculture accounts for 68% of Whatcom County summer use (July, August, and September), bringing farmers into compliance with water law is important.[10] That is, increasing summertime instream flows in the tributaries and mainstem of the Nooksack River may require less human use of water during that period.[11]

DATA SOURCES

The data used for this project include:

- Water rights from Ecology, its Geographic Water Rights Information System (GWIS).[12] These data were used to determine the spatial distribution (locations and acreage) of water rights for agricultural irrigation in Whatcom County.
- Crop distribution data for 2014 from the Washington State Dept. of Agriculture (WSDA).[13] These data were used to determine the spatial distribution of crops and the use and types of irrigation equipment in Whatcom County.
- Shapefile[14] for Washington and Whatcom County. All datasets were projected into NAD 1983,[15] NSRS 2007[16] State Plane Washington North FIPS 4601 (US Foot) to ensure spatial accuracy.

Table 1. Irrigated cropland (acres) by crop

Crop	Acres irrigated		Acres without Water Right	% Acres without Water Right
	Total	Allowed		
Blueberry	5,600	3,600	2,000	36%
Raspberry	10,700	6,600	4,100	38%
Corn, Field	15,000	9,200	5,800	39%
Grass Hay	17,500	11,200	6,300	36%
Potato	700	300	400	57%
Totals	49,500	30,900	18,600	38%

[10] E. Hirst, *Analysis of Whatcom County Water Use*, Jan. 2017.
[11] Very little irrigation occurs in the watersheds of the three forks of the Nooksack River.
[12] http://www.ecy.wa.gov/services/gis/data/data.htm
[13] http://agr.wa.gov/pestfert/natresources/aglanduse.aspx
[14] Shapefile is a geospatial vector data format (location, shape, and attributes of geographic features) used for GIS software.
[15] NAD 1983: North American Datum of 1983
[16] NSRS 2007: National readjustment of the North American Datum (1983) which was conducted in 2007 to increase accuracy.

RESULTS

Whatcom County has 49,500 acres of irrigated cropland. Of this area, as much as 18,600 acres (38%) might lack a water right (Table 1).[17] Grass/hay and corn account for the most unpermitted acreage, almost two-thirds of the total.

Table 2. Irrigated cropland by crop and water use

Crop	Water use, acre-feet			% Water Use without Water Right
	Actual	Unpermitted	Permitted	
Blueberry	9,100	4,500	4,600	49%
Raspberry	17,700	8,300	9,400	47%
Corn, Field	13,300	5,300	8,000	40%
Grass Hay	27,700	11,600	16,100	42%
Potato	700	400	300	57%
Totals	68,600	30,200	38,400	44%

Irrigation water use totals 68,600 acre-feet (af), which suggests a usage of about 1.4 af/acre (Table 2). Of this water use, 44% lacks a water right. Grass/hay and raspberries dominate unpermitted water use, accounting for two-thirds of the total.

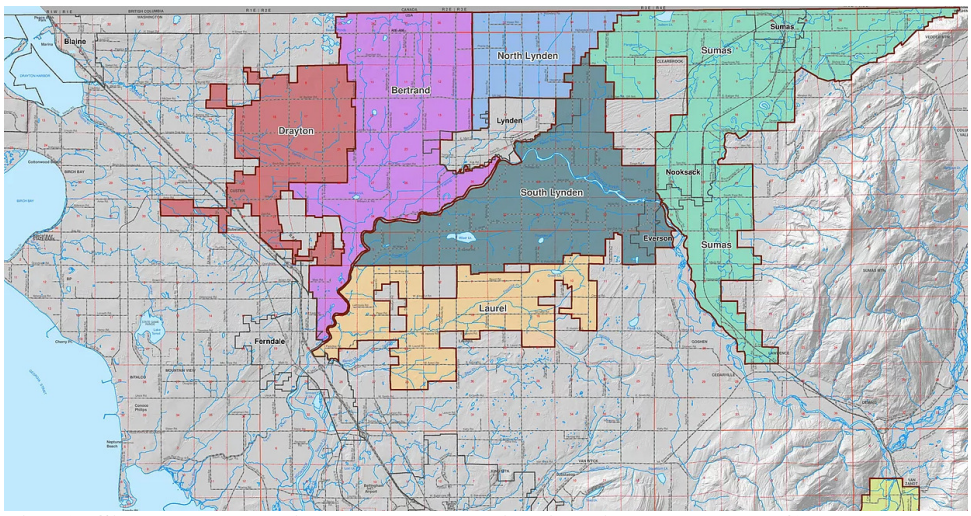

Fig. 1. Six watershed improvement districts in Whatcom County.

Another way to look at water use is by WID (Fig. 1). The six WIDs account for more than 90% of the irrigated acreage and unpermitted water use in Whatcom County (Tables 3 and 4). By far, the Sumas WID has the greatest acreage irrigated without a water right (6,600 acres), and the Drayton WID has the highest percentage of land irrigated without a right (50%).

Table 3. Irrigated cropland by WID

WID	Acres irrigated		Acres without Water Right	% Acres without Water Right
	Total	Allowed		
Bertrand	10,900	7,600	3,300	30%
Drayton	3,400	1,700	1,700	50%
Laurel	3,800	2,800	1,000	26%
North Lynden	5,900	3,600	2,300	39%
South Lynden	7,900	5,400	2,500	32%
Sumas	14,300	7,700	6,600	46%
Outside WID	3,300	2,000	1,300	39%
Totals	49,500	30,900	18,600	38%

[17] As explained in the Appendix, this analysis does not include many Claims that did not show any value for allowed annual water use. Therefore, the numbers presented here might be too high.

With respect to water use, the Sumas WID contains the largest amount of unpermitted water use, followed by Bertrand (Table 4). The Drayton and Sumas WIDs contain the highest percentages of unpermitted water use, 55 and 51%, respectively.

Table 4. Irrigated cropland by WID and water use

	Water use, acre-feet			% Water Use without Water Right
	Actual	Unpermitted	Permitted	
Bertrand	16,000	5,900	10,100	37%
Drayton	5,500	3,000	2,500	55%
Laurel	5,300	1,700	3,600	32%
North Lynden	8,600	3,600	5,100	42%
South Lynden	9,500	3,600	5,900	38%
Sumas	18,900	9,700	9,200	51%
Outside WID	4,900	2,600	2,200	53%
Totals	68,600	30,200	38,400	44%

The Appendix provides additional detail on acreage and water use, both authorized and unauthorized, for each of 20 watersheds in Whatcom County.

POLICY IMPLICATIONS

Assuming these results are roughly correct, what can be done to correct the situation? Fortunately, the data suggest a solution that is – at least conceptually – straightforward. The solution is to focus on the WIDs and allow/encourage each WID to solve its water-rights problems in whatever fashion works best for that WID.

Permitting the WIDs to identify, develop, negotiate, and implement solutions would require approval, and possibly financial assistance, from Ecology. Because state water law might not allow such a comprehensive approach to dealing with this problem, the state legislature might need to provide Whatcom County with a temporary (say five to ten years) exemption from certain aspects of water law.

Table 5. "Surplus" water rights by WID

	Acre-feet allowed	"Surplus" Water Rights
Bertrand	28,700	12,700
Drayton	5,800	300
Laurel	9,400	4,100
North Lynden	12,600	4,000
South Lynden	19,600	10,100
Sumas	25,500	6,600
Outside WID	7,800	2,900
Totals	109,500	40,900

Each WID would follow a two-step process:

- Identify the locations and amounts of water used for irrigation, both with and without water rights;
- Establish a local water market to facilitate the sale/lease of surplus water rights to those that lack water rights.[18]

[18] The Snoqualmie Valley WID, in King County, provides a useful existence proof for WID-run water markets. In its initial market, the WID facilitated 45 af of 1-year leases at a market price of $125/af. It is planning for a larger market with some long-term leases for 2018 (C. Krass, Executive Director, Snoqualmie WID, personal communication, Sept. 2017).

Why focus on WIDs? The six WIDs are government entities with the power to tax. More relevant to this discussion, the magnitude of water rights in all six WIDs is more than enough to cover all the existing permitted *and* unpermitted irrigation water use (Table 5 and Fig. 2). "Surplus" water rights are those in excess of what is actually used (both permitted and unpermitted) in the particular area, e.g., WID or watershed.[19]

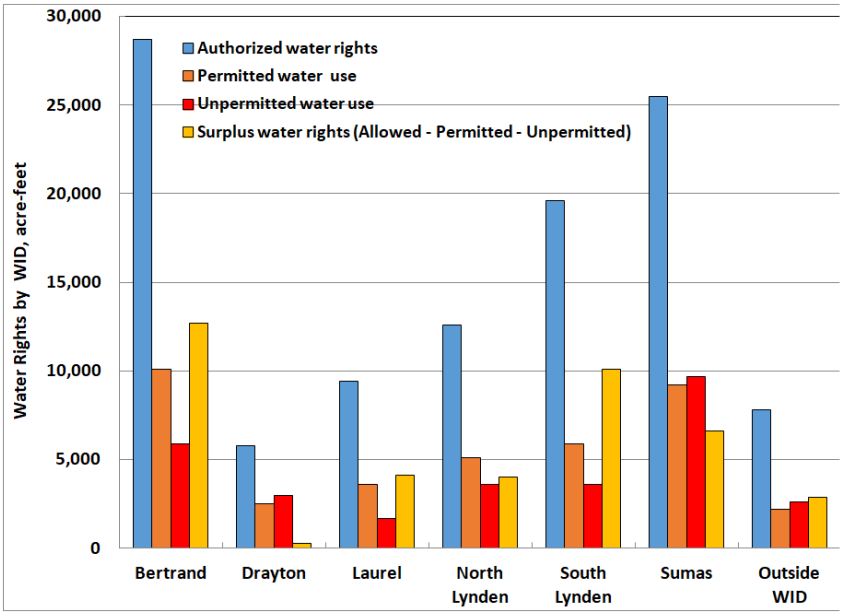

Fig. 2. Authorized, permitted, unpermitted, and surplus water rights and use by WID.

Perhaps most important, the WIDs were created by farmers and are run by and for farmers. Thus, farmers, both those with and without water rights, are likely to trust *their* WID and be willing to work with the WID to accurately determine where and how much water rights exist and to identify irrigated acreage that lacks a water right.[20] These WID-specific data and calculations would replace the estimates provided here and produce a much more detailed and accurate picture of water use and water rights.

Consider Bertrand, the oldest WID. About 30% of its nearly 11,000 acres of irrigated land lacks a water right. And just over one-third of its water use lacks a water right. But Bertrand farmers, in aggregate, hold rights to almost 29,000 af, far more than the 16,000 af actually used. Thus, farmers holding more rights than they use could sell or lease these rights to those farmers who lack sufficient or any water rights. If enough deals were made to cover all irrigation water use in this WID, the farmers would still have almost 13,000 af of "extra" water rights.

If this solution is so straightforward, why hasn't it been implemented already? The answer, I believe, is because state water law is so complicated and, in some cases, counterproductive. For

[19] Several measures of irrigation water use (acre-feet, af) are used here: Used – amount of water actually used to irrigate the crop, based on the RH2 method; Permitted – portion of amount used that is authorized by Ecology; Unpermitted – portion of amount used that is not authorized by Ecology; Allowed – total of water right claims, permits and certificates for agricultural irrigation; Surplus – Allowed water rights – Used water.

[20] Ecology might need to allow each WID to guarantee confidentiality of farmer-specific data to ensure widespread cooperation. At the end of the process, the WID would report to Ecology all the details, but the public might have access only to aggregate results under this approach.

example, relinquishment (the use-it-or-lose-it requirement) prevents farmers from admitting that they might not be using all the water to which they are entitled.[21] If a farmer with enough rights to cover his/her irrigation use improves efficiency of irrigation scheduling, is more conscientious about maintaining and repairing irrigation equipment, and/or installs more efficient equipment, then water use will drop. Under current state law, Ecology is obligated to take away that unused water right, a serious obstacle to both efficiency improvements and water markets.

Each water right is specific about the point of diversion/withdrawal, point of use, and purpose (e.g., domestic, industrial, or irrigation). A farmer wanting to "spread" an existing water right over more acreage (e.g., made possible by the kinds of efficiency improvements noted above) is required to file a change application with Ecology, which could be a lengthy, complicated, uncertain, and expensive process.[22]

In addition to the complications and obstacles associated with state law, resolving this issue of unpermitted water use would require negotiations and compromise with other interests, especially the Lummi Nation and Nooksack Indian Tribe. While I can't speak for either tribe, my guess is that they would accept the kind of solution proposed here only if the end result included more water left in the tributaries and mainstem Nooksack River. A final deal might, as an example, require that a certain percentage (10%?, 25%?) of the water rights transferred to farmers who now lack these rights be used to increase instream flows.[23]

If Ecology, either under its own rules or with permission from the legislature, allows the Whatcom County WIDs to explore, develop and implement WID-wide solutions, this problem of unpermitted water use could be resolved.

Finally, note that the WID boundaries do not correspond exactly with watershed boundaries (Table A-4). At one end of the spectrum, 96% of the acreage within the North Lynden WID is within the Fishtrap watershed (and 78% of the Fishtrap drainage is within this WID), 81% of the Drayton WID is within the Dakota Creek watershed (and 93% of the Dakota drainage is within this WID), 72% of the Bertrand WID is within the Bertrand Creek watershed (and 98% of the Bertrand drainage is within this WID), and 71% of the Laurel WID is within the Barrett Lake watershed (and 74% of this watershed is within this WID). At the other end of the spectrum, The South Lynden and Sumas WIDs are spread across several watersheds, complicating creation of water markets within these areas.

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[21] Ecology, *Focus on Water Right Relinquishment*, 98-1812-WR, January 2013.

[22] One local firm completed 69 change applications in Whatcom County during the past six years. Each application took about six months to complete and the average cost was about $5,000 per application. (J. Bucknell, RH2 Engineering, personal communication, Sept. 2017).

[23] Options to increase instream flows include, as examples, increased efficiency, streamflow augmentation, and transfer of water rights from surface to ground water.

CONCLUSIONS

The data and analysis presented here show that lots of water is being used in Whatcom County without authorization from Ecology. This unpermitted water use has two serious consequences:

- Environmental – Unauthorized water use, whether taken from surface waters or groundwater wells, reduces instream flows, which hurts fish and other wildlife as well as recreational and scenic values.
- Legal– Unauthorized water use takes water from senior water rights holders, including instream flows. Especially during dry years, this could be a serious problem. In addition, widespread knowledge that state law has been violated for three decades likely undermines our respect for the rule of law.

To date, Ecology's response to this situation has been ad hoc. It occasionally fines farmers who egregiously use water without authorization. For example, Ecology fined a berry grower $102,000 in 2016 after five years of noncompliance.[24] Ecology occasionally grants interruptible water rights to some farmers, but limits on Ecology staff and budgets makes it challenging for Ecology to properly monitor compliance with the limits on these rights. The Lummi Nation periodically complains to Ecology about unauthorized water use, but receives little in the way of a substantive response to these concerns. For example, one letter stated:[25]

> "Illegal water diversions from the Nooksack River and its tributaries have been occurring far too long, to the detriment of salmon and the Lummi Nation's treaty rights to harvest. We expect that Ecology will enforce existing state laws and issue both cease and desist orders and appropriate monetary penalties when it is determined that individuals are diverting water without a legal right to do so. Ecology should not allow individuals and businesses to illegally divert a public resource for profit at the expense of others and the natural environment that depend on the same resource. Please keep us informed of Ecology actions that are taken in response to this complaint."

These factors all point to the need – and opportunity – for a comprehensive, systemwide solution that addresses farmer need for certainty over the right to use water for irrigation (especially important in light of the effects of a growing population and climate change). The solutions proposed here are possibilities, but not the only ones. Others should offer alternative ways to address the problems raised here. And the limitations in the data and present analysis suggest the need for experts to repeat and refine the current analysis, e.g., Ecology, Lummi Nation, and/or consultants hired by the WIDs.

[24] K. Johnson-Waggoner, "Ecology News: Berry grower fined for illegal water use in Whatcom County," Dec. 27, 2016.
[25] M. Jefferson, Lummi Nation Natural Resources Dept., letter to M. Bellon, director of Ecology, July14, 2015.

APPENDIX: LIMITATIONS AND ADDITIONAL DETAILS

LIMITATIONS

As noted in the Introduction, this analysis suffers from several defects, some known and others unknown. As a starting point, consider the estimates of irrigated acres by crop.

We used the WSDA crop distribution dataset to isolate crops in Whatcom County with some form of irrigation. The WSDA data, which includes a township, range, and section identifier for each parcel, shows the distribution of crops in Whatcom County, classifying them by crop type, crop group, irrigation method, and acres irrigated. This was then processed further to remove features which were identified as using no irrigation or if irrigation was unknown for the crop. In addition, several crop types that were not applicable to this study were removed.[26] The final result was a dataset which identified the spatial distribution of crops in Whatcom County, classifying their respective crop type, acreage, and irrigation method. Each polygon in the WSDA dataset may represent a single farm or a portion of a farm. If a farmer grew different crops (e.g. raspberries and blueberries), each area with a distinct crop would have its own parcel.

Table A-1 compares the present analysis with the RH2 Engineering results.[27] Although the estimates of blueberries and raspberries are close, the present estimates of corn and grass are much higher than those from RH2. Overall, this analysis is based on an estimated total of 49,500 irrigated acres, 22% more than the RH2 total.[28]

Table A-1. Comparison of irrigated crop acreage: this analysis and RH2 Engineering

	Irrigated Acres		
Crop	Hirst	RH2	Hirst/RH2
Blueberry	5,600	5,400	104%
Caneberry	10,700	9,600	111%
Corn, Field	15,000	11,600	129%
Grass Hay	17,500	12,400	141%
Potato	700	1,600	44%
Grand Total	49,500	40,600	122%

The next step was to determine the spatial distribution of water rights within Whatcom County, according to Ecology, to identify irrigated acreage with and without a water right. Using Ecology's Water Resources Explorer (2015) identifying water rights in the Nooksack Basin, records representing water rights applicable to irrigation were aligned, with each record's document number, water right, allowed instantaneous flowrate, and allowed annual usage. That table was joined to the GWIS dataset based on water right document numbers and the resulting dataset was clipped to the extent of Whatcom County (with tribal lands erased, as with the crop distribution dataset).

[26] We excluded from our analysis land in the WSDA database used to grow Christmas trees, in the Conservation Reserve Program, developed land, golf courses, nurseries, poplar farms, and those with an unknown crop.
[27] RH2 Engineering, *Quantification of Agricultural Water Use and Water Rights*, prepared for Whatcom County PUD#1, Dec. 2016.
[28] Ecology estimates 47,300 acres, based on 2016 data from WSDA (Ecology, *Draft Washington State Drought Contingency Plan*, July 24, 2017).

As noted by RH2 Engineering, "There is a considerable amount of missing attribute data within the [Ecology Water Rights] database, especially for long-form claims. … not all the water rights mapped by Ecology are likely to be valid, either partially or in their entirety." The present database confirms these observations. About 5,100 acres of irrigated cropland had a water right of zero acre-feet, although the right might have allowed an instantaneous use (gallons/minute, gpm). An additional 17,500 acres had a water right with no value at all for acre-feet. It was unclear how to treat these 22,600 acres, 46% of the total. I assumed the existence of a valid water right if *either* the record showed a positive acre-feet value or a positive gpm value.[29]

At the other end of the spectrum, some of the parcels in the Ecology database had values of allowed acre-feet that were unreasonably large. Specifically, the top 22 parcels in the database account for 508,321 of Ecology allowed af. A simple approach, the one I chose, is to limit the allowed af to 5 times the actual water use; the result of this assumption is a total of 110,900 af, 60% more than estimated actual water use. I selected the value 5 because the resulting total closely matched that from the RH2 analysis (112,600 af). Double-counting is also a problem with the water-rights database, because some farmers filed multiple claims and applications for the same water, and Ecology may not have eliminated these duplications.

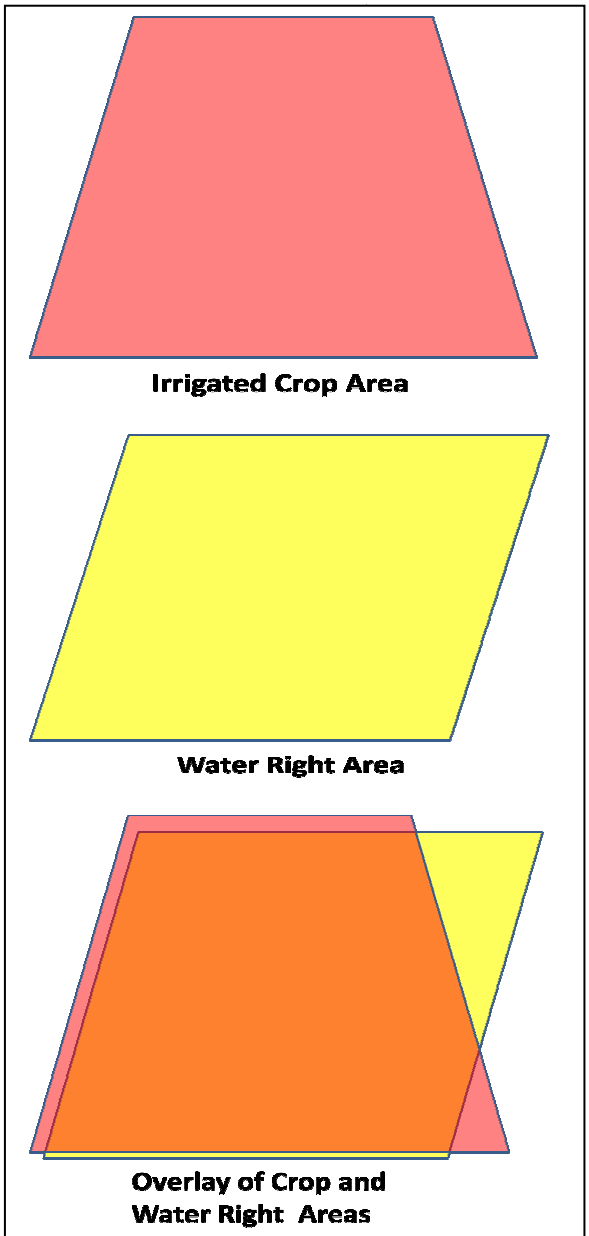

Fig. A-1. Schematic illustration of the non-convergence of WSDA and Ecology polygons.

Another problem is imperfect spatial correlation between the WSDA and Ecology parcel polygons. This lack of congruence required assumptions about the areas of no overlap. For example, if the WSDA and Ecology overlap was 90% of the area, should we assume that the

[29] These decisions may have excluded Claims, which often lack an annual allotment, maximum flowrate, or both.

entire parcel has a water right? Or should we take the results literally to imply that 10% of the area is being irrigated without a water right? Ultimately, we chose 75% as the cutoff point, meaning that the Ecology water right was assigned to the WSDA irrigated acreage only if the overlap was 75% or more.

Figure A-1 illustrates schematically how this process aligned irrigated crops with associated water rights. The top panel shows in pink a parcel that is irrigated. The middle panel shows in yellow, for the same general area, a water right. The two areas do not line up perfectly with each other. By conducting a union and matching polygons that have both crop and water right data, we can identify crops that are irrigated with a right to do so. The orange area in the bottom panel is irrigated *and* has a water right. The small pink areas are irrigated but lack a water right. Depending on how these polygons are matched, the overall estimate of unpermitted water use could be too high or too low. The WWU students used areal interpolation and other methods to quantify the magnitude of this problem and reduce its impact on the results; but I cannot explain how their assumptions affect these results.[30]

Table A-2. Irrigated cropland by watershed

	Acres irrigated			
	Total	Allowed	Acres without Water Right	% Acres without Water Right
Coastal North	**3,900**	**2,100**	**1,800**	**47%**
California	900	600	300	34%
Dakota	3,000	1,500	1,500	51%
Coastal West	**200**	**100**	**100**	**36%**
Jordan	100	100	-	21%
Lummi Peninsula West	100	-	-	34%
Schell	-	-	-	100%
Lower Nooksack	**30,600**	**20,800**	**9,800**	**32%**
Anderson	200	100	-	29%
Barrett Lake	3,600	2,500	1,100	30%
Bertrand	8,000	5,700	2,300	28%
Fishtrap	7,300	4,500	2,800	38%
Kamm	2,900	1,900	1,000	34%
Nooksack Deming to Everson	700	300	300	51%
Schneider	2,100	1,300	700	35%
Scott	2,600	1,700	900	35%
Silver	300	300	-	10%
Smith	100	-	-	34%
Wiser Lake/Cougar Creek	3,000	2,400	600	20%
Sumas	**14,800**	**7,800**	**7,000**	**47%**
Breckenridge	4,300	2,400	1,900	44%
Dale	1,800	900	900	50%
Johnson	6,200	3,200	3,100	49%
Saar	2,400	1,300	1,100	45%
Grand Total	**49,500**	**30,900**	**18,600**	**38%**

[30] The area of each crop polygon was calculated before the union with the Water Right dataset. The area of each polygon was calculated again after the use of the union tool in ArcMap. A new field was then created which was a ratio for each polygon based on its new area calculation and original area calculation. If a water right covered 100% of a crop polygon, then the ratio would equal one. If only one percent of a crop polygon was covered, then then the ratio would equal .01 or 1%. Polygons with less than less than 75% of their area covered by a water right were counted as not having a water right.

ADDITIONAL DETAILS

Tables A-2 and A-3 show the same data presented above, this time for 20 detailed watersheds, both within the Nooksack River basin and outside the basin. The Johnson, Fishtrap, and Bertrand drainages each account for more than 10% of the total acreage irrigated without a right. The same three watersheds each account for more than 10% of the total water used without a right.

Table A-3. Irrigated cropland by watershed and water use

	Water use, acre-feet			
	Actual	Unpermitted	Permitted	% Water Use without Water Right
Coastal North	**6,300**	**3,600**	**2,700**	**57%**
California	1,500	800	700	56%
Dakota	4,800	2,800	2,100	57%
Coastal West	**200**	**100**	**100**	**29%**
Jordan	100	-	100	17%
Lummi Peninsula West	-	-	-	
Schell	-	-	-	
Lower Nooksack	**42,800**	**16,500**	**26,300**	**39%**
Anderson	300	100	200	32%
Barrett Lake	5,000	2,100	2,800	43%
Bertrand	11,700	4,300	7,400	36%
Fishtrap	10,700	4,400	6,300	41%
Kamm	3,500	1,300	2,100	39%
Nooksack Deming to Everson	1,100	700	400	61%
Schneider	2,900	1,000	1,800	36%
Scott	3,100	1,200	1,900	40%
Silver	400	100	300	18%
Smith	100	-	100	45%
Wiser Lake/Cougar Creek	4,100	1,200	2,900	29%
Sumas	**19,300**	**10,000**	**9,200**	**52%**
Breckenridge	5,300	2,400	2,900	45%
Dale	2,600	1,500	1,100	59%
Johnson	8,200	4,400	3,700	54%
Saar	3,200	1,700	1,600	51%
Grand Total	**68,600**	**30,200**	**38,400**	**44%**

Finally, Table A-4 shows the contribution of irrigated land from each watershed to each WID. For example, parts of four watersheds comprise the Bertrand WID, dominated by Bertrand Creek (72% of the WID's irrigated acres). By contrast, the South Lynden and Sumas WIDs are each made up of parts of seven watersheds.

Table A-4. Irrigated acres within each WID by watersheds

	Acres	% of Acres by watershed
Bertrand WID	**10,910**	
Bertrand	7,840	72%
Dakota	60	1%
Fishtrap	1,150	11%
Schneider	1,860	17%
Drayton WID	**3,430**	
Bertrand	50	1%
California	450	13%
Dakota	2,770	81%
Schneider	160	5%
Laurel WID	**3,750**	
Barrett Lake	2,670	71%
Silver	40	1%
Wiser Lake/Cougar Creek	1,050	28%
North Lynden WID	**5,870**	
Fishtrap	5,640	96%
Johnson	70	1%
Kamm	160	3%
South Lynden WID	**7,920**	
Barrett Lake	350	4%
Fishtrap	40	0%
Johnson	350	4%
Kamm	2,720	34%
Nooksack Deming to Everson	110	1%
Scott	2,570	32%
Wiser Lake/Cougar Creek	1,780	22%
Sumas WID	**14,300**	
Breckenridge	3,890	27%
Dale	1,520	11%
Fishtrap	360	3%
Johnson	5,530	39%
Nooksack Deming to Everson	510	4%
Saar	2,440	17%
Smith	60	0%