Water Marketing: Literature Review

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ABOUT THE AUTHORS

This report was produced in consultation with Kittitas Reclamation District and Trout Unlimited by four recent graduates of the Master of Public Administration program at the Evans School of Public Policy and Governance at the University of Washington. The authorship team previously collaborated as consultants to the Washington State Department of Ecology to produce a case study report on water marketing policies and programs in the western United States in fulfillment of their MPA capstone requirement. Their diverse professional histories combine experience in research, project management, communications, business development, and engineering.

All usage of “we” or “our” throughout this report refers to the authors.

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EXECUTIVE SUMMARY

This report, commissioned by Kittitas Reclamation District (KRD) and Trout Unlimited (TU), summarizes findings from a review of water marketing and water banking literature in the western United States and relevant international contexts. The purpose of this report is to improve knowledge and data available to guide the formulation of market strategy in the Yakima River Basin. The findings presented in this report support that goal by reviewing water market performance and strategy within the identified literature. Our literature sample was generated through database searches of academic publications and grey literature supplemented by key Yakima-specific documents. Over 300 documents were identified for consideration in the search process, of which we selected a final sample of 89 documents that were most relevant for review in this project.

The findings of this report are organized around the following thematic elements we identified in the literature sample:

- **Transaction Costs**: Structural barriers to market entry and low-cost bargaining that inhibit market activity
- **Externalities**: Secondary effects of trading on communities and environmental goods that result from water trading
- **Valuation and Economic Welfare**: Assessment of the economic value of water goods and potential gains from trade
- **Public Perception of Water Markets**: Acceptability of market institutions as a demand management tool to stakeholder groups
- **Suggestions Provided by the Literature for Improving Water Markets:** Summarizes recommendations explicitly provided by the literature to improve water market performance and address common issues
- **Findings in Washington State Literature:** Summarizes findings in literature provided by Trout Unlimited specific to Washington State and the Yakima River Basin in order to provide insights pertinent to the Yakima Basin Integrated Plan

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1. PROJECT CONTEXT

This report was commissioned by the Kittitas Reclamation District ("KRD") in partnership with Trout Unlimited ("TU") as a component of a larger water market strategy research and development effort for a potential "smart" water market strategy in the Yakima River Basin. This report was made possible by the Washington Department of Ecology ("Ecology") through a grant, Agreement No. WRYBIP-2019-KittRD-00005.

Both KRD and TU are participants in the Yakima River Basin Integrated Water Resource Management Plan ("the Plan" or "YBIP") to provide guidance for the project's ongoing priority of facilitating efficient and equitable reallocation of water resources through market mechanisms. Market reallocation of water is one of seven elements identified in the Plan to address Yakima Basin water supply in conjunction with water quality to improve water resources for human consumption, economic productivity, and environmental values within the watershed.

This report reviews recent literature on water markets and water allocation models and provides lessons learned to inform a potential Yakima-specific smart market strategy and structure. Information on successes and failures of various water market methods will assist the Yakima Basin Integrated Plan Workgroup, Executive Committee, and relevant subcommittees in assessing appropriate strategies that may be successfully applied in the Yakima Basin.

2. RESEARCH METHODOLOGY

This report examines contemporary academic journal articles and grey literature evaluating the economic, legal, and policy considerations of formal water markets or water banking in the western United States and relevant international contexts. It includes a thorough review of literature with a focus on Washington State and the Yakima Basin from the last 20 years.

Our research targeted references to either water banks and/or water banking, water markets and/or water marketing, water transfers, water reallocation, or water right exchanges (see Appendix A for a search string listing). We performed our literature search in six databases—Scopus, Hein, Proquest Dissertation, Proquest Agriculture and Environmental Sciences Database, Google, and Google Scholar—to identify relevant articles in legal and academic journals in addition to government and non-governmental reports. We limited our search to reports published after 2008 to focus our review recent findings and recommendations.

We augmented our review of water marketing specific to Washington and Oregon by expanding the qualifying time frame to documents published after 1998 for documents that explicitly mentioned these states. TU and KRD provided additional literature specific to the Yakima Basin that were not produced in our search to be included in our review (these documents are specifically discussed in Chapter 4).

The initial literature search produced 446 documents that met the search criteria, including 44 documents from the expanded search of literature specific to Oregon and Washington. To reduce the amount of literature to consider, we narrowed our search with two rounds of screening. First, we refined the scope to literature focused primarily on Australia, Canada, Chile, and the western United States—areas with legal division of land and water rights and literature on public perception of water markets. This round of screening removed 146 documents from consideration.

The second round of screening was to identify articles that were deemed most relevant to the consideration of the Yakima River Basin Integrated Water Resource Management Plan. Relevance was determined by: 1) discussion of formal water trading, 2) analysis or assessment of performance of instituted water markets, and/or 3) a consideration of the impacts of a government entity's involvement, as a water market user or regulator. This round of screening removed articles that focused on abstract economic theory or hypothetical water markets, only discussed riparian water rights, or evaluated indigenous water rights absent of adjudicated markets. Of the 300 documents initially considered, we identified 89 as the most relevant to include in our in-depth review.

Key Descriptive Characteristics of Literature Reviewed

Our review included 89 articles and of these: 65 mention temporary transfers (73%) of varying length; 37 articles (43%) discuss federal involvement of some kind in water markets; and 38 (43%) mention some other government entity's involvement. Sixty-one percent (61%; 54 documents) mention environmental uses of water, and fifty-two percent (52%; 46 documents) touch upon drought or other climatic variability in the context of water marketing.

3. FINDINGS

Findings from the literature highlight common issues that hinder the administration of water markets, as well as proposed or implemented solutions. This chapter presents our findings in the following sections:

- **Section 3.1** begins with a discussion of transaction costs associated with water markets.
- **Section 3.2** identifies commonalities in environmental, economic, and social externalities.
- **Section 3.3** highlights considerations for valuing water rights and opportunities for improving economic welfare from water trading.
- **Section 3.4** examines studies that assess public perceptions of water markets and case studies of political conflict or opposition.
- **Section 3.5** discusses suggestions from the literature for improving water markets. Solutions presented in the literature generally address transaction costs and externalities identified in sections 3.1 and 3.2 as well as education and governance strategies to address public perception and acceptance of water markets. These recommendations reflect the content of reviewed documents, *not* the views or suggestions of the authors of this report.

3.1 TRANSACTION COSTS

Water markets, like those for any good or service, function best when the friction of trade is minimized. In economic theory, a market system will generate the optimal allocation of a good without regulation if the bargaining process does not significantly distort the market process (Coase, 1960). If the initial endowment of a good is less than perfectly efficient (that is, some amount of the good is consumed by users who value it less than users without endowments), users who value the good less will realize economic gains by selling (or leasing) some or all of their endowment to users who value it more. As a result of this bargaining process, consumption of the good is shifted to more efficient uses without incurring penalties to the original consumers. If the basic conditions of low-cost bargaining are met (i.e. minimal transaction costs), the efficient allocation of a good will be achieved through trading regardless of the initial allocation.

However, water markets struggle to provide suitable bargaining conditions to participants due to the unique nature of the specification of water as a good. As a result, water transfers incur transaction costs that constitute the necessary cost incurred during the trading to meet the legal, administrative, and hydrological requirements for amending the use requirements of water. As such, they are not representative of social value (Grafton et al., 2016) and influence the market similarly to a tax (Regnacq et al., 2016). Transaction costs therefore dampen both the willingness

and ability of potential market participants to trade and represent the most substantial barrier to the development of water markets. However, Hadjigeorgalis (2009) argues that water markets do not necessarily incur greater transaction costs than other water allocation systems due to the integration of private cost-minimizing incentives. In fact, they can significantly improve the overall efficiency of existing allocations when certain market conditions are met.

Transaction costs impede effective water marketing in three ways. First, transaction costs reduce the economic surplus of trading that does occur. Second, the costs discourage entry of new market participants. Finally, the costs encourage water users to engage in unregulated informal transfer arrangements with potentially significant third-party impacts or environmental externalities (Thampapillai, 2009). The following subsections will discuss the three major categories of transaction costs identified in the literature: limited market information, risk and uncertainty, and administrative costs. Taken collectively, these costs provide insight into the relative transferability of water rights and entitlements across users.

3.1.1 Limited Market Information

Market information constitutes data on market activity regarding existing market participants and transactions. For a market to function efficiently, participants must be able to easily identify potential trading partners and judge the value of their assets against prevailing price conditions. Due to the thinly-traded nature of many water markets, however, potential participants often do not have access to sufficient market information to facilitate activity. Lack of market information specifically inhibits water markets by imposing two types of barriers: search costs and lack of price signaling.

Search Costs

Search costs constitute the expense of identifying potential trading partners. Identifying suitable trading partners is often difficult and time-consuming, especially in thinly traded markets (Hadjigeorgalis, 2009; Thampapillai, 2009; Young, 2016). Records of water rights users may be difficult to locate (Borzutsky and Madden, 2013), and potential trading partners are often hesitant to share information on their existing rights for fear of regulatory scrutiny (Cook and Rabotyagov, 2014; Szeptycki et al., 2015; Kenney, 2015). Search costs also tend to increase over geographical distances, and there may be a necessary threshold population of visible trading parties within a locality for a market to be viable (Regnacq et al., 2016). Search costs are also incurred by trading participants due to difficulty finding qualified consulting services to support transfer applications (Purkey and Landry, 2001) and assist navigating trading rules and procedures (Thampapillai, 2009).

Price Signaling

Price signaling occurs when potential market participants gain visibility of past transactions, allowing them to formulate a willingness-to-trade schema on the basis of their own value product

and the potential fairness of a transfer. Price signaling is important because it guides per-unit costs toward equilibrium (at least within a locality) and provides relative valuations to different types of water users across all sectors. Lack of price signaling therefore inhibits price negotiation and constitutes a type of information cost, contributing to higher transaction costs (Kenney, 2015). Price discovery is especially damaging for short-term transfer markets that are only active during drought years due to the high opportunity costs of delays (Janmaat and Rahimova, 2018; Alevy et al., 2010). Price signaling difficulties are further exacerbated in watersheds with limited measurement or adjudication (Szeptycki et al., 2015).

Market Visibility

Many information costs can be mitigated through the public provision (in a physical or online format) of market information by either the regulatory agency or a water banking institution (Jaeger and Doppelt, 2002). Effective information systems for water marketing may include some or all of the following: a geospatial database of water rights; basic locational transfer suitability guides; documentation and explanation of transfer rules and procedures; comprehensive data on historical transactions including unit price, volume, and review process duration; and a forum for interested buyers and sellers.

3.1.2 Risk and Uncertainty

Transaction costs attributable to risk and uncertainty are incurred as a result of limitations on the definition, measurement, enforcement, and protection of existing property rights (Duane and Opperman, 2010). As a result, these costs vary significantly between regions and countries due to differences in the legal administration of water.

Definition of Rights

Notably, risk and uncertainty costs of water trading are substantially higher when subject to seniority-based prior appropriation doctrine than in entitlement-based allocation systems, though costs are further stratified within prior appropriation systems by the extent and effectiveness of existing management infrastructure (see below). Entitlement-based allocation systems generally reduce the risk and uncertainty of trading for a couple of reasons: first, entitlements are derived from a well-defined supply of water; and second, the absence of a seniority system reduces the burden of fulfilling no-injury requirements. Furthermore, entitlement-based systems typically occur in systems with well-developed infrastructure and accurate consumptive use measurements, reducing the potential for adverse environmental impacts due to altered return flows (Taylor, 2016; Dilling et al., 2019; Breviglieri et al., 2018).

Measurement of Rights

Measurement costs are the result of inadequate existing assessment of the extent and availability of water rights to meet trading requirements. Upon submitting a proposed trade for

administrative review, trading participants (particularly sellers) are typically required to demonstrate both the validity of the existing water right and the availability of that existing right for transfer to the regulatory agency (Lovrich and Siemann, 2004). Trading of water rights therefore often necessitates that participants incur substantial fees for legal and hydrological consultants and requires sufficient knowledge of both fields to determine the acceptability of their assessment results for the review process (Purkey and Landry, 2001; Lovrich and Siemann, 2004).

Enforcement and Protection of Rights

Potential market participants often fear that the results of an assessment may lead to a permanent revision of the existing water right if it is found that the right has not been fully utilized under "use it or lose" rules (Cook and Rabotyagov, 2014; Szeptycki et al,, 2015; Kenney, 2015). This lack of protection is especially evident in seniority-based systems because water rights constitute a private use of a public good, not a private good in and of themselves. McCrea et al. (2007) found this fear especially evident in the Yakima River basin where the agency responsible for transfer review had also functioned as plaintiff in the adjudication of rights in the basin. As a result, potential participants may infer an adversarial relationship with the reviewing agency and opt out of trading due to the anticipation of a negative revision to their water right.

Determining the availability of a water right for transfer also requires trade participants to adequately demonstrate that the transfer will not adversely affect the accessibility of third-party senior water rights within the water system. Satisfying the requirements of such "no-injury" rules can be notoriously difficult due to the complexity of assessing altered return flows and the potential for *de minimis* impacts (Nicholas et al., 2016; Hansen et al., 2014; Squillace and McLeod, 2016). Furthermore, measurement costs can be worsened as the result of historically limited water rights enforcement, leading to expensive processing delays if subjected to third-party protest. Such conflicts not only impose an opportunity cost during the extended period of review, but also may result in costly litigation (Grafton, 2011b; Squillace and McLeod, 2016).

As implied above, a major structural factor in the extent of risk and uncertainty costs is the extent of adjudication and conjunctive management within a basin. Both management systems are obviously cost- and time-intensive, but dramatically improve the specification of rights prior to trade (Szeptycki et al., 2015). As a result, comprehensive adjudications in particular provide substantiation of water right validity and transfer suitability at the time of review, and also minimizes the cost of assessing the impacts of altered return flows on third parties (Wheeler et al., 2017).

3.1.3 Administrative Costs

Administrative costs are those incurred by the time and expense of bureaucratic review of proposed trades. These costs are incurred both as a direct expense by the regulatory agency and

as an opportunity cost to the trading parties. Direct costs to regulation of transfers may be considered transaction costs regardless of whether they are covered by fees assessed on the trading parties or imposed as taxpayer burden; in either case they constitute a social cost of the transaction itself. The extent of administrative costs is correlated to the magnitude of review requirements and therefore may be reduced in conjunction with measurement costs (Borzutsky et al, 2013; Clifford et al, 2004; Szeptycki et al, 2015).

Opportunity costs vary greatly: the value of long-term or permanent transfers are relatively insensitive to processing delays, but short-term transfers are often extremely time-sensitive for agricultural and environmental uses under drought conditions (Slaughter and Wiener, 2007; Szeptycki et al., 2015). Moreover, many regulatory agencies face substantial backlogs in their review systems, rendering time-sensitive transfers functionally impossible (Szeptycki et al., 2015). As a result, the value (and therefore activity) of these short-term transfers is strongly associated with a prompt and responsive process for review and approval.

3.2 EXTERNALITIES

Externalities are costs incurred by transactions at the societal level that are not incorporated into the value of the traded asset. Because these costs do not accrue directly to transactional entities or individual third parties, they are often difficult to measure. As a result, potential external effects are often difficult to regulate against. This section will discuss two major categories—economic and environmental—of externality identified in the literature as prevalent in water markets.

3.2.1 Secondary Economic Effects

Opposition to large-scale water reallocation has been voiced in numerous locations due to concerns about potential secondary impacts on rural economies. These cases (discussed below) primarily concern the dislocation of water usage across sufficient geographic distance that it results in a loss of productive capacity in the community of origin. Subsequent impacts are the result of costs incurred beyond the scope of the transaction itself; that is, damages beyond the scope of economic surplus gained or lost as a result of the transfer, as well as any transaction costs.

Varzi and Grigg (2019) find three types of external costs attributable to reduced agricultural productivity: 1) decreased revenue from crop sales; 2) decreased demand for agricultural support industries (e.g. seed and fertilizer); and 3) reduced demand for agricultural labor resulting in declining wages. Nicholas et al. (2016) identify decreasing appraised land values leading to a reduction in the local tax base as a further external cost.

In order to mitigate these effects on rural community, the state of Colorado has gone so far as to propose imposing a one-time fee on out-of-district transfers to compensate for potential degradation of the local economy (Kenney, 2015). Similar termination or exit fees have been integrated into inter-district entitlement trades in Australia with positive results (Waye and Son, 2010; Garrick et al., 2009). Rather than assess fees for short-term inter-district transfers, the state of Victoria has imposed limits on the volume of such transfers as well as the total volume of entitlements that may be held by out-of-district users (Grafton et al., 2009).

These negative economic impacts are predicted as a result of reduced employment in regions that are dependent on agricultural activity for economic welfare. Employment losses may occur directly (through the layoff of farm employees) or indirectly (as a result of reduced viability of agriculture-dependent industry such as process) (Jaeger, 2004). Further impacts could also be incurred in the case of transfer outside of infrastructure-based entitlement systems (such as irrigation districts) when fewer irrigators remain to support the fixed cost of transmission (Waye and Son, 2010).

Empirical assessment of impacts is limited. Gollehon (1999) estimates that net income lost to an agricultural community may be as high as 20 percent of the value of production. However, Varzi and Grigg (2019) find that external costs in the Arkansas River Basin in Colorado due to water transfers existed but were relatively minor. Jaeger (2004), modeling a potential water market in the Klamath Basin of Oregon and California, estimates the impact of a 20% reduction of agricultural water usage will result in a 10% decrease in gross income and employment given that agricultural transfers primarily target lower-value crop uses. Thampapillai (2009) and Grafton et al. (2016) similarly found that Australian entitlement transfers to environmental uses have resulted in limited secondary impacts during drought years given the existing constraints on supply, and further confirmed that transfers primarily originated from low-value crops.

Nevertheless, dry-year productivity reductions in low-value crops may still impact sector-specific dependent industries. Jaeger (2004) posits the example of a potato processing plant whose local supply drops below a threshold level for operations as agricultural water is shifted to other crops (p. 182). Despite minimal losses to total agricultural productivity in the community, the isolated impacts on potato productivity result in layoffs at the processing plant (or, in an extreme scenario, its complete closure). However, the extent and permanence of impacts due to water trading is not clear: Janmaat and Rahimova (2018) identify a functional market for option contracts as an effective tool for mitigating these costs over the short term. Moreover, short-term losses of crop-specific productivity do not necessarily result in long-term damage to dependent industries (Wheeler, 2013a).

3.2.2 Environmental Externalities

Water transactions have the potential to produce a positive externality when the diversion point is transferred downstream. When occurring on a natural body of water, such transfers can result

in a net streamflow improvement over the lineal distance between the original diversion and the new diversion (Jaeger, 2001). Furthermore, if these transfers reduce agricultural activity at the original location, they may also result in a reduction of agricultural and animal waste introduced into the system through return flows, improving habitat quality (Jaeger, 2001).

However, some external costs may accrue to the environment as well. Positive instream effects will be reversed in the case of upstream transfers (Montilla-López et al., 2016). Park (2017) observes that wildlife may be dependent on return flows in addition to stream flows and subsequently impaired by return flow reductions. Similarly, Griffin (2012) argues that transfers from a controlled system such as an irrigation canal may impair downstream irrigators dependent on return flows to a natural body of water. Summarizing these conflicting cost indications, Young (2016) states that potential costs and benefits of locational transfers present a "spatially heterogeneous externality" that must be assessed on a case-by-case basis.

3.3 VALUATION AND ECONOMIC WELFARE

Twenty-nine (29) articles in our review mention valuing trade activity and quantifying increases in economic welfare resulting from water transfers. These studies assess the potential for improving economic welfare from water rights transfers, while underscoring the impact they may have on rural, agricultural communities in cases of intersector water transfers between rural and urban users.

It can be difficult to substantiate gains from water trading, but many[1] studies have attempted to do so. Methodologies for determining potential for economic gains from trade vary. One technique of estimating welfare gains is using drought years as a natural experiment, comparing drought year trading activity and economic output against climatically "normal" baseline periods (Broadbent et al., 2014; Janmaat and Rahimova, 2018; Squillace, 2016). These studies observed economic output during years of drought was not proportional to the relative scarcity of water resources, and therefore provides evidence that water is being traded from low- to relatively high-value uses. For example, Wheeler et al. (2013a) estimated that increased trading activity in Australian markets reduced the impact of drought in the southern Murray-Darling Basin from AUD$11.7 to $7 billion between 2006 and 2011.

Another method used in the literature is an assessment of the prices from successful water rights transactions. These prices are an estimate of the buyer's willingness to pay, or the "perceived income that the buyers will derive from utilizing the water in their business ventures (e.g., maintaining municipal supply, developing an industrial site, maintaining a planted crop)" (p. 23;

[1] Clifford et al., 2004; Pease, 2012; Jaeger, 2001; Jaeger et al., 2002; Jaeger, 2004; Burke et al., 2004; Hansen et al., 2014; Holley and Sinclair, 2016; Grafton et al., 2014; Grafton et al., 2016; Wheeler, 2013a; Yoder et al., 2016; Debaere et al., 2014; Broadbent et al., 2014; Janmaat and Rahimova, 2018; Squillace, 2016

Clifford et al., 2004). For example, Hansen et al. (2014) note prices paid for municipal water are higher than the prices paid for irrigation or environmental purposes, suggesting that there are untapped economic benefits of reallocating water to the higher bidder. Jaeger (2004) and Lovrich and Siemann (2004), however, warn that transaction costs and excessive price expectations of sellers are embedded in these prices and difficult to disentangle from the true economic value of water, therefore obfuscating any real capacity for gains from trade (Jaeger, 2004; Lovrich and Siemann, 2004).

Other studies examine the kind of transactions that promote improvement of economic welfare. Nine studies[2] focus on the economic welfare impacts of intersectoral trading (such as transfers from agricultural to municipal use), while several studies[3] discuss how intrasectoral transfers (such as between agricultural users) also generate welfare gains. Intrasectoral transfers can increase economic welfare particularly when economically low-value agricultural water is transferred to relatively higher-value agricultural uses (such as alfalfa or viticulture), which is often observed during droughts or where water resources are most scarce (Szeptycki et al., 2015; Burke et al., 2004). In practice, this can be the result of junior water users obtaining water security from senior rights holders to support capital-intensive perennial crops, such as avocados and grapes in Chile (Alevy et al., 2010).

Welfare gains from trade are predicated on having diverse uses of water in the market and agricultural water uses that are less sensitive to periodic water shortages (Wheeler et al., 2013a; Wheeler et al., 2017; Alevy et al., 2010; Kenney, 2015). During instances of severe drought, water users who maintain permanent crops, such as orchards, tend to monopolize water use to protect their long-term investments (Heard et al., 2017; Grafton et al., 2009; Szeptycki et al., 2015). If the permanent crop is not the highest value use from an economic standpoint, this homogenizing effect of water use may restrict efficient reallocation of water in the market. Alevy et al. (2010) discuss one such instance from a Chilean study by Zegarra (2002) where an extreme drought caused the market trading to grind to a halt at the point when water users engaged in farming permanent crops resisted trading away their water.

Two studies propose making water rights more flexible in trading to further improve potential economic gains from trade. Young (2016) suggests one means of increasing flexibility: enable simultaneous matching of many buyers to many sellers rather than matching a single buyer to a single seller. “Instead of a seller with 100 acre-feet of water having to find a buyer who needs exactly that amount, she can sell to several buyers, each needing different, but smaller quantities. The reverse is also true: a smart market can aggregate many sellers' water rights for a large bidding quantity.” (p. 3) Grafton et al. (2009) found that seasonal and temporary water trading in

[2] Liedner et al., 2011; Pease, 2012; Debaere et al., 2014; Liedner et al., 2011; Heard et al., 2017; Griffin, 2012; Grafton et al., 2011; Hadjigeorgalis et al., 2009; Hadjigeorgalis, 2009
[3] Debaere et al., 2017; Squillace, 2016; Heard et al., 2017; Janmaat and Rahimova, 2018; Broadbent et al., 2014; Scott et al., 2004

the Murray-Darling Basin of Australia offered a safety valve for the farmers who irrigate orchards and vineyards, while also increasing the volume of sales at high water prices.

3.4 Public Perception of Water Markets

Forty-four (44) of the 89 reviewed studies mention public perception of water markets, opposition to water markets, or conflict and political action related to water markets. These studies highlight characteristics that hinder positive perceptions of water markets and trade, and common concerns among stakeholder groups. Several studies highlight factors that promote positive perceptions of water markets as well. These factors are generally the inverse of factors thought to diminish the performance of water markets.

Five[4] studies cited administrative concerns as a characteristic that hindered positive perceptions of water markets or positive relationships among users. Inconsistencies and lack of clarity in the administering water markets often fuel distrust and wariness, as was the case for the Arkansas River Water Bank Pilot Program in Colorado (Lepper and Freeman, 2010). Lepper and Freeman (2010) found that farmers were suspicious of the state's intentions in implementing the program, because the Pilot Water Bank was run by cosmopolitan regulators who were not accountable to the farmers.

A study of Ecology's Washington Water Acquisition Program in the Dungeness, Yakima, and Walla Walla basins conducted by Lovrich and Siemann (2004) found that many interviewees viewed water markets as complicated, bureaucratic, and inconsistent. Users complained of slow processing times, inconsistent rules and lack of transparency. Lengthy delays and lack of responsiveness on the part of Ecology were cited as reasons landowners were discouraged from participating in the program. Multiple focus groups of Yakima landowners convened in 2007 found similar concerns: when asked why they did not participate in Ecology's reverse water right auction of that year, respondents voiced complaints about the complexity of the process, lack of flexible transfer arrangements, and vague program goals as major motivations (Rux, 2007).

Similar administrative concerns were cited by the United States Government Accountability Office (2005) in a study on the United States Bureau of Reclamation's water banking program in the Klamath basin from 2002-2004. The study states that Reclamation was unclear in communicating various management and accounting decisions to users. Additionally, the study stated that Reclamation failed to provide program users with clear information regarding water bank operations. Furthermore, Reclamation's policy of providing users with information upon request resulted in stakeholders receiving conflicting information at different times.

[4] Lepper and Freeman, 2010; Lovrich and Siemann, 2004; United States Government Accountability Office, 2005; Lieberherr, 2011; Wheeler, 2014

Lieberherr (2011) discusses concerns related to bureaucratic and time-intensive processes in the Deschutes Groundwater Mitigation Program that led to frustration among active participants and was cited as a reason why some potential participants didn't engage with the program. Similar concerns were cited by Lepper and Freeman (2010) in Colorado, where lack of clarity and consistency led to a distrust and discouraged users from engaging in water markets. Finally, in the Murray-Darling Basin in Australia, Wheeler (2014) notes that the release of a guide to the MDB Plan calling for an increase in environmental water holdings resulted in unrest among water users due to the secrecy associated with the Guide's release.

Other studies underscore general distrust of markets and commoditization of water (Wheeler et al., 2017; Nikolakis and Grafton, 2009), a mistrust of government involvement in water markets (Wheeler et al., 2013; Lepper and Freeman, 2010; Rux, 2007), and misgivings among agricultural communities, with a perception that they have nothing to gain and everything to lose, even in the context of voluntary transactions (Conrad et al., 2017; Jaeger and Doppelt, 2002). Some studies found that cities were reluctant to transfer water out of agricultural communities due to a widespread perception that this disrupts rural communities and is politically charged. (Debaere et al., 2014; Duane and Opperman, 2010).

A common theme in these studies was that non-economic factors generated common concerns among stakeholder groups and hindered positive perceptions of water markets. One study of environmental flow transactions in the U.S. noted that irrigator participation was impacted by several non-economic factors including social pressures, concerns regarding impacts to irrigation districts or rural communities, and a lack of trust (Lane-Miller et al., 2013). Cook and Rabotyagov (2014) echo this finding, stating that irrigators do not make simple profit maximizing decisions, but instead incorporate the cultural value of rural lifestyle into considerations of water transfers. Participation by irrigators may hinge upon whether the buyer of their water right is another irrigator or a growing town, or if the transaction is facilitated by an entity they trust.

Thampapillai (2009) found similar concerns in a study of water trading in the Murray-Darling Basin in Australia. Community members in this study were concerned about permanent transfers negatively impacting agricultural communities. The study found evidence of social pressure to avoid out-of-district transfers. Concerns regarding out-of-district transfers were echoed in two studies conducted by Wheeler et al. (2013a, 2017) in the Murray-Darling Basin in Australia as well. Here, the authors discuss distrust of the redistribution of water entitlements among irrigation communities in addition to a preference for within district transfers. Several other studies cite irrigator concerns about potential negative impacts of market participation on their own communities, or else highlight social pressures within communities, irrigation districts or canal companies to not engage in transfers (Nicholas et al., 2016; Hanak and Stryjewski, 2012; Libecap et al., 2011; Hadjigeorgalis, 2009; Jaeger, 2004). In this same vein, a study in the Okanagan Basin in Canada found that farmers expressed a preference for intrasectoral agricultural transfers over intersectoral transfers to new uses.

A few[5] studies discussed equity concerns in water markets. Holley and Sinclair (2016) find that 67% of indigenous respondents disagreed with the assertion that all parties were being treated equally and fairly under the water management regime in New South Wales, Australia, compared to 40% of non-indigenous respondents. In a study conducted in the Deschutes Basin, equity concerns were framed around differences between big water users and smaller water users. Lieberherr (2011) notes that many users in the Deschutes Groundwater Mitigation Program felt that bigger water users (such as golf courses) weren't paying their fair share or were being wasteful, which negatively impacted their perception of the program.

Potential negative secondary effects of water transfers on rural economies constitute a major concern for potential water market participants. Studies highlighted community concerns with transferring water from agricultural to other uses, including concerns related to loss of the agricultural economy and associated infrastructure, as well as fear of population loss within rural communities (Loch et al., 2013; Lovrich and Siemann, 2004). One study specifically highlighted community concern regarding transferring water from "traditional" consumptive uses to instream uses (Grafton et al., 2009). Similar user concerns included loss of flexibility to respond to changes in weather or market access as a result of permanent or long-term leases (Lovrick and Siemann, 2004).

Several studies reference the cultural stigma associated with fallowing agricultural land and how this stigma has increased the popularity of conserved water acquisitions for streamflow augmentation purposes (Debaere et al., 2014; Garrick et al., 2009). Wheeler et al. (2013b) points to evidence that Australian agricultural communities are more willing to engage in transfers of conserved agricultural water. The authors note that one-fifth of irrigators who stated that they would be uninterested in selling their water entitlements also stated that they would be interested in alternative trading arrangements. Furthermore, 40% of irrigators who showed only slight interest in selling their water entitlements expressed interest in alternative trading arrangements. However, Kenney (2015) notes that water constituencies disagree on whether alternative agricultural transfer methods (ATMs) such as the sale of conserved water avoids or accelerates the dry-up of agricultural lands.

Factors identified as promoting positive perceptions of water markets and improved willingness to participate address the elements that lead to opposition to water markets: credibility and trust. Lovrich and Siemann (2004) specifically mention that interviewees stressed the importance of using credible intermediary organizations, such as a private non-profit (e.g. Washington Water Trust) or non-regulatory government agency (e.g. conservation districts), to facilitate participation. Additionally, both Lovrick and Siemann (2004) and Lane-Miller et al. (2013) discuss the importance of tailoring the design and management of a program to local conditions

[5] Holley and Sinclair, 2016; Lieberherr, 201; Wheeler et al., (2013b)

of each watershed area, and messaging success stories or testimonials to help promote positive perceptions of water transfers.

3.5 Suggestions Provided by the Literature for Improving Water Markets

The literature in our review contains various suggestions for improving the performance and public perception of water markets. Commonly noted as "recommendations" in the literature, these ideas address provisions to minimize barriers to trading activity such as transaction costs, negative economic impacts on agricultural communities, and technical issues related to measurement, monitoring, and enforcement.

3.5.1 Promoting Temporary Transfers

Five[6] articles in our review recommend that water market administrators promote some form of temporary transfer over permanent transfers. Referencing the growing need to transfer agricultural water to other uses in the west, MacDonnell and Rice (2008) discuss the importance of easing the requirements of temporary transfers in order to provide flexibility to farmers and minimize economic externalities on rural agricultural communities. Szeptycki et al.'s (2015) review of state laws relating to environmental water transfers finds that temporary transfers promote water market participation (especially in conjunction with a streamlined review process).

Several[7] articles specifically recommend the use of dry-year option contracts or split-season transfers to provide greater flexibility to agricultural water users. Jaeger and Doppelt's 2002 examination of two case studies from Washington (Salmon Creek in the Okanogan River Basin) and Oregon (Upper Klamath River Basin) argues that contingent dry-year option contracts for instream uses should be developed in places where the value of instream water only exceeds its out-of-stream value during drought years. This type of system would avoid frequent renegotiation of temporary leases.

One such contract was implemented in the Oregon portion of the Walla Walla River Basin in 1998. Under this agreement, the Oregon Water Trust agreed to pay an individual irrigator growing spring-irrigated crops an initial one-time payment over a 10-year period for an option to divert the irrigation water to instream uses in dry years (Jaeger and Doppelt, 2002). The amount of the initial payment was based on projections of the number of dry years likely to occur over the 10-year period, as well as the volume and value of foregone production. Jaeger and Doppelt

[6] Jaeger and Doppelt, 2002; MacDonnell et al., 2008; Szeptycki et al., 2015; Squillace, 2013; Squillace, 2016.
[7] Jaeger and Doppelt, 2002; Squillace, 2016; Borzutzky and Madden, 2013.

(2002) also identify out-of-stream option contracts as an important tool for situations “where the value of water in one use or the other is uncertain or fluctuates from year to year” (p. 16).

In “Marketing Conserved Water,” Squillace and McLeod (2016) note that the frequency of dry-year option contracts for municipal uses are sometimes restricted due to the risk that a prolonged drought could take agricultural land out of production for multiple consecutive years. In order to mitigate this risk to farmers while providing municipal users with greater security, Squillace and McLeod recommend that dry-year option contracts be used to transfer conserved agricultural water (via rotational fallowing, deficit irrigation, or crop switching) as an alternative to the permanent transfer of agricultural water rights.

Split-season transfers can also offer a way to minimize conflict between users by capitalizing on the fluctuations in the marginal value of water for various uses over the course of the irrigation season (Jaeger and Doppelt, 2002). Jaeger and Doppelt (2002) argue that this strategy is especially useful for areas where water storage does not exist and irrigators are able to shift their irrigation schedule earlier in the season, leaving more water for instream uses later in the season when flows are lower. For example, in the Upper Klamath River Basin, irrigators growing grains and pasture were able to irrigate prior to the start of curtailments introduced by a 2001 Federal Klamath Reclamation Project. This approach resulted in normal yields on 17,000 acres without additional irrigation later in the season, mitigating economic damage from lost agricultural production (Jaeger and Doppelt, 2002).

3.5.2 Transfer Process and Market Visibility

A common theme in the literature is the need for a centralized market authority to establish consistent standards for water application approval processes and disseminate market and price information. High levels of uncertainty due to incomplete market information present a major barrier to efficient water markets; incomplete or inconsistent price data inhibits the ability of water users to effectively manage water resources to adapt to drought and other climate-induced scarcity (Jaeger and Doppelt, 2002; Loch et al., 2013; Zuo et al., 2014).

A centralized website or other publicly visible platform can help mitigate this uncertainty by providing transparent market information including transaction data (price and volume), climate modeling, forecasted water availability, allocation information (if applicable), and water market activity to date (Doherty and Smith, 2012). Montilla-López et al. (2016) examine water markets worldwide and recommend that administrators provide as much information as possible to the public including prices and trading volumes, parties involved, and the terms of transactions.

A study by the U.S. Government Accountability Office (GAO) found that the Bureau of Reclamation failed to communicate key information related to the operation and status of the Klamath Water Bank, confusing stakeholders and undermining the bank’s legitimacy and efficacy. The GAO recommended the creation of a centralized website or publication of

biweekly press releases to explain the rationale of management decisions and keep water users informed of significant events (United States Government Accountability Office, 2005).

Similarly, Loch et al. (2013) cite poor price information and lack of transparency in allocation announcements in Australia's Murray-Darling Basin as a constraint within that market. Jaeger and Doppelt (2002) note that price information can be distinguished between market transactions consistent with a seller's willingness-to-pay price and those that reflect idiosyncratic willingness-to-pay prices (such as agricultural lifestyle valuation).

As a caution to publishing price information, however, Young (2016) notes that "confidentiality of price information is one of the most underappreciated aspects of trading" (p. 5). Young (2016) found that farmers in Nebraska were hesitant to divulge sensitive personal financial information as a condition of participating in the local water market. However, the operation of a smart market by a neutral private third-party sharing limited price information (price ranges instead of exact prices) with the public protected confidentiality and encouraged trading (Young, 2016).

Some opportunity costs related to lengthy transfer approval processes can be defrayed by establishing a priority system for application processing wherein time-sensitive transfers jump to the top of the queue (Lovrich and Siemann, 2004). However, priority systems can also create other issues: in the Walla Walla River Basin, for example, Lovrich and Siemann (2004) note that the required priority for trust water right change applications interfered with processing other rights. Lovrich and Siemann (2004) recommend that the Washington State Department of Ecology develop a flexible approach to application processing that strikes a balance between Trust Water Right Program applications and other change applications.

Administrative costs can be further reduced by either expanding the scope (volume or duration) of each transfer or streamlining the approval process of short-term transfers (Jaeger and Doppelt, 2002). Expanding the scope of transfers minimizes transaction costs by increasing the welfare gains from trade relative to the fixed costs of transfer (Jaeger and Doppelt, 2002).

Streamlined approval can be implemented in multiple ways. Many jurisdictions relax the requirements of no-injury rules for seasonal and one-year transfers, especially under drought conditions (Jaeger and Doppelt, 2002; Hansen et al., 2014). For example, Oregon employs an expedited process for reviewing short-term transfers, reviewing leases of less than five years based on paper rights and allowing transactions to be revoked after the fact if they are found to negatively affect other users (Szeptycki et al., 2015). Subsequently, providing a simplified renewal process for temporary transfers (rather than process each iteration as a new transaction) can dramatically reduce the time and expense of annual review (Jaeger, 2002).

3.5.3 Establishing Consistent Standards

Several[8] articles emphasize the importance of establishing consistent evaluation standards for the validity and availability of a water right for transfer as well as the importance of communicating these standards transparently to the public. Important standards include consistent methodologies for measuring consumptive availability of a given water right as well as standardized evapotranspiration rates that incorporate crop type, soil type, and regional considerations. These are especially important for markets in conserved agricultural water (Jaeger and Doppelt, 2002; Kenney, 2015).

Setting consistent and transparent standards for measuring consumptive use also mitigates uncertainty for buyers and sellers which promotes the functioning of a healthy water market (Squillace, 2016). In Colorado, Kenney (2015) recommends that water market administrators standardize methods for calculating water savings from transfers of conserved agricultural water in a way that would guarantee that their approval would also satisfy the no-injury rule.

The technical challenges involved in measuring consumptive use can add considerable time and expense to the approval of a water right transfer, suggesting the need for better technology to measure the amount of transferable water in a given transaction (Szeptycki et al., 2015). Jones and Colby (2012) review measurement, monitoring, and enforcement strategies for temporary transfers of agricultural water conserved through rotational fallowing programs. The authors examine methods for measuring consumptive use including water savings, water delivery-based measurement, traditional evapotranspiration calculation, and remote sensing of evapotranspiration.

Jones and Colby (2012) find that traditional evapotranspiration methods are accurate and cost-effective if crop coefficients used in a region are current, but recommend using satellite-assisted estimators if crop coefficients are outdated. In contrast, the report finds that water delivery measurement is cost efficient but less accurate. For transfers of conserved water, Squillace (2016) and Kenney (2015) recommend a policy of reducing the volume available for transfer by 10% to account for uncertainties in calculating changes in consumptive use.

3.5.4 Education and Outreach

Closely related to the establishment of consistent and transparent transfer rules is the need to educate the public about water market processes. Five articles in our review provide recommendations for specific education and outreach activities to influence public perception and promote common understanding of the benefits of water markets. The recommendations are:

[8] Grafton et al., 2009; Jones and Colby, 2012; Szeptycki et al., 2015.

- Public meetings to inform stakeholders about water market processes, inform participants about water acquisition efforts, answer questions from community members to clarify rules and procedures, and address basin-wide economic impacts of transfers (Purkey and Landry, 2001; Doherty and Smith, 2012);
- Education geared specifically toward creating realistic price expectations in the community, such as mock water trading workshops (Clifford et al., 2004);
- Frequent and accessible public presentations (Jaeger and Doppelt, 2002); and
- Messaging focused on the benefits of transfers to agricultural users (Lovrich and Siemann, 2004).

3.5.5 Collaboration and Governance

Four[9] articles recommend including key community representatives and stakeholders as a part of the institutional water market planning process in order to improve acceptability for potential market participants. Jaeger and Doppelt (2002) identify the ability to establish strong collaborative relationships with stakeholders as important in basins throughout the Pacific Northwest where some irrigation districts may be reluctant to work with NGOs or government agencies. Additionally, Dilling et al. (2019) and O'Donnell et al. (2010) recommend the creation of a conflict resolution mechanism to reduce transaction costs.

Loch et al. (2013) and Young (2016) discuss the importance of avoiding conflicts of interest in the case of government-run water markets to prevent erosion of public trust. For example, a government agency administering a water market while simultaneously participating as a buyer or seller in the market will gain insider price information that creates a conflict of interest. In such cases, Young (2016) recommends relegating financial administration of the water market to a third party.

3.5.6 Monitoring and Enforcement

In the face of increasing strain on water resources due to more frequent droughts and the intensifying effects of climate change, implementing standard and predictable methods for monitoring and enforcing water transfers is crucial to ensure proper water accounting and program accountability (Jones and Colby, 2012; Jaeger and Doppelt, 2002). Review costs may also be expedited through the use of assessment tools that do not require on-site monitoring (Szeptycki et al., 2015).

Jones and Colby (2012) recommend using satellite-based methods for monitoring purposes for rotational fallowing programs as opposed to site visits, especially if fields in the area are large enough to access at no cost as Landsat images—"as long as fields are monitored far enough into

[9] Jaeger and Doppelt, 2002; Clifford et al., 2004; O'Donnell et al. (2010); Doherty and Smith, 2012.

the growing season for the difference between weeds and crops to be apparent, this approach would be cost effective, require minimum staff time, and provide a history of fallowing compliance given that images are archived" (44).

Jones and Colby (2012) note that the implementation of remote sensing technology for monitoring and enforcement would require substantial involvement from irrigators, suggesting that rotational fallowing programs should emphasize the benefits of remote sensing technology for irrigators, including real-time data on crop-water interactions leading to improved irrigation scheduling and higher crop yields. Additionally, the authors also recommend that program agencies pursue cost-sharing agreements between the agricultural and non-profit sector or government sectors to offset the high cost of remote sensing technology.

As an alternative to imposing fines on irrigators, Jones and Colby (2012) point out that compliance rewards may actually increase compliance rates in agricultural water conservation programs. Finally, Jones and Colby (2012) suggest that targeted monitoring and employing a variety of monitoring and enforcement methods may help to encourage compliance while keeping costs down.

3.5.7 Inter-District and Trans-Basin Trades

Recommendations from the literature on transfer rules for trans-basin trades are largely focused on Australian water markets. Recommendations are mixed, demonstrating the necessary balance between facilitating transfers and preventing negative externalities, and indicating that transfer rules should be tailored to the local, social and hydrological context of each region. Several authors recommend the removal of trade restrictions in order to promote water transfers (Grafton et al., 2009; Loch et al., 2013), while others emphasize that transfer rules should be structured to minimize negative environmental impacts (MacDonnell and Rice, 2008; Waye and Son, 2010; Doherty and Smith, 2012).

For example, the State of Victoria in Australia set a 4% cap on out-of-irrigation-district trades which is designed to protect the economic interests of agricultural communities (Grafton et al., 2009). Grafton et al. (2009) advocate for the removal of such inter-district trading restrictions that benefit a particular group, arguing that they could be detrimental to the public interest and prevent environmental water transactions from taking place[10]. However, Waye and Son (2010) argue that although removing the 4% rule in Victoria would make more water available for environmental uses, it would encourage a more opportunistic market which would be less likely to incorporate the full cost of third party or environmental externalities.

[10] The Australian Competition & Consumer Commission ruled to phase out the 4% cap on out of district trades in the State of Victoria starting in 2014.

Loch et al. (2013) identify trade restrictions on inter-regional trade in the Murray-Darling Basin in Australia as a barrier to maximizing gains from trade for buyers/sellers and argue for their removal. In contrast, MacDonnell and Rice (2008) argue that out-of-basin transfers in the western United States should be subject to additional requirements including a no net environmental degradation standard, and should only be approved after the applicant has demonstrated that existing supplies are being used efficiently and there are no better alternative supplies.

Four articles[11] in our review suggest mitigating environmental and social externalities on rural agricultural communities through measures such as a mandatory formal commitment to land restoration from water right buyers (Squillace, 2015), community mitigation funds (Clifford et al., 2004, Doherty and Smith, 2012, MacDonnell and Rice, 2008), revegetation and noxious weed management programs, or improvements to infrastructure (Doherty and Smith, 2012).

3.5.8 Financing and Fees

Three[12] articles in our review address financing models for supporting water markets. Two articles recommend a cost-based pricing model to cover operational and management costs and avoid hidden subsidies (O'Donnell et al.; Montilla-López et al., 2016). In addition, Doherty and Smith (2012) propose a real estate transfer or development tax as a potential financing option.

[11] Clifford et al., 2004; Doherty and Smith, 2012; MacDonnell and Rice, 2008; Squillace, 2015.
[12] O'Donnell et al.; Montilla-López et al., 2016; Doherty and Smith, 2012.

4. FINDINGS IN WASHINGTON STATE LITERATURE

Within our literature sample, we identified a subset of documents that identified and discussed findings within Washington State and the Yakima River Basin. Many themes from these documents echo the findings from the larger sample of literature, while others are more regionally specific. This chapter will discuss findings sourced from (and therefore applicable to) Washington State and the Yakima River Basin within the context of the thematic elements of our literature sample identified above. This subset of the literature sample includes nine[13] documents.

4.1 TRANSACTION COSTS

McCrea et al.'s (2007) technical report on market-based reallocation of water resources in the Yakima Basin identifies similar administrative and market information transaction costs as our sample of global literature. McCrea et al. (2007) find that processing time is a significant obstacle to market transfers and recommend expanding the scope of the priority processing system for change applications. However, the report also finds that the Yakima Transfer Working Group has reduced transaction costs by providing proactive technical assistance to market participants. The authors also emphasize the importance of outreach and education and making information widely available to the public in order to foster trust and encourage market participation (McCrea et al., 2007).

In addition, several authors highlight the importance of other factors in the Yakima including adjudication and legal complexity:

- Completion of comprehensive adjudication should reduce measurement and enforcement costs and associated transactional risk (Welch et al., 2013; McCrea et al., 2007).
- Legal pluralism and jurisdictional complexity require transfers to meet a higher legal threshold for approval than in many other regions (Welch et al., 2013).

4.2 EXTERNALITIES

Similar to themes from the global literature that highlight concerns over negative effects of transactions on local economies, a report to the Washington State Legislature (Clifford, 2012)

[13] Clifford, 2012; Clifford, 2006; Clifford, 2004; Graham and Montgomery, 2011; McCrea et al., 2007; Niemi, 2011; Roza, 2016; Rux, 2007; Welch et al., 2013.

points to negative economic externalities of water transfers on communities in northeast Washington. Like other authors who recommend promoting transfers of conserved agricultural water in order to protect the economic interests of rural agricultural communities (Squillace and McLeod, 2016), Clifford cites MacDonnell and Rice's 2008 report which recommends the formation of rotational fallowing pools in Washington State to mitigate the local effects of water transfers. Clifford's report further encourages regulatory agencies, agricultural groups, and environmental groups to promote their use to stakeholders (Clifford, 2012).

4.3 PUBLIC PERCEPTION

Welch et al.'s 2013 situation analysis of market-based water reallocation in the Yakima basin finds that a market institution with a well-defined purpose may facilitate participation. However, a top-down approach to market creation (defined and empowered by government agencies) may deter participation when users perceive that reallocations prioritize marketwide results over their individual or community interests (Welch et al., 2013). This finding relates to the recommendations of several authors (Jaeger and Doppelt, 2002; Clifford et al., 2004; O'Donnell et al., 2010; Doherty and Smith, 2012) in the broader literature review who emphasize the importance of collaboration with local representatives and groups in market design to promote the legitimacy of markets.

Findings from McCrea et al.'s 2007 report suggest that social capital may be generated by increasing the visibility of past and current transfers within the markets. Potential market participants will be encouraged to pursue trading if they trust the consistency of process and outcome across the body of market transactions. This echoes the theme from several authors in the larger literature sample that emphasizes the importance of establishing consistent transfer processes and standards (Grafton et al., 2009; Jones and Colby, 2012; Szeptycki et al., 2015).

Finally, McCrea et al. (2007) find that Yakima stakeholders have demonstrated a lack of trust in the Washington Department of Ecology as a market regulator due to its past role as plaintiff in water rights adjudication in the basin.

4.4 VALUATION AND ECONOMIC WELFARE

Niemi et al. (2011) studied net economic effects on the agricultural sector under several drought-year scenarios. They find that the Yakima Integrated Plan baseline trading scenario (transfers summing 30,000 acre-feet, primarily inter-district) has the potential to reduce economic losses of severe drought by $20 million. Moreover, unrestricted trading with active participation has the potential to fully offset net economic losses of severe drought.

4.5 Suggestions in Washington Literature for Improving Water Markets

Suggestions for improving water transfers in the Yakima River Basin broadly discuss process and fee standardization across districts as well as multiple alternative water market structures.

Welch et al. (2013) propose the creation of a joint committee to manage all water transfers within the Yakima River Basin to improve the transfer process. The authors identify three primary responsibilities for this committee necessary to facilitate a healthy water market: 1) registry services to validate users' water rights and standardize entitlements across irrigation districts; 2) transaction management to regulate the transfer process in accordance with transaction rules and standardize transaction fees; and 3) shared reduction management to establish use preferences during drought periods. The authors assert that the creation of such a joint committee will simultaneously reduce administrative costs associated with transfer as well as improve willingness to participate through a stakeholder-inclusive approval process.

McCrea et al. (2007) discuss several alternative water marketing systems in the context of the Yakima River basin:

- *Water market using existing authority*: a water market administered by a private non-profit functioning as a clearinghouse entity. The administering organization publishes information on location, use, and availability of interested sellers and conducts outreach to potential buyers and other stakeholders about market opportunities. Transfer approval would remain under the authority of existing Ecology processes.
- *Open water market*: a water market administered by a private non-profit functioning as both clearinghouse and broker. The administering organization publishes market information but also seeks actively to match potential buyers and sellers. Transfer approval would remain under the authority of existing Ecology processes.
- *Water banking using existing trust water rights program*: the existing Trust Water Rights Program functions as a water bank to interested buyers and sellers within the basin. Participants transfer rights into and out of the bank (rather than transact with other private entities in a market setting). Water rights remain protected from relinquishment as long as they remain in trust.
- *Non-regulatory water bank*: similar to the previous alternative but featuring a newly created bank administered by either a private non-profit or non-regulatory government agency. Prices can be either set by the administering organization or negotiated on a case-by-case basis.
- *Drought-year transfers outside of irrigation districts*: inter-district transfers are relaxed to allow up to 30% of district supply to be transferred elsewhere during drought years. Individual users petition for temporary transfer at a set price subject to approval by both the district of origin and the district of final use.

- *Irrigation district bank*: individual irrigation districts function as a water bank during drought and non-drought years. Each district will solicit sale offer from its members at a fixed price and negotiate leases to purchasing members or to outside districts.

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6. APPENDIX A – DATABASE SEARCH STRINGS

Below is a list of the seven search strings used in our initial literature search, which was limited to reports published after 2008.

1. "water bank" OR "water banks" OR "water banking" OR "groundwater bank" OR "groundwater banks" OR "water supply bank" OR "water supply banks" OR ("rental pool" AND "water") OR "water lease bank"
2. "drought bank" OR "drought banks" OR "augmentation bank" OR "augmentation banks" OR "water trust"
3. ("water market" OR "water markets" OR "water marketing") AND NOT ("water bottle" OR "bottle")
4. ("water transfer" OR "water transfers" OR "water right transfer" OR "water rights transfer" OR "water rights transfers") AND voluntary
5. ("water reallocation" OR "water right reallocation" OR "water rights reallocation" OR "water right allocation" OR "water rights allocation") AND voluntary
6. "water exchange" OR "water right exchange" OR "water rights exchange" AND voluntary

We expanded the time horizon of our search to capture additional reports that focused on Oregon and Washington state. Below are the modified search strings that we used:

1. "water bank" OR "water banks" OR "water banking" OR "groundwater bank" OR "groundwater banks" OR "water supply bank" OR "water supply banks" OR ("rental pool" AND "water") OR "water lease bank" AND ("Oregon" OR "Washington")
2. "drought bank" OR "drought banks" OR "augmentation bank" OR "augmentation banks" OR "water trust" AND ("Oregon" OR "Washington")
3. ("water market" OR "water markets" OR "water marketing") AND NOT ("water bottle" OR "bottle") AND ("Oregon" OR "Washington")
4. ("water transfer" OR "water transfers" OR "water right transfer" OR "water rights transfer" OR "water rights transfers") AND voluntary AND ("Oregon" OR "Washington")
5. ("water reallocation" OR "water right reallocation" OR "water rights reallocation" OR "water right allocation" OR "water rights allocation") AND voluntary AND ("Oregon" OR "Washington")
6. "water exchange" OR "water right exchange" OR "water rights exchange" AND voluntary AND ("Oregon" OR "Washington")

7. APPENDIX B - SUMMARY OF INITIAL LITERATURE SEARCH

	SEARCH STRING					
DATABASE	1. "Water bank…"	2. "Drought bank…"	3. "Water market…"	4. "Water transfer…"	5. "Water reallocation…"	6. "Water exchange…"
Google						
Results returned	191	4	200	190	179	189
Results reviewed	191	4	130	100	70	30
Source for further review	17	0	10	7	1	0
Google Scholar						
Results returned	3,610	1,420	14,300	3,670	578	2,370
Results reviewed	150	100	300	100	100	100
Source for further review	45	26	108	25	36	1
Hein						
Results returned	231	130	583	256	56	6
Results reviewed	100	50	100	100	56	6
Source for further review	20	3	18	9	3	0

	Search String					
Database	1. “Water bank…”	2. “Drought bank…”	3. “Water market…”	4. “Water transfer…”	5. “Water reallocation…”	6. “Water exchange…”
Scopus						
Results returned	12	1	69	2	1	159
Results reviewed	12	1	50	2	1	100
Source for further review	2	0	8	0	0	1
Proquest Dissertation						
Results returned	109	335	1,054	8	3	3,151
Results reviewed	90	50	100	8	3	50
Source for further review	15	0	5	2	0	0
Proquest Ag & Envs						
Results returned	192	161	1,041	12	44	15
Results reviewed	120	161	20	12	44	15
Source for further review	14	0	23	0	3	0