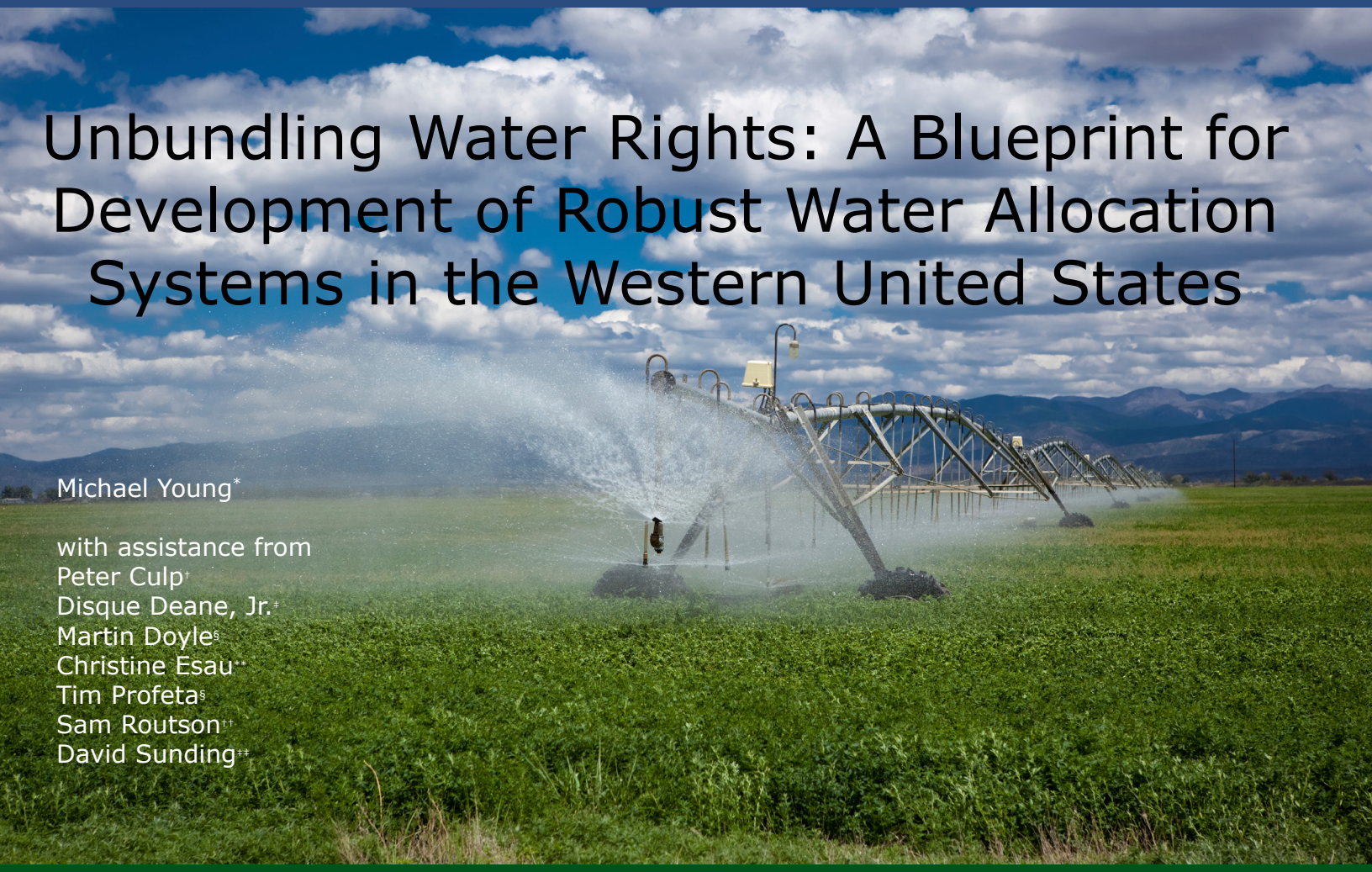
Nicholas Institute for
Environmental Policy Solutions

Unbundling Water Rights: A Blueprint for Development of Robust Water Allocation Systems in the Western United States



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During the preparation of this report, many people willingly sought ways to adapt the Australian experience to the U.S. West. The contribution of these people has been immense, especially as their time was given during one of the West's biggest droughts and when crops needed to be brought in.

Thanks also go to the following: colleagues and students in the Global Food Studies Program at the University of Adelaide; Michael and Mary Hanemann for use of their home as a base from which many of the ideas contained in this report took shape; and the late John Briscoe and others for my appointment to the Australia Chair at Harvard University, which gave me time to think about ways to adapt the Australian water reform experience.

SUMMARY

This report lays out a blueprint for transitioning to robust water rights, allocation, and management systems in the western United States—a blueprint ready for pilot testing in Nevada's Diamond Valley and Humboldt Basin. If implemented, the blueprint's reforms would convert prior appropriation water rights into systems that keep water withdrawals within sustainable limits, allow rapid adjustment to changing water supply conditions, generate diverse income streams, and improve environmental outcomes.

The blueprint's essential element is unbundling of existing water rights. In law and economics, property rights are often described as a bundle of sticks. When applied to a water right, unbundling involves separating an existing right into its specific, component parts. In an unbundled system, each part is defined and can be managed and traded separately. During the unbundling process, as proposed here, the value of each component is enhanced, and the taking of property rights is avoided.

Unbundling brings clarity to water rights and reveals the true value of the water, because willing buyers and sellers are able to trade with one another with dramatically reduced transaction costs. "Liquid markets" emerge. Shares, a primary product of the unbundling, can be used to finance innovation, and opportunities for improving environmental outcomes are increased through the transparent value of water rights shares and allocations.

If water managers in Nevada find that an unbundled water rights system is more desirable than the current system, they can use this report's proposed reforms and schedules to facilitate the transition to it. Although the state engineer and governor's office may have sufficient perquisites to proceed without the support of new legislation, implementation would be easier if underpinned by legislation.

Executive Summary

Overview

This report lays out a blueprint for transitioning to robust water rights, allocation, and management systems in the western United States—a blueprint ready for pilot testing in Nevada's Diamond Valley and Humboldt Basin. If implemented, the blueprint's reforms would convert prior appropriation water rights into systems that stabilize water withdrawals to sustainable limits, allow rapid adjustment to changing water supply conditions, generate diverse income streams, and improve environmental outcomes.

The blueprint's essential element is unbundling of existing water rights. In law and economics, property rights are often described as a bundle of sticks. When applied to a water right, unbundling involves separating an existing right into its specific, component parts. In an unbundled system, each part is defined and can be managed and traded separately. During the unbundling process, as proposed here, the value of each component is enhanced. If implemented properly, no taking of property rights occurs.

Unbundling allows each right holder to pursue new opportunities. Clarity is brought to water rights, and the true value of the water can be revealed because willing buyers and sellers are able to trade with one another with dramatically reduced transaction costs. "Liquid markets" emerge. Shares, a primary product of the unbundling, can be used to finance innovation, and opportunities for improving environmental outcomes are increased through the transparent value of water rights shares and allocations.

Many of the concepts developed in the blueprint presented here derive from Australian experience. Over a 20-year period, beginning in 1994, Australia embraced the idea that the low-cost trading of water shares (i.e., entitlements) and allocations, coupled with the use of statutory water resource sharing plans, could be used to improve water use. Under the system that Australia has now put in place

- Plans are used to set limits and determine how and when water is allocated,
- Share trading is used to encourage innovation and the efficient management of risk, and
- Allocation trading used to encourage users to put water to the use that best serves community and individual interests.

The key insight that emerges from this experience is that low-cost trading and a transition to sustainable use arrangements is possible only when existing water right arrangements are converted into ones that are designed to achieve these goals.

This blueprint has been developed in consultation with water users, administrators, and community leaders in the Diamond Valley and the Humboldt Basin. It should be interpreted as the beginning of a more comprehensive conversation about how water rights could be unbundled in the western United States.

If the proposed pilot tests suggested that the proposed system is beneficial and more desirable than the current water right system, this blueprint could be used to assist with the preparation of proposed legislative reforms necessary to facilitate the proposed system's wider application in the United States.

Application in Nevada

As a tightly connected but rapidly depleting groundwater resource used by a relatively small number of irrigators, the Diamond Valley presents an ideal location for testing the viability of the proposed blueprint. By contrast, the transition to a new system in the Humboldt Basin will require greater preparation. This basin, like many others in the United States, includes a river system fed by several estuaries, storages that are used to regulate flow, and a number of connected groundwater resources. Some river reaches flow continuously. Other reaches flow episodically. As such, this basin represents a good test of the more general applicability of the blueprint.

Because both case studies are wholly located in Nevada no interstate complications are involved.

Because the proposed water rights system is relatively new to the United States, a pilot test of five years is recommended. To provide a level of confidence at the outset and to reduce the risk of legal challenge to the proposed system, all involved in the test should be offered the opportunity to revert to the existing system at the end of five years.

In essence, this blueprint proposes four changes to the existing water rights system:

- **Unbundling** of existing water rights into shares, allocations, and use approvals so that long- and short-term interests and impacts on third parties can be managed separately from one another and at reduced costs.
- Development and use of **statutory water resource sharing plans** to ensure use remains within sustainable limits.
- Appointment of **expertise-based boards** to prepare plans and oversee implementation of the new system in partnership with the Office of the State Engineer or an equivalent office.
- Establishment of **government-guaranteed water-right registers and bank-like water accounting systems** so that the value of water can be used to finance private investment and increase the speed and transparency of water rights and volumes trades.

This report details recommendations for changes in administrative arrangements, the mechanisms used to deliver environmental outcomes and to protect third-party interests, and the role of the courts—recommendations aimed at increasing stakeholder engagement and rigorous monitoring.

Application to the Diamond Valley

Located near Eureka, 250 miles east of Carson City, the Diamond Valley contains an aquifer from which water is pumped for agricultural, urban, mining, and livestock uses. Most of the water is extracted with some 200 center-pivot irrigators to grow alfalfa.

The first water right in the Diamond Valley was issued in 1890. Today, water rights are held by approximately 110 legally distinct interests. The most junior water right was issued in 2005 for livestock purposes.

Because water use in the Diamond Valley is not metered by the Office of the State Engineer, the rate of use has to be estimated. At present, annual water use is thought to be around 70,000 acre feet, and at this rate of use, the aquifer is declining at 2 to 3 feet per year. The U.S. Geological Survey (USGS) has estimated the aquifer's sustainable yield to be 35,000 acre feet per year; at current withdrawal rates, the aquifer will likely be depleted within 30 years. A significant proportion of Diamond Valley water users have indicated that they would like to find a way to avoid this outcome by transitioning to a new water rights system that would enable them to bring use within sustainable limits and to open up opportunities for further development. At the same time, the state engineer announced that because Diamond Valley groundwater is being overused, he intends to declare it a "critical management area." Once a groundwater resource is declared such an area, groundwater users have 10 years to prepare a management plan. If they fail to do so, the state engineer is required to restrict all water use, including withdrawals from domestic wells, on the basis of seniority.

If Diamond Valley water users wish to prepare a plan that is consistent with this blueprint, the following actions would be appropriate:

- The county should appoint a five-member, expertise-based Diamond Valley Water Board to prepare and, following approval by the state engineer, implement a sustainable water resource sharing plan that would gradually bring withdrawals in the valley into alignment with recharge.
- The board should establish a community reference panel to help it develop and implement the water resource sharing plan.
- In recognition of increases in water-use efficiency that the pilot test can be expected to produce, grant funding should be sought to expedite preparation of the water resource sharing plan, meter installation, and development of water registers and water accounts.
- The water resource sharing plan should outline the transition to a new unbundled water rights system and a process that will reduce water use to ensure sustainability of the aquifer.
- The water resource sharing plan should

    - Issue shares to all existing water right holders using a formula that accounts for water right seniority.
    - Begin with a total allocation equivalent to current use and propose a pathway for the transition to sustainable yield.
    - Require the board to make allocations in proportion to the number of shares held and to do so well before the start of each irrigation season (February 1 of each year is suggested).
    - Allow water account holders to carry forward as many unused water allocations as desired from one season to the next.

- Require all significant water use to be metered and recorded in a robust water accounting system.
- Discourage intentional overuse by setting the penalty for a water account deficit of more than 21 continuous days at three times the cost of restoring the account to a zero balance.
- Require the county to hold sufficient shares to offset the estimated impact, thereby allowing households and businesses that take small amounts of water without holding a water right.
- Require the board to commission an independent review of the plan three years after commencement and, after five years, to implement a process to determine whether the new system should continue.

- The Office of the State Engineer should establish a water share register and water accounting system for trial in the Diamond Valley.
- If a majority of water holders wish to abandon the new system and revert to the old system after five years, the plan should be dissolved and all the previously held water rights should be returned.[1]

Assuming that timely funding can be obtained, implementation of the Pilot Diamond Valley Water Resource Management Plan could commence as early as the start of the 2016 irrigation season.

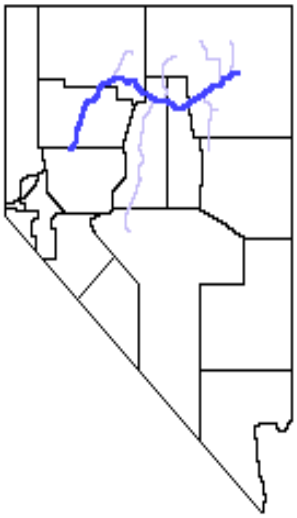
Application to the Humboldt Basin

The Humboldt Basin represents a substantial opportunity to fully implement an unbundled water rights system in the United States. This river is more than 330 miles long and includes both surface and groundwater resources. Wholly located in Nevada, it drains into the Humboldt Sink east of Reno. No interstate issues are associated with water in the Humboldt Basin.

The first stages of implementation, including establishment of the Humboldt Water Management Authority and preparation of the Basin Plan could begin under existing legislation. Detailed implementation, however, may be possible only in those parts of the basin that the state engineer can declare a "critical management area." Full implementation would be less risky if underpinned by legislation.

For administrative purposes, the Humboldt is split into two regions—the Upper Humboldt and the Lower Humboldt—near Palisade. A holding dam has been built in the Lower Humboldt to help supply water to users during periods of low flow. In both regions, there are a number of significant groundwater bodies. A five-year study to assess the degree of connectivity between the ground and surface water systems is under way. In recent years, allocations to irrigators in the Lower Humboldt have been zero.

[1] If at the end of 10 years after the declaration of the Diamond Valley as a critical management area no management plan for this resource has been agreed, the state engineer is obliged to curtail use of all junior water rights and bring the total amount of water used back to into alignment with his or her estimate of perennial yield. On the basis of currently available data, this "brutal solution" would curtail all 316 water rights issued after June 3, 1960, and allow only ongoing use of the 85 water rights issued prior to that date.



To transition to the unbundled water rights system, this blueprint would have to be applied in stages, beginning with system governance, which must be streamlined. The 15-member Humboldt River Authority, which meets several times a year to provide advice and oversight for surface water but not groundwater, would need to be reconstituted as a much smaller board and staff with greater powers as well as supported by the Community Reference Panel. The authority would prepare the Humboldt Basin Water Resource Sharing Plan, encompassing and setting limits on the use of surface water and groundwater resources. It would then develop separate plans for each of the basin's defined water resources (e.g., upper region surface water management plan).

The Basin Plan would set sustainable diversion limits for each defined water resource and establish the sharing rules necessary to enable robust management of flows from one resource to another. In parallel with and consistent with the rules set out in the Basin Plan, a detailed plan would be prepared for each defined water resource.

While the Humboldt Basin Basin Plan and detailed plans for each defined water resource are being prepared, conversion of water rights into shares and use approvals could commence for (1) the main stem of the Humboldt River, (2) each tributary, and (3) each groundwater resource.

Surface Water Resources of the Humboldt Basin

For surface water systems, there is a strong case for grouping shares into multiple priority tiers so that supply risk can be efficiently managed. Allocations would be made first to tier-one shares, then tier-two shares, and so on. Once allocations have been made, shareholders would be free to transfer them to any person.

The transition to a less rigid water rights system would significantly increase economic opportunity. Allocations could, for example, be traded on a daily basis. During periods when there is no flow in the lower Humboldt, tier-one shareholders in the lower system would be able to trade allocations with shareholders upstream.

Groundwater Resources of the Humboldt Basin

In under-allocated groundwater bodies, share allocations are relatively simple and can be made in proportion to each right-holder's volumetric entitlement weighted by seniority. In seriously over-allocated groundwater systems, conversion could follow the processes recommended for the Diamond Valley. Once the sharing system is in place, seasonal allocations would be made and immediately become fully tradeable and bankable at rates that reflect system losses. Under the new system, groundwater users would be able to accept surface water and store it in a groundwater system.

Likely Benefits

As the first western state to pilot test and demonstrate the feasibility of moving to a new system reflecting lessons from Australia's experience, Nevada can expect to gain a leadership position and first-mover advantage.

Under the current water rights system, there is little incentive to innovate and ensure that every drop of water is put to its best use. In the proposed unbundled system, innovation is encouraged. Investment and risk taking is rewarded. A blunt, all-or-nothing irrigation system is replaced with a smart one that encourages every water user to be as efficient and as productive as they possibly can. Two water markets soon emerge, one for shares and the other for allocations.

Australian experience suggests that adoption of a system consistent with the concepts set out in this blueprint will reveal the true value of water and that this value will be used to underwrite and fund much of the investment that can be expected to occur. Widespread innovation and economic development should be expected commensurate with the increased recognition and realization of the value of water. The expected impact of droughts will likely be lessened for those who convert to the proposed sharing system. All water users, whether large or small, will be given equal opportunity.

If the proposed system is rolled out quickly, Nevada might become a leader in providing advice on the most appropriate way to transition to state-of-the-art water right and allocation systems. Development of smart irrigation technology might be ignited. Development of integrated meter recording and water accounting systems as well as development of the systems needed to establish state-guaranteed registers and efficient validation processes might bring significant benefits to the state.

Introduction

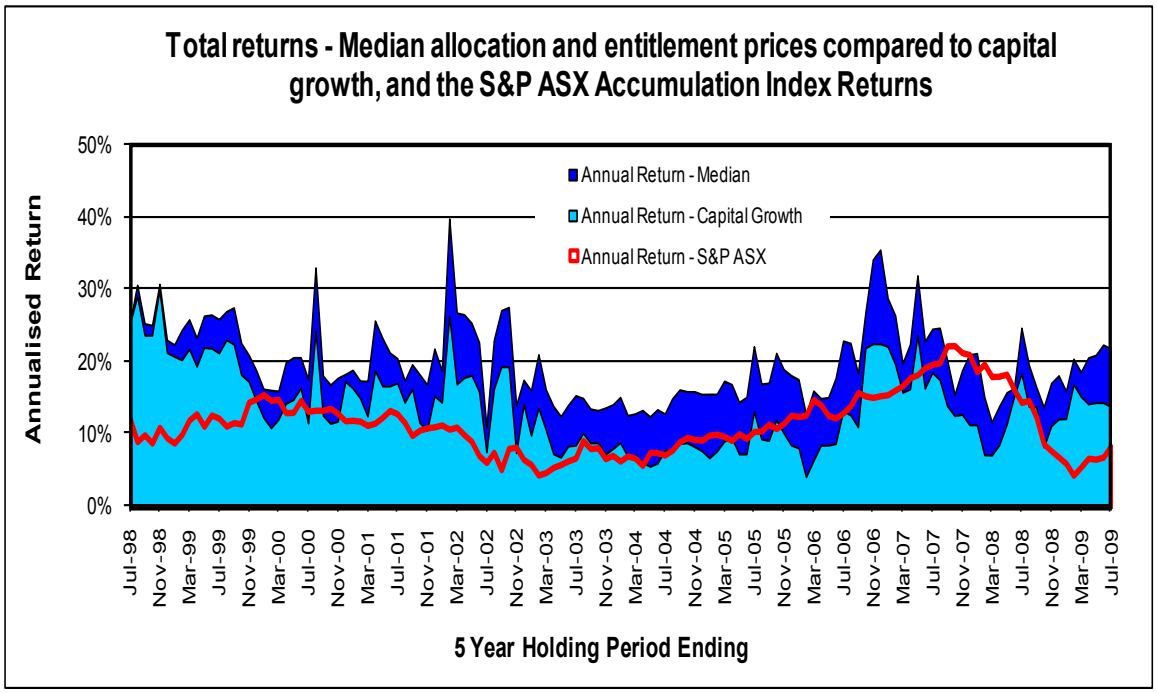
The persistence of droughts across regions of the western United States has triggered a re-examination of water rights and use. Irrigators, manufacturers, and now public utilities face economic losses. Existing water rights no longer appear as secure as they used to be. Their supply is limited. Often, ecosystems are squeezed out of the little water left or are sustained only through complex and costly litigation, often with unclear benefits. The challenges of water management in arid landscapes are driven obviously by scarcity, but perhaps equally by uncertainty about year-to-year water availability and the inability of current water governance to allow transfers of water to those who value it most. That is, many of the challenges now before western water users are due as much to the way water is managed as to how much water there is.

At the start of the 21st century, Australia faced a similar suite of challenges. Fortunately, Australia had already begun transitioning to a much more robust water-sharing system. When the near decade long "millennium" drought hit, Australia was able to increase the pace of reform. Work on long-term sustainability plans and a water rights system in which rights were "unbundled" was already well under way. As the drought hit, the benefits of transitioning to this new system for both the economy and the environment were quickly apparent. Even though water allocations to the irrigation industry had to be cut by two-thirds, the gross value of irrigated agricultural production fell by less than 20% (Gooday 2011). In one year alone (2008–2009), the reforms added $200 million to national GDP. [2]

Despite many differences between the western United States and Australia, there are also important similarities. Much can be learned from the Australian experience, both positive and negative. The primary insight of that experience is that progress comes from building the institutional conditions that enable markets to flourish. In Australia, the gains came from implementation of a sequence of reforms that simplified the system and gave users every incentive to consider selling their water to someone else. As the systems used to define water rights were improved, the value of the rights increased. Water trading became the norm, and profits increased. In the first decade of water reforms, the internal rate of return from holding a water right averaged well over 15% per year (Figure 1).

[2] Economic modeling commissioned by the National Water Commission estimated that Australia's GDP in 2008–2009 was enhanced by AUD220 million as a result of water trading (Bennett 2015). For more information on this reform experience, see Young (2010; 2015).

Figure 1. Return on investment from holding a water right in the Southern Connected River Murray System, selling all the water received for a five-year period, and selling the right after five years



Source: Adapted from Bjornlund and Rossini (2007).

If implemented, the reforms proposed in this paper could be expected to bring similar benefits to the western United States.

Transitioning from an "Old" to a "New" System

This report focuses on increasing the range of economic opportunity available to all water users, on simplifying the systems used to manage change, and on generally reducing costs and risks. The proposed changes also make it easier to ensure realistic opportunities for water to be allocated to ecosystem uses.

Two case studies are developed for the state of Nevada, but at different levels of detail. Although both have been developed in consultation with water users and water managers in Nevada, they should be viewed as illustrative. Stakeholders in these two case study regions should be given access to the resources and allowed the political time and space necessary to consider this blueprint carefully. In addition, the transition from an "old" to a "new" water right system should be the subject of a pilot test. If it fails, all involved in it should be given the option to revert to the "old" system (i.e., the existing water rights system).

Core Concepts

The blueprint is built around six concepts:

- **Well-defined rights and legal enforcement coupled with constraints and limits** on the amount of water that can be taken.
- **Unbundling** of water rights into their component parts:

    - A perpetual right to a proportion of all allocation made,
    - The actual allocation made in any season or part thereof, and
    - An authorization to take water from a defined water resource coupled with an obligation to use it for a beneficial purpose.

- A voluntary, **pilot approach** within well-identified geographical boundaries, with "exit ramps" to protect water rights holders.
- **Legislated plans** that address environmental and regional development concerns up front and that set limits so that water rights holders and water users can go forward without fear that the courts may intervene.
- Electronic access to **water-entitlement registers and water accounts** that define ownership, track water use, and allow trading with bank-like certainty.
- **Administratively efficient processes** designed to speed adjustment and keep transaction costs low.

The result is a regime that is characterized by

- **Robustness** in the sense that the resultant water rights, allocation, and governance systems are designed to work well during times of extreme stress.
- Water rights and administrative systems with **hydrological integrity** in the sense that they properly account for hydrological relationships between each water resource.
- **Efficient management of supply risks** so that those who need access to a very reliable water supply have the opportunity, at an appropriate cost, to secure it.
- **Incentives** that encourage people to search for more efficient ways to save and use water and, also, to invest in resources that use water.

The idea of robustness has led specialists in the design of water rights and allocation systems to search for administrative structures that work well under stress. The literature looks, in particular, for systems that have withstood the test of time (Young 2014). Structures that have endured for centuries include many of the protocols associated with using and accounting for money. One example is the structure of limited liability companies that was invented nearly 150 years ago. In limited liability companies, unit shares are used to define ownership and equity.[3] The rule is simple: once shares are issued, those desiring a larger number of shares must find someone who is prepared to sell them shares. Structures like this are readily

[3] For more information, see Young and McColl (2002, 2003).

transferred to water management. If water users want access to more water, they must find someone who is prepared to sell them this opportunity.

Share corporations have another feature relevant to the management of connected water resources. Shares are unitized and are organized in a manner that makes it relatively simple to move some parts of a company from one business to another and to merge two companies. These same features can be used to enable the equitable rearrangement of water resource boundaries without prejudice to the interests of those affected by the change. If, for example, research reveals that the assumed boundary between two groundwater resources is wrong, then under a unit share system the shares assigned to the wrong resource can be cancelled and replaced with shares in the new groundwater resource without changes to all the shares issued in each resource. If, however, the shares had been defined as proportional shares, each and every share would have to be re-issued.[4]

Another feature that can be borrowed from the corporate world is the importance of boards that can and do make final decisions. When the board of a corporation makes a decision, that decision is final. Shareholders can vote to change board membership, but neither they nor the courts have the power to prevent implementation of a decision (unless illegal). So it is with management of water; shareholders are co-owners of the resource based on the number of shares owned, but the board directs the management of the overall resource itself. As a guiding rule and within reason, the smaller the size of a board, the more likely it is that a good decision will be taken.

Further insights into the best way to manage water can be found by looking at the way money is managed. One fairly recent innovation has been the development of bank accounts that can be accessed over the Internet. Seasonal allocations of water can also be managed with this tool.

Another concept directly applicable to water is the idea of double-entry book keeping, which requires everyone to operate under a simple rule: if one account is to be credited, another account has to be debited.

These ideas and their institutional supports not only simplify water management but also protect third-party interests and keep water use within sustainable limits, making all water users better off.

Building Blocks

Multiple changes to the existing water rights system are needed to establish a robust foundation for a shares-based system.

Unbundling

A key limitation of the current, bundled system is that each water right is fairly unique, and great care must be taken to assess the legal risks associated with existing rights (and potential trades) and to ensure that beneficial use is maintained. In many cases, the decisions associated with a trade get locked up in

[4] Each shareholder's proportional entitlement can be calculated, but shares are never defined as a percentage. No one is ever allowed to own a fraction of a share.

expensive legal proceedings that run for many years. As a general rule, water markets in the western United States have high transaction costs.

The driving concept of this blueprint is that existing water rights be unbundled into their component parts. Among other things, unbundling increases the fungibility of each component. As fungibility increases, each component becomes easier to value, monitor, and trade.

In an unbundled system, the component of a water right that defines the long-term interest is defined as a share. The water that is available for use within a time period (e.g., year or season) is then defined as a seasonal allocation. A share can be thought of as a perpetual entitlement to a portion of any water that is allocated for use. A seasonal allocation can be thought of as an acre foot of water available in a particular season. In an unbundled system, this acre foot can be used, traded, or, with adjustment for losses, saved for use in a subsequent season. The number of seasonal allocations a person receives is a function of the number of shares he or she holds in that particular water resource. When an allocation is made, it is recorded in a water account, but not recorded on a share certificate.

In some systems, the bundle of rights also includes rights to storage, delivery, and, with many caveats, obligations to return water to a water body.

As part of the unbundling process, "old" system water rights will be validated and converted into **priority shares**. The shift from the current bundled rights system to an unbundled system involves several steps. During the conversion process, those with senior rights are issued more shares than those with junior rights. This task is accomplished by multiplying the maximum volume of the right by a seniority co-efficient.

Water shares are like shares in a corporation in that they provide the proportional access or rights to a resource. In the case of water, the number of shares held determines the proportion of allocated water that a shareholder was allowed to withdraw or transfer to someone else. Each year the total amount of water available (i.e., the total allocation) is divided among users by the number of shares held by each. Because all shares and all allocations are identical in form, it is easy to establish their value and to decide quickly whether or not to sell them. If a water user wants access to a larger amount of water (i.e., larger portion of the allocation), he or she must find a shareholder who is prepared to sell shares. In systems in which the total amount of available water fluctuates, several share classes of differing reliability can be used to facilitate the efficient management of supply risk.

During every relevant time period, shareholders will be given **seasonal or annual allocations** of water in proportion to the number of shares they hold. The amount issued to each shareholder is decided by reference to allocation rules set out in the water resource sharing plan for the resource. As these volumes of water become available for use, allocations are formally credited to each shareholder's water account. Each shareholder is then free to use this water, sell it, or, with adjustment for losses, carry it forward for use or sale in a subsequent year.

Every shareholding is linked to a water account, and when water becomes available for use, this fact is established an allocation to the water account. Once an allocation is made, decisions about how, when,

and where to use the allocation are no longer linked to the share. Separated management of shares and allocations enables two forms of trading: (1) **share trading,** which facilitates efficient management of risk and investment and (2) **allocation trading,** which ensures that all water is put to its best economic use.

To enable trade, brokers and dealers can hold water allocations without holding shares or owning land.

Most existing water rights contain a beneficial use requirement obligating the holder of the right to use 100% of any water allocated to him or her in a period. During the unbundling process, this requirement is replaced with an approval that places conditions on the taking and use of water. In an unbundled system, these approvals are similar to the permit needed to construct a house. A typical beneficial use approval would, for example, be location specific and require that all use at that location be metered. There is, however, no requirement for an allocation to be used.

These changes, coupled with parallel changes in governance arrangements, should increase the value of water rights held by local landowners, reduce the adverse impacts of drought on local and regional economies, improve environmental outcomes, and lessen the cost of resource recovery.

Water Resource Sharing Plans

A robust water right and allocation system requires statutory water resource management plans that set out binding rules for the allocation and use of water in each defined water resource. These plans need to be prescriptive and leave as little as possible to judgments that can be contested in courts. When it is possible to trade water allocations from one river reach to another, for example, the plan should dictate the exchange rate that should be used.

Water resource sharing plans are common in many western states but are rarely binding. To make such plans statutory—as would be desirable for the water rights and management regime set out in this blueprint—legislation would require preparation of water resource management plans, registers, accounts, and so on. During the pilot testing proposed for this blueprint, new legislation may not be necessary, but ultimately new legislation would be desirable to ensure that the new water right registers, new accounting systems, and water resource sharing plans have a strong legal basis. Once a plan has received statutory recognition, an allocation trade cannot be appealed, provided it is executed in accordance with exchange rate and trading rules set out in a water resource sharing plan.

In the proposed system, allocations are made to water accounts that relate to a specified river reach or groundwater body. Trade within a reach or groundwater body occurs at a one-for-one exchange rate. Trade from one reach to another occurs at a prescribed exchange rate. Trade, however, does not establish permission to take water from a water body. Taking water from a water body is possible if and only if the taker has shares, has a use approval, and has allocations in the water account associated with that use approval.

In essence, a water resource sharing plan sets out the rules for determining how much water needs to be set aside to provide for base flows, transfer to other systems, and allocations to shareholders. Plans also stipulate how this water may be used and how flows should be managed to take account of environmental

needs, facilitate recreation, maintain water quality, and provide other types of public goods. If these plans are made statutory or are prepared under pre-existing executive authority, the opportunity for a third party to legally challenge them is limited.

For an unbundled water rights system to operate, water resource management plans need to be prescriptive and dictate outcomes. If, for example, a plan prescribes that the exchange rate for the transfer of water from one location to another is 0.8, there should be no opportunity for a third party to oppose a transfer provided the exchange rate used is 0.8. If, however, a plan simply states that transfers should cause no harm to third parties, there is opportunity for the transfer process to hold up a transfer due to the vagueness of language about the exchange rates that need to be made and so on.

Each plan needs to be developed in close consultation with the local community and those who hold water rights. At least one plan is needed for each water resource, and it must establish a set of rules for establishing the sharing regime. In particular, the water resource sharing plan must address how much water must be (1) set aside for conveyance and meeting of downstream obligations, (2) allocated to shareholders, and (3) defined as flood water and, hence, not held as a right.[5]

Each plan should be required to set a maximum sustainable limit on diversions/withdrawals and to put in place a regime allowing this limit to be adjusted as assessments of likely future climatic conditions, run-off, and so on evolve. Rules for allocating (sharing) water as it becomes available need to be unambiguous. If a water resource is over-allocated, for example, the plan must have a scheme that shows how use will be brought back within sustainable limits.

In cases in which interaction between a groundwater resource and a surface water resource is significant, administrative efficiency dictates a high-level "basin" plan providing rules for system interaction and exchange and separate, detailed plans for each defined water resource. These detailed plans focus on sharing relationships within each defined water resource.

The underpinning concept of this blueprint is that third parties need to assert their concerns and positions as water resource plans are being developed. Once a plan has been finalized, third parties can lobby for its review, but they cannot stop trades or allocations made in a manner consistent with plan rules.

As already noted, plans need to be prescriptive and prepared using the best available knowledge. An initial review three years post-transition to the new rights system and at regular intervals thereafter is desirable. Because knowledge will increase as monitoring improves understanding of the impacts of water use on the resource under the new rights system, periodic review of each plan is needed at least every 7 to 10 years.

[5] If it was held as a right, right holders might be legally responsible for its control.

Once a plan is finalized, it must be endorsed by the person responsible for the state's water management and, if possible, it should be approved by the legislature.[6] In Nevada, the responsible person is the state engineer. This blueprint recommends that water resource sharing plans be developed by skill- and expertise-based boards appointed through a process involving the state engineer and county commissioners.

Appendix C contains more detailed guidelines for the preparation of water resource sharing plans.

Pegram et al. (2015) have produced a set of guidelines for the preparation of water resource sharing plans. They stress that such plans and associated sharing systems need to be sufficiently robust to cope with multiple future scenarios, including changes in water availability, water use efficiency, and water demand.

Water Registers

Although present in all western states, water registers are typically incomplete. Even when water rights have been adjudicated, there is no place to identify the rightful owners and the interests associated with them. Some water is managed by the courts, some by government, and some under arrangements that have yet to be defined or quantified. As a result, transactions of water rights involve risk and thus greater expense than they would if rights were clear and transparent. Transparency and certainty can be achieved by building Torrens Title-like water right registers. Under a Torrens Title registration system, water rights are recorded in a central location and the only way a person can secure ownership of a right is to change the name in the register. This system is used for property (i.e., land) ownership in the United States. The system is simple and minimizes all arguments (and associated litigation) about who owns what and to what they are entitled.

The legislation used to establish the Torrens Title system also makes it clear that the only way a person may hold a financial interest in a water right issued under the proposed system is to have that interest recorded in the register.[5] The most common example of an interest is a mortgage. Unrecorded interests have no legal standing and cannot be used to stop the sale or other dealings associated with the right. Torrens Title systems, once implemented, make the costs of buying and selling property and using it as a security for a loan much simpler and more likely.

Torrens Tile-like water registers are likely to be strongly supported by the banking industry, because they simplify and cut the cost of lending money against the value of recorded water entitlements. And because the integrity of new system registers are guaranteed by the state, no title insurance is necessary.

Replacing the current paper-based system with one that relies on a single register would increase the efficiency of water trades. In the United States, it would require a state to legislate to establish a new water entitlement register and to set up an office to build and maintain it. It would also require the

[6] In Australia's Murray Darling Basin Plan development process, the board prepares and submits the plan to the equivalent of the state engineer, who has a fixed time to respond and request changes. The board then considers the suggested changes and submits a revised plan. The engineer must either accept that plan or amend and submit it for ratification by the legislature.

[5] Interests include a mortgage, a caveat, and a right of way or any other condition attached to the right.

surrender of an "old" system title and its replacement with an entry in the "new" register of guaranteed integrity.[6]

Another desirable feature of a Torrens Title-like register is secure, low-cost mortgageability. In Australia, any bank that wishes to take out a mortgage over a water right needs only to complete the necessary forms and to get all parties to sign and lodge the application. The state government then records the mortgage in its water rights register and then guarantees not to transfer this right to another entity without clearance of the mortgage. Legislation establishing the register ensures that no holder of an unregistered interest in a right recorded in a register may prevent its transfer to another person.

In the first instance, conversion from the "old" to the "new" system would involve surrender of an existing right and, following validation of its authenticity, entry of priority, acre feet, and ownership details in the register. As a default position, all names recorded on the land title associated with an old system water right would be assumed to hold an interest in the new right and all such people would be given enough time to propose a different arrangement. Banks are given time to negotiate new mortgage arrangements.

Priority Tiers

In large surface water systems, shares can be grouped into priority tiers or classes so that long-term supply risk can be efficiently managed. In some systems, especially those with little variability, it will make sense to have only one share class. In others, it may make sense to have two, three, or even four. For instance, in Victoria's Southern Connected River Murray System, there are two broad share classes: high-security shares and low-security shares.[7] In New South Wales, high-security shares and general security shares are traded on a regular basis. A single sharing pool would be sufficient for groundwater in the Diamond Valley, because allocations would be made only once a year. In the Humboldt Basin, however, several priority sharing pools might be needed so that users can efficiently manage supply risks by holding a mix of shares of differing reliability.

Conversion from Existing to New Rights System

The first step in establishing a share system is to close access to a water resource and declare that no more shares, licences, or other forms of water right will be issued. Then, a formula for deciding how many shares should be issued to each water right holder is developed and shares are issued. Thereafter, all allocations are made in proportion to the number of shares held.

In most systems, a simple approach is to issue one share per acre inch of water in the existing right. To address seniority of water rights, the formula used to determine the number of shares issued usually starts with multiplication of the maximum volumetric entitlement by the number of years in 100 that a full allocation would be made. If the most senior rights holder is entitled to 4 acre feet, he or she would receive 4,800 shares (4 acre feet x 12 inches x 100 years). If the next most senior rights holder also held 4

[6] The processes are relatively efficient and, in the case of water in Australia, involved about one hour of administrative staff time per water right (Young and Esau 2003).

[7] The Victorian Share register can be inspected at http://waterregister.vic.gov.au/water-trading/water-share-trading#watersharevolumeandpricestats.

acre fee but could expect only to receive an allocation 99 years in a 100, he or she would receive 4,752 shares (4 acre feet x 12 inches x 99 years). Under this approach, those with more senior rights are issued more shares per maximum volumetric entitlement than those with more junior rights.

From this starting point on, all shares within each defined water resource are identical and, as a result, all shareholders gain from the increased opportunity to discover value, to trade, and to borrow. The transfer of a share from one person to another is not subject to third-party appeal, because shares do not determine where or how water will be used. These "water use" considerations are managed through arrangements set out in water resource management plans and in use approvals. Trades, once approved by the system manager, cannot be undone.

Unbundling of rights should reflect the status quo as closely as possible. In over-allocated systems, a case can sometimes be made for simultaneous re-assignment of shares, but unless there is broad community consensus about the best way to do this, great care needs to be taken.[8] The entire conversion process can be destroyed by arguing that the existing regime is inequitable or that now is the time to give someone else an opportunity, to give additional shares to the environment, or both. As a general rule, these conversations are best dealt with separately from the process used to build a register.

Appendix B contains a more formal and detailed specification of the key features of a Torrens Title-like water rights register.

Use It, Sell It, or Save It—Never Lose It

In an unbundled water rights system, there is no obligation to use water. Instead, every encouragement is given to each water user to find ways to use water most efficiently. The emphasis here is on "economic efficiency" not "technical efficiency." When supplies are variable, for example, it is more economically efficient to have a mix of technically efficient and technically inefficient irrigation systems. When little water is available, technically inefficient systems can be shut down at little cost to a business or community. Conversely, when water is abundant, water can be diverted quickly into the inefficient system in a manner that increases the revenue generated from water use.

The spreading of water on a meadow pasture is one example of a technically inefficient but economically efficient water use when supplies are abundant. In a drought, however, all might be better off if the holder of a right to irrigate a meadow pasture is able to sell "his or her water" to someone who could make more money by buying the water and using it to water fruit trees or grow a vegetable crop. Such a water rights holder will be much more willing to sell water during a drought if the investment he or she made in the irrigation land is minimal.

An unbundled water rights system allows unused water to be carried forward from year to year when hydrologically feasible. When unused water is carried forward, adjustments are needed for losses in surface and groundwater systems. The importance of allowing market-driven carrying forward of unused water allocations was driven home during the early stages of developing Australia's water trading

[8] To date, there is no objective review of attempts to simultaneously convert to an unbundled rights system and re-assign shares. For information on the costs of such a process, see Young and Esau (2013).

systems, when it was discovered that all the gains from trade in some parts of the country were being lost because too little water was being carried forward. Trading was deepening rather than reducing the impacts of drought. When the policy was changed to allow water to be carried forward to the next year, the price of allocations doubled, that is, the value of water increased dramatically.[9]

Although robust water entitlement and allocation systems allow unused water to be carried forward, they should not allow borrowing from allocations yet to be made. This feature is necessary to maintain overall system integrity. When a water account is overdrawn, it is usual to allow a grace period, of say, 21 days, to "make good" through the purchase of an allocation. If a water account is not returned to a positive balance within the grace period, the system manager is required to make good on behalf of the account holder and charge that person several times the cost of bringing the account back to a zero balance. [10]

Australian water administrators learned the hard way that a government should never allocate water until it exists in reality rather than forecast. In earlier times, Australian governments promised that some water would always be available at the start of an irrigation season so that irrigators could plan with confidence. In the Southern River Murray system, this promise was based on the assumption that the lowest amount of water available would always be more than the sum of all monthly minima. In 2005–2006, the monthly minima was broken for 11 months in succession and sometimes by a factor of two. As a result, water allocations that people had been planning on accessing had to be cancelled.[11] Today, no Australian water manager makes a water allocation until delivery can be guaranteed. In a robust water allocation system, risks are made clear.

Issuing and Accounting for Allocations

In an unbundled water rights system, water allocations are managed using bank-like accounting systems. Every use approval is linked to a water account. Every share is linked to a water account. All use is metered and accounted for. As soon as an allocation announcement is made, allocations are credited to an account. Use is possible only if user holds a use approval and this approval is linked to a water account. As allocations are used or sold, they are debited from the account. Trading is as simple as logging onto the system and entering the name of the person to whom an allocation is to be transferred. Each individual can access his or her account online and at any time. The availability of summary information to system managers dramatically improves managers' ability to actively inventory water in the system and use impacts on sustainability.

Once bank-like accounting is in place, water-brokering businesses can emerge. Brokers advertise water for sale, and interested water users approach them. Very quickly, break-even prices can be calculated, and, if the price is less than the break-even price, water is purchased.

In an unbundled system, all water use is metered so that the total amount of water that has been used can be tracked and unused allocations can be traded with confidence. With adjustment for losses, metering also allows unused water to be carried forward from one season to the next.

[9] Young and McColl (2007).
[10] Three times the cost of making good is suggested as a penalty.
[11] For a discussion of the 17 mistakes Australia made and the way each error was corrected, see Young (2010).

Table 1 provides a simple mock-up of a water account that shows how allocations are made, trades are executed, and water use is recorded. Access rules are just like those that apply for a bank account. Each account is confidential to the account holder and the system manager.

Summary reports of the state of a system as a whole are available in an anonymized format. For any water resource, everyone can discover how much water has been used, how much is available, and how much has been being carried forward from the previous irrigation season. Unidentified information on the prices being paid is published. Brokers have an incentive to make price information available, because the more that information is available, the more likely they are to be able to organize to transfer water from one person to another.

Table 1. Mock-up of an individual water account

J & J Smith
Diamond Valley Groundwater Resource

Date		Debit	Credit	Balance acre inches
Jan. 1, 2016	Opening Balance			12,000
Jan. 1, 2016	Allocation to shares held in the name of J&J Smith 3,000 shares @ 3 acre inches per share		9,000	21,000
March 10, 2016	Transfer from B&T Smith		3,000	24,000
April 21,2016	Transfer to B Harvey Farms	2,000		22,000
June 10, 2016	Use May 10 to June 10, 2016	500		21,500
July 10, 2016	Use June 10 to July 10, 2016	3,000		18,500
Aug. 10, 2016	Use July 10 to Aug. 10, 2016	9,000		9,500
Sept. 10, 2016	Use Aug. 10 to Sept. 10, 2016	6,000		3,500
Oct. 10, 2016	Use Sept. 10 to Oct. 10	500		3,000
Dec 30, 2016	Use Oct. 10 to Dec. 30	0		3,000
	Closing balance			3,000

Once a water accounting system along the lines shown in Table 1 is established, water trading can occur on a continuous basis.

Regular announcement protocols are important to ensure that insider trading risks are minimized. In Australia's Murray Darling Basin, most announcements are made on the first working day after the first and fifteenth day of each month at 9:00 a.m. In most groundwater rights systems, announcements can be made one month before the start of an irrigation season.

In unregulated systems, in which there is no capacity to regulate flows, allocation announcements need to be made on a near-continuous basis. In some systems, it is possible to establish opportunities to trade options to take water only if water becomes available. These opportunities can created by transferring what is, in effect, an option to take water from one location within a reach to another. In some unregulated systems, water allocations are more efficiently managed by issuing shares in flow rates at the top of a reach and then by using an allocation-exchange rate to determine how much water can be taken at any point along the reach.[12]

Beneficial Use Approvals

As noted above, most existing water rights in the western states require water to be used for a beneficial use and, if water is not used, the status of the right is put at risk. As many others have noted, this kind of beneficial use requirement discourages innovation and efficient water use. However, it allows water managers and the courts to limit impacts on third parties.

Under the proposed system, control of third-party impacts is achieved by issuing separate use approvals and works approvals and by including rules for the transfer of allocations from one reach to another in water resource sharing plans. Use approvals and works approvals are like a development permit and are typically issued by the Office of the State Engineer and or a local government authority. Use approvals are specific to a location and set out all the rules associated with taking water from a water resource. Separation of the use approval from allocations and shares increases efficient use of capital. It is possible, for example, for a landowner to obtain approval to irrigate an acre of land without indicating where or how he or she will source the water.

Among other requirements, a beneficial use approval must always be linked to a water account, and any water used at the location must be sourced from that account. There is, however, no need for all water accounts to be linked to a land title or to a share—a water trader, for example, could have a holding account—groups interested in purchasing water allocations for ecosystems could also hold a water account.

Rules-based Water versus Shares-based Water

In sharing systems, more attention is paid to the physical than to the theoretical nature of water that flows through the system. Rather than simply calling this water environmental or ecosystem water, sharing systems make a clear distinction among the water needed for conveyance, that required for transfer to other systems, that available to enhance environmental outcomes, and flood water. Well-written water resource sharing plans give first priority to the water needed for conveyance. In the United Kingdom, this water is called a "hands off" flow. After water has been set aside for conveyance, the next tranche of water can be shared. In some systems, it is desirable to issue shares, purchase shares, or both for the environment during the conversion process. Australian experience suggests that the allocation of water shares to the environment can increase the efficient delivery of environmental outcomes.

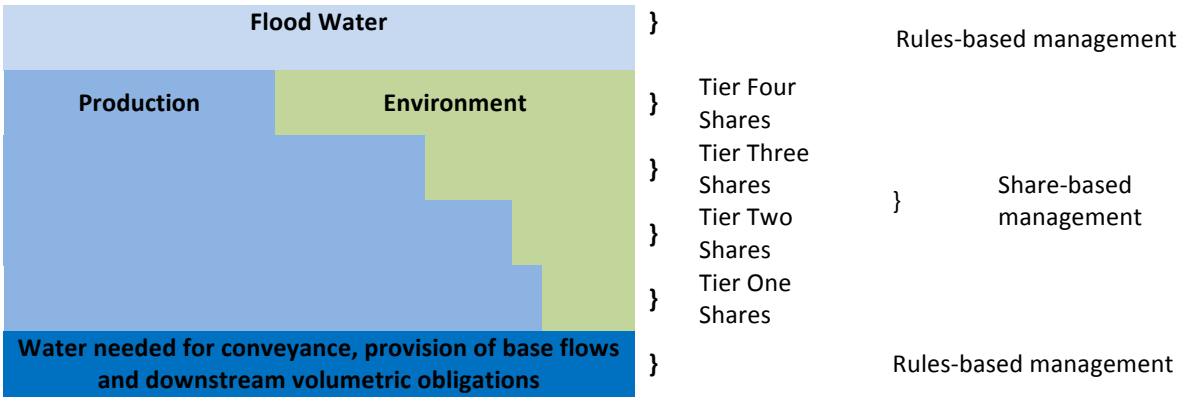
[12] In these systems, a maximum limit on surface water storage can be worthy of consideration.

Great care needs to be given when assigning rights to flood waters. In many cases, these waters are best managed through decision-making rules that do not assign liability to those who seek to minimize the harm that flood waters can cause.

One of the most difficult decisions to resolve when developing a water resource sharing plan is how much water should be managed according to rules and how much through the sharing and allocation system. Figure 2 shows the relationship between rules-based water and shares-based water.

Rules-based water should include water necessary for sustaining broad society priorities such as conveyance water (water delivered to other systems or states) or water for ecosystems. Typically, rules rather than rights are used to manage floodwater. If rights are assigned to floodwater, the rights holder can become liable for any damage that he or she allows "his or her" water to cause.

Figure 2. Relationship between rules-based and shares-based water



Environmental Water Management

In Australia, much has been gained from inclusion of the environment as a shareholder in the allocation system. In the Murray Darling Basin, for example, nearly 20% of water shares are held in trust for the environment by state, federal, and private trusts.[13] Empowered to decide when and how to use water, those responsible for managing shares now held in the environment's interest have begun exploring ways to improve the efficiency of environmental water use. The concept of "more crop per drop" is being matched with the concept of "more environment per drop," and considerable progress is being made.

In some systems, it may be possible to convert some rules-based water to shares-based water. In other systems, however, water shares for ecosystem purposes may have to be purchased from willing sellers and reassigned to an environment trust. To this end, Australia's federal government has been actively purchasing water rights for the environment and investing in projects that enable it to secure water shares for the environment.

[13] For a detailed summary of federal government holdings, see http://www.environment.gov.au/water/cewo/about/water-holdings.

Once a significant environmental share has been established, environmental trusts can engage in counter-cyclic trading. Counter-cyclic trading involves the sale of environmental allocations to irrigators during a drought and the use of this money to purchase shares and thereby increase expected future allocations to ecosystem purposes.[14]

A related issue is the question of how delivery losses are to be managed. In the process of setting up its new systems, Australia gave irrigation districts shares in the *water being lost* from their distribution system (through seepage and other means) but gave individual irrigators shares for the *water being used*. This approach created an incentive for individual irrigators to improve irrigation efficiency and an incentive for districts to improve distribution efficiency.

Trading Rules and Restrictions

Unbundling of rights enables water users to trade both shares and allocations, which allows the emergence of two "markets"—both of which work efficiently without reference to one another. Because the holder of a share holds a perpetual right to a share of all future seasonal allocations, shares tend to be valuable and, hence, are worth using as a bankable security. Allocations, on the other hand, are much less valuable because of their transience. Once allocated, an acre foot of water is exactly that. It should not be possible to mortgage or in any way encumber an allocation, but it should always be possible to encumber a share. In short, a share is something akin to a land title, whereas a seasonal allocation is a volume of water waiting to be used.

When trading is first set up, the most appropriate exchange rate to be used may not be well understood. In that case, in lieu of conversion of a share in one management zone into a share in another management zone (e.g., from the upper to the lower Humboldt River), tagged share trading arrangements can be used. **Tagged trading** involves an agreement to always transfer allocations made to shares in one reach or zone to be "tagged" for trade to another zone as soon as the allocation is made. This trade is made at the exchange rate applying at the time the trade is made. The share always retains its original characteristics, and any person making a tagged trade needs to understand that exchange rates can vary with seasonal conditions and can vary as knowledge about transmission losses and so on improves. In tagged trading, the risk is always borne by the shareholder. But in large river systems, downstream water users can use such trading to reduce supply risk.

During the early stages of this blueprint's implementation, both share trading and allocation trading could be expected to start within a district and to gradually extend to trading within reaches and among hydrologically connected systems. Therefore, rules about the setting of exit fees will need to be developed. An exit fee is the charge that a water user can be required to pay if he or she chooses to permanently transfer water out of an irrigation district and, potentially, leave those within the district with increased operating costs. In Australia, where a water delivery contract is not in place, the maximum exit

[14] In January 2014, in the midst of a drought in the Gwydir Valley, the Commonwealth Environmental Water Holder announced that it had accepted 16 offers to buy a total of 10 gigalitres of water allocations for A$3.217 million and is holding this money until a purchase of water for greater environmental benefit within the Murray-Darling Basin is identified. See http://www.environment.gov.au/mediarelease/commonwealth-environmental-water-holder-water-sale-gwydir.

fee that may be set is 10 times the fixed annual charge that an irrigator would have to pay to his or her district.[15]

Some restrictions on trade make hydrological sense. In Australia's River Murray, for example, the amount of water that can pass through the Barmah Choke is constrained by the choke's narrowness, and trading rules to prevent congestion have had to be developed. The arrangement ensures and maintains hydrological integrity. The aim of trade, however, should be to encourage completion and innovation.

Appendix E contains a set of trading principles. Because many of the controls needed to ensure efficient water trading are generic, it can be more efficient to legislate a set of generic water trading rules and protocols than to include them in each water resource sharing plan.

Governance

During any transition to a new system, the design of governance systems is critical. The key difference between the current and the proposed governance systems is the appointment of boards that take over many of the responsibilities currently undertaken by courts. A sense of trust in and respect for the appointment process must be established. Boards must be perceived to be good listeners and competent decision makers.

As a general rule, literature suggests that the optimal number of board members is five to seven; each person beyond this number diminishes effectiveness by some 10%.[16] This literature also recommends that board members be chosen on the basis of skill and expertise. Skills that need to be well represented on any water board include stakeholder communication and engagement, hydrology, environmental management, irrigation and business management to which end a community reference panel might be established. Community reference panels can assist the board to understand the interests of stakeholders.

It is suggested that boards be comprised of an independent chair with excellent communication and negotiation skills, two to three individuals who have experience in the water-using industry and who are trusted by the community, one individual nominated by the government department responsible for managing water rights and planning arrangements, and one individual responsible for day-to-day management of the water resource.[17]

Boards must be seen to be managing in the interests of all rather than protecting a specific interest, particularly if its members hold shares in or are directly involved in the irrigation industry. Some of the decisions considered by boards can open up opportunities for insider trading. Therefore, if a shareholder

[15] See https://www.accc.gov.au/regulated-infrastructure/water/water-guides for more information.

[16] For a good summary of this literature, see http://dorgerconsulting.com/2011/07/20/size-matters-right-sizing-your-board-of-directors/.

[17] Australia's Murray Darling Basin Authority consists of a chair, a chief executive, and four other members. To be eligible for appointment, an individual must have a high level of expertise in one or more relevant fields. The list of relevant fields includes water resource management, hydrology, freshwater ecology, resource economics, irrigated agriculture, public sector governance, and financial management. Appointments are made for up to four years, and no person is allowed to serve for more than eight years.

is appointed to a board, restrictions on the times when he or she may and may not trade need to be established. Public disclosure of all trades undertaken by board members should be required.

The most appropriate way to appoint members to a board is context specific and depends on the size of the system, the number of counties involved, and so on. As a guiding rule, members should be paid for the work they do and should be appointed on the basis of their skills and expertise. Normally, applications would be called for and an appointment process used. In all cases, the State Engineer would need to approve an appointment and have the power to dismiss members should they behave in an inappropriate manner. In small systems, the local county could run the process. In systems that involve several counties, a formal selection committee would need to be established.

Boards can be advised by a community reference panel of a much larger size (e.g., to obtain broad stakeholder input). Water planning legislation must include a process to ensure that disputes between the board and those responsible for final approval of a water resource sharing plan can be resolved efficiently. In Australia's Murray Darling Basin, for instance, the equivalent of the state engineer has to approve a plan within 12 weeks or refer it back to the board with recommendations for change. On receipt of a revised plan, the equivalent of the state engineer must then either approve the plan or make an alternative one within six weeks. The final plan is then presented to the legislature for approval as subordinate legislation.

System Specifics

When designing a new system, boards must make many important system-specific decisions for which no general guidelines can be provided. In most cases, however, it is useful to consider the administrative costs of the trade-off and the cost of acquiring the knowledge needed to improve decision making. It can be better to be approximately right than comprehensively wrong. The cost of being precisely right can be very high.

Return flows: Net versus gross allocation systems: The first decision is whether to run a "net" or "gross" allocation system. In a net system, the quantity of water likely to be returned to the water resource by each irrigator is estimated. Because the proportion of an allocation that returns to a system depends on irrigation practice, a net system typically adjusts each water account accordingly. But this practice can be administratively expensive because records of irrigation practice, crop type, and so on need to be kept for each water user.

In gross allocation systems, no account is taken of the proportion of water that each user returns to the system from which it was taken. Instead, return flows are managed at the catchment level. Each year, a general assessment of the proportion of water that has been returned to the system is made, and in the following year allocations per share are reduced by an appropriate amount.

The decision to establish a gross allocation system or a net system depends primarily on administrative cost considerations. Most Australian systems are run as gross systems because they are cheaper to administer. These systems incentivize increases in water use efficiency and reward those who move first and, thereby, initially gain access to more allocations than others. If one person never improves the

efficiency of his or her irrigation system and everyone else does, that person's return flows end up subsidizing everyone else's.

Interception by dams, trees, check banks, and so on: Another decision is how to account for actions that reduce the amount of water available to others without using a pump or taking water from a stream. The most common examples of interception include construction of small farm dams and levy banks and planting of trees. In each case, these actions intercept water that otherwise would have reached a water source. Construction of a dam high up in a catchment or of a levy bank will reduce the volume of water that reaches a river. Trees planted over a shallow aquifer can quickly send their roots down into the aquifer and start using large amounts of water.

If the administrative regime is to have hydrological integrity, the sharing system needs to require interception impacts to be offset. In the southeast of South Australia, the planting of trees is regulated because those trees can take as much water as they would if they were being irrigated. In recognition of this fact, any landholder who plants a significant area of trees over a shallow aquifer is required to purchase water shares and or allocations from the dairy farmers and wine producers that tree planting otherwise would have adversely affected. In western states, the introduction of similar mechanisms would do much to reduce the opportunity for third parties to appeal to the courts. All legislation should include a mechanism that allows for the management of significant forms of interception as and when it occurs.

Minor uses: Another decision is which users should not be required to hold a water share because their individual impacts on a water source are minor. In many countries, the taking of water for stock and domestic purposes does not require a water right. The state of the art in the management of minor impacts—which can be significant when added together—is to require a legal entity to hold shares on behalf of all minor interests. In this way, the aggregate impact of minor uses on other shareholders is zero and, hence, hydrological integrity is maintained.

In each case, a pragmatic judgment needs to be made. It may, for example, be appropriate for all people who take less than two acre feet of water per year not to be required to account for the effect of their actions on other right holders. If that is the case, the water resource sharing plan could require a regular assessment of the total volume of water taken by minor water users and could include a mechanism to account for the established collective impacts. In Nevada, one option would be to require each county to hold water shares sufficient to offset this water use.

The environment, floods, and conveyance water: In sharing systems, more attention is paid to the physical than to the theoretical nature of water that flows through the system. Rather than simply calling this water environmental or ecosystem water, these systems make a clear distinction between the water needed for conveyance, that required for transfer to other systems, that available to enhance environmental outcomes, and flood water.

Well-written plans give first priority to the water needed for conveyance. The next tranche of water can be shared. In some systems, it is desirable to issue shares, to purchase shares, or both for the environment during the conversion process. Experience suggests that the allocation of water shares to the environment can increase the efficient delivery of environmental outcomes.

System interconnectivity: Relationships among connected water resources are most efficiently organized through development of a basin plan that sets out, for example, the rules for accounting for and managing interactions among surface and groundwater resources. Plans for each specific water resource can then be prepared in a manner consistent with the basin plan.

One authority should be responsible for managing all connected surface and groundwater resources. Where knowledge about connectivity is uncertain, an adaptive approach should be taken. Full attention should be given to the distribution of risks and clarity about risk assignment.

As a general rule, it is more efficient to replace conjunctive use arrangements with systems that assign shares to each river reach and each groundwater zone and to leave it to users to decide how best to manage supply risk by mixing opportunities to invest in and use ground and surface water resources. Connectivity issues are most effectively managed at the system, not the individual, level.

Terminology: One of the more serious mistakes that Australia made during the early stages of water policy reform was to fail to pay attention to the definition of terms and concepts. Progress was stalled by the tendency of each state to use different terminology. Terms used in one state had a totally different meaning in another state. Early agreement among states and among those involved in developing reforms on terminology and language would have sped progress.

In Australia, discussion was facilitated when it dropped the use of terms like "water right" and focused on the meaning of terms like "shares," "entitlements," and "obligations."

Appendix A contains a glossary that may be helpful in securing agreement on terminology.

Two Case Studies

Two case studies illustrate how the blueprint proposed here might be implemented. Both locations are in entirely within Nevada and thus avoid interstate complications.

The **Diamond Valley** was chosen in part because of the relative simplicity of its ground water system. The case study here has been prepared to demonstrate that

- Conversion from a prior rights to a sharing system is possible.
- Compulsory metering can bring significant benefits.
- Over-allocation problems can be addressed efficiently and equitably.
- Water banking—the carrying forward of unused water from one year to the next—can be highly beneficial for water uses.

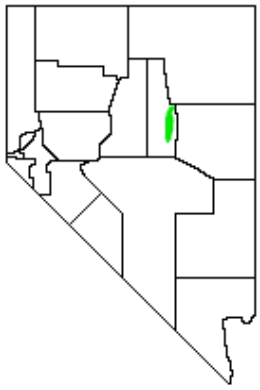
The **Humboldt Basin** was chosen because in many ways it represents an incremental yet significant step in complexity. This basin is substantially larger than the Diamond Valley, includes dams as well as regulated and unregulated surface water reaches, and has connected groundwater systems. If water users in this basin can transition from their current system to an unbundled water rights system, users in many more systems with comparable levels of complexity should be able to transition as well. This second case study has been prepared to address the following issues:

- Trading within and between districts,
- Ground-surface water connectivity,
- Inclusion of environmental/ecosystem water uses, and
- Assignment of rights to transmission losses.

Case Study 1: Diamond Valley

Located, near Eureka, 250 miles east of Carson City, the Diamond Valley contains an aquifer supplying groundwater for agricultural, urban, mining, and livestock purposes. The main product is high-quality hay, which is produced with groundwater pumped through some 200 center-pivot irrigation systems. The first water right in the Diamond Valley was issued in 1890. Today, 720 water rights are held by approximately 110 legally distinct interests. The most junior water right was issued in 2005 for livestock purposes.

The Diamond Valley aquifer is unconfined and highly connected. Pumping at any one location likely changes the water level throughout the valley. A small part of the valley benefits from heavier soil close to the surface, and in these areas some flood irrigation remains.



The quantity of water use has been estimated by tracking changes in depth to groundwater and by combining crop area statistics with estimates of water use per acre. Annual use is thought to be approximately 70,000 acre feet but has recently been closer to 100,000 acre feet. The State Engineer reports that, since 1960, water withdrawals from the Diamond Valley have decreased groundwater elevation by more than 100 feet; the current rate of decline is 2–3 feet per year.[18] The USGS has estimated sustainable yield to be approximately 35,000 acre feet per year. To bring use within sustainable yield, the current rate of water use should be cut in half. Otherwise, the aquifer will be depleted within 30 years.

The Diamond Valley community has indicated that it would like to find a way to transition to a new water rights system, and the state engineer has issued a notice indicating that he intends to declare the valley's groundwater resource a "critical management area."

If Diamond Valley water users wish to prepare a plan that is consistent with this blueprint, the following actions would be appropriate:

- The county should appoint a five-member, expertise-based Diamond Valley Water Board to prepare and, following approval by the state engineer, implement a sustainable water resource sharing plan that would gradually bring withdrawals in the valley into alignment with recharge.
- The board should establish a community reference panel to help it develop and implement the water resource sharing plan.

[18] Notice of intent to declare the Diamond Valley a critical resource management area dated June 29, 2015.

- Given increases in water-use efficiency that the pilot test can be expected to produce, grant funding should be sought to expedite preparation of the water resource sharing plan, meter installation, and development of water registers and water accounts.
- The water resource sharing plan should outline the transition to a new unbundled water rights system and a process that will reduce water use to ensure sustainability of the aquifer.
- The water resource sharing plan should

    - Issue shares to all existing water right holders using a formula that accounts for water right seniority.
    - Begin with a total allocation equivalent to current use and propose a pathway for the transition to sustainable yield.
    - Require the board to make allocations in proportion to the number of shares held and do so well before the start of each irrigation season (February 1 of each year is suggested).
    - Allow water account holders to carry forward as many unused water allocations as desired from one season to the next.
    - Require all significant water use to be metered and recorded in a robust water accounting system.
    - Discourage intentional overuse by setting the penalty for a water account deficit of more than 21 continuous days at three times the cost of restoring the account to a zero balance.
    - Require the county to hold sufficient shares to offset the estimated impact, thereby allowing households and businesses to take small amounts of water without a requirement to holding a water right.
    - Require the board to commission an independent review of the plan three years after commencement and, after five years, to implement a process to determine whether the new system should continue.

- The Office of the State Engineer should establish a water share register and water accounting system for testing in the Diamond Valley.

- If a majority of water holders wish to abandon the new system and revert to the old system after five years, the plan should be dissolved and all the previously held water rights should be returned in a manner that protects the interests of mortgagees.[19]

Assuming that timely funding can be obtained, implementation of the Diamond Valley Water Resource Management Plan could commence as early as the start of the 2016 irrigation season.

Because irrigation water use throughout the Diamond Valley is relatively uniform and little water is returned from urban water use and mining enterprises, the valley would likely obtain maximum benefit by

[19] If at 10 years after the declaration of Diamond Valley groundwater as a critical management area no management plan for this resource has been agreed, the state engineer is obliged to curtail use of all junior water rights and bring the total amount of water used back to into alignment with his or her estimate of perennial yield. On the basis of currently available data, this "brutal solution" would curtail all 316 water rights issued after June 3, 1960, and allow only ongoing use of the 85 water rights issued prior to that date.

implementing a "gross" water-accounting system and by requiring the board to periodically assess changes in return flow and to reduce allocations per share accordingly.

The most difficult issue to consider when developing this proposal has been the design of the formula used to convert existing water rights to shares. More discussion with irrigators and further analysis of data are required to make a final decision. However, on the basis of the available data, it is suggested that all duties under current water right arrangements first be brought into alignment with best practice. In most instances, irrigators in the Diamond Valley have a duty to apply 4 acre feet of water per acre of their irrigated land. In practice, however, most irrigators find it difficult to apply more than 3 acre feet per year to a crop. Best practice is thought to be in the vicinity of 2.5 acre feet. If the duty is reduced from 4 to 2.5 acre feet, the combined duty to use water would be reduced from 131,000 acre feet to 81,000 acre feet.

If this approach is acceptable, the next question is how much weight should be given to those who hold more senior rights, given that many irrigators hold a mix of senior and junior rights. On the basis of available data, it would appear that if rights issued after 1960 are weighted on a sliding scale of between 100% and 70%, the initial total allocation would start at approximately 70,000 acre feet, which is close to current use. If this starting point is acceptable and allocations per share are reduced at a rate of 3.2% per year, sustainable yield (perennial yield) would be reached in 20 to 25 years. A faster adjustment rate might be possible, and the board should be required to carefully consider opportunities to reach a sustainable yield at a faster rate.

In summary, it is suggested that the conversion be accomplished by

- Reducing all rights by a proportion such that each duty aligns with best irrigation practice;
- Assigning shares on the basis of one share per acre inch multiplied by a seniority co-efficient that declines slowly from 100% in 1960 to 60–70% in 2015; and
- Allowing each shareholder to use, trade, or save allocations.[20]

An alternative approach is simply to weight all rights by a seniority factor without adjustment for improvements in irrigation efficiency occurring after the initial 4 acre feet allocation decision. Discussions with existing irrigators and spreadsheet evaluation of the likely implications of this approach suggest that this approach is likely to be preferred only by a small proportion of irrigators.

Another approach is to give each water rights holder the option to opt in or out of the new sharing system and to comply with whatever actions the state engineer imposes on him or her during the test period.

In the Diamond Valley, two surface water springs have not flowed at a rate sufficient to enable rights attached to them to be exercised. Recently, the holders of rights to take water from these springs have taken action in the courts with a view to ensuring recovery of their claimed rights. Under the sharing proposal contained in this blueprint, it would be possible for these claimants to be issued shares and, in effect, become part of the groundwater system. Given the nature of the Diamond Valley's water

[20] The spreadsheet model used to develop this proposal has not been validated. Further analysis is necessary.

resources, it would make hydrological sense to define the springs as part of the Diamond Valley's groundwater system and to include them in the Diamond Valley Water Resource Sharing Plan.

Case Study 2: Humboldt Basin

The Humboldt River is 330 miles in length and drains into the Humboldt Sink east of Reno. The basin includes five counties: Elko, Eureka, Lander, Humboldt, and Pershing.

Fewer than 2,000 surface water rights and some 3,000 groundwater rights are listed in government records for the Humboldt Basin. In total, these rights are held by nearly 1,500 legal entities.

The Humboldt Basin contains some of the largest gold mines in the United States. Although agriculture remains that major user, a significant proportion of water rights are held by mining and mineral processing interests.

The surface waters of the Humboldt Basin were adjudicated over an 18-year period ending in 1935 in what is now known as the "Humboldt Decree." The basin's groundwater resources have not been adjudicated, but because most groundwater development is relatively recent, the Office of the State Engineer's records are considered reliable. All groundwater users in the basin are required to have meters installed by the end of this year and to begin reporting how much water they are using.

On a day-to-day basis, the Humboldt River is managed by two water commissioners, one for the Upper Humboldt and one for the Lower Humboldt. The dividing point between the upper and the lower river system is near Palisade. Several small dams are located in the Upper Humboldt and are used to regulate flow and assist with the supply of essential services. In the Lower Humboldt, the Rye Patch Dam is used to supply water during periods of low flow. In 2014 and 2015, deliveries of water to the Lower Humboldt's Pershing County Conservation District were zero, and in the two years before that they were reduced significantly.

Governance

The 15-member Humboldt River Basin Water Authority meets several times a year to provide advice and oversight for the surface water system but not the groundwater system. To transition to a new water rights system, it is recommended that the existing authority be disbanded and replaced with a board of seven people. Board members would be paid and established as a new authority empowered to employ staff. In practice and once a Humboldt Basin Water Resource Sharing Plan had been approved, this board would take over many of the functions currently managed through appeals to courts. One of their first challenges would be to oversee preparation of a basin plan and resource-specific plans that reduce the need to involve the courts in many decisions.

One of the first tasks of the new Humboldt River Basin Water Authority would be to appoint a community reference panel of 15 to 20 people to help gauge the likely views of all people interested in water use throughout the basin. Most members of the existing authority would likely be appointed to this panel, but it would be widened to include mining and other interests. The authority would regularly meet with and provide detailed briefings to this panel as well as discuss most sensitive issues with it.

The board would then begin preparing a Humboldt Basin water resource management plan that sets limits on the use of the basin's surface and groundwater resources and on the sharing of water among water sources. Basin-wide planning would need to be conducted in parallel with the development of plans for each hydrographic region. A considerable amount of information is already available to assist with plan preparation. In the Upper Humboldt, the USGS has identified eight hydrographic areas.[21]

While the basin plan and resource-specific plans are being prepared, conversion of water rights into shares and unbundling of rights could commence for (1) the main stem of the Upper Humboldt River, (2) each tributary, and (3) each groundwater resource.

By beginning with the unbundling of water rights within each part of the system, progress could be made while the basin plan is being developed. This progress could include installation of meters and development of a means to read them and record use in the water accounts.[22] Registers could be validated during this period.

Surface Water Use

In each surface water resource, careful consultation is necessary to determine whether to establish two, three, or four priority sharing tiers. Australian experience suggests the need for at least two tiers in each part of the surface water system so that supply variability can be efficiently managed. Given that average inflow to the river is in the vicinity of 300,000 acre feet and that the sum of all decreed and permitted water rights is more than double average flow, a case could be made for four classes of shares in most parts of the Humboldt River. As a starting point, is suggested that

- Tier one shares encompass rights issued before 1880;
- Tier two shares cover rights issued between 1881 and, say, 1910;
- Tier three shares include rights issued between 1911 and 1960; and
- Tier four shares cover rights established after 1961.

Currently, allocations in the Humboldt River are made by reference to priority date and crop type and are made on rotation and follow rules established by the Humboldt Decree. When in seniority, "harvest crop" right holders have a duty to use water over a 120-day period; "meadow pasture" holders, for a 60-day period; and "diversified pasture" holders, for a 30-day period. Locked down in the 1930s, the framework

[21] http://pubs.usgs.gov/sir/2009/5014/section5.html.

[22] Integrity of the metering system would be easier to maintain if all meters are owned and read by either by the authority or the Office of the State Engineer.

is rigid and severely restricts the options available to each irrigator. In a low-flow period, water is delivered on rotation, and when it is their turn, the holders of a water right are required to take it.[23]

Under the system proposed in this blueprint, allocations would be made, and users would be free to accept them or to transfer some or all of them to someone else with an adjustment for delivery losses. In the surface water system, shares within each tier would be issued in proportion to the volume that could be expected within a 100-year period and with a further weighting to compensate for differences in the length of time for which water is allocated. Careful consultation with users would be needed to decide whether to issue 120-, 60-, and 30-day shares within each tier.

In the interests of simplicity, it may be more administratively efficient to establish three rather than four priority tiers and to issue them by time period so that nine share types are established, as shown in Table 2.

Table 2. Priority tiers issued by time period that water is available

Priority	**Allocation Period**		
	April 15 to May 14	May 15 to June 14	June 15 to August 15
Tier One	April–May flow shares	May–June flow shares	Summer flow shares
Tier Two	April–May flow shares	May–June flow shares	Summer flow shares
Tier Three	April–May flow shares	May–June flow shares	Summer flow shares

In some reaches and tributaries, it may be politically impractical to unbundle rights and to move to a share system in one step. Where this is the case, the first step could simply be introduction of meters and volumetric accounting coupled with the unbundling of existing rights from use requirements. Allocations would then be made in proportion to the priority table book currently used, and they would be made tradeable.

Each right holder would be issued a separate beneficial use approval that would **not** nominate the crop or pasture that has to be irrigated. It would, however, specify the location or locations where water could be taken, all the conditions associated with its use, and the water account from which allocations are to be deducted as it is used.

In this first step, no right holders would be worse off, and all would be given the opportunity to trade any allocations made to them. Many are likely to choose to sell part of their allocation.

The economic and investment advantages of share title guarantee and mortgageability, however, would be limited to those who proceed to the second step and convert their existing rights into shares.

[23] Informally, some flexibility is offered on a case-by-case basis.

The Lower Humboldt River

Downstream in the Lower Humboldt, right holders could be given a right to a share of delivery losses under a continuous accounting system and shares could be defined by reference to the flow rate at the top of the Lower Humboldt River. At present, the flow rate at Palisade is used to define water-sharing relationships between the Upper and the Lower Humboldt and this flow rate could be used as a basis for issuing shares. If so, shareholders could let their water flow down to Rye Patch Dam and decide how long, with adjustment for losses, to hold it there.

In the Lower Humboldt, as indicated above, there is a case for establishing a system that gives Lower Humboldt shareholders ownership of delivery losses. If losses upstream of Palisade are defined as zero, these shareholders would have an incentive to consider selling allocations made during a dry period upstream. Careful modeling of the proportion of delivery losses to be managed through shares and through system-based rules is warranted.

Consider provision of some 30,000 acre feet in Rye Patch Dam to irrigators in the Pershing Irrigation District. When the system is dry, most of the water released would be lost in transmission. Under a new sharing system, allocations could be made to all shareholders in the Lower Humboldt, and a bidding process could be used to determine how best to maximize agricultural production and minimize transmission losses. The likely consequence is that a few shareholders would decide to irrigate their fields and the rest would decide to sell their water to these shareholders. If so, a much higher proportion of the available water could be used, and a much lower proportion would be lost during transmission. Those who choose to sell their allocations would be compensated by those who end up using the small amount of available water.

Under the proposed sharing system, Lower Humboldt shareholders would be free to carry forward unused allocations in Rye Patch Dam from year to year with adjustments for evaporative and other losses. Similarly, when flows are very low and it is not possible to deliver water to the Lower Humboldt, tier one shareholders would be able to trade allocations upstream to a place where this water can be used. To this end, careful consideration needs to be given to the allocation of a proportion of delivery losses to individual irrigators in a manner that would allow them to sell the resultant savings to upstream users. Rights to some of these delivery losses, however, should be allocated to the district as a whole. If the district can find a way to improve the efficiency of water delivery, it would be free to offset the cost of improving its system by selling the resulting savings.

Efficient Trading

All water use would be metered so that rapid within-reach allocation trading becomes possible throughout the Humboldt River. As in the Diamond Valley pilot test, it is recommended that meters be installed and owned by the state.

Metering would allow each irrigator to optimize water use within and between seasons. Each user would benefit from increased flexibility. The current practice of forcing some irrigators to produce a harvest crop, some to irrigate meadow pasture, and others to diversify pasture would be replaced with a practice that allows each shareholder to optimize use. Considerable restructuring should be expected. New crops may be introduced, and new irrigation land may be brought into production.

Groundwater

Significant groundwater bodies are located on either side of the Humboldt River. A five-year study to assess the degree of connectivity between the groundwater and the surface water systems is under way.

Like surface water use, all groundwater use in the Humboldt Basin would be metered, and, preferably, all meters would be owned and read by the state.

Within each groundwater system, there would be a single share pool.

In under-allocated groundwater systems, share allocation would be relatively simple. Water users would be given an initial allocation of shares in proportion to their maximum volumetric entitlement and would have this amount weighted by expected annual yield. In cases in which the total volume of rights on issue is still within sustainable limits, holders would receive the same weighting. In over-allocated groundwater systems, conversion could follow the processes recommended for the Diamond Valley.

In over-allocated groundwater systems, share assignment would follow the arrangements recommended for the Diamond Valley. Transition to the proposed water rights system could be implemented under the state engineer's existing power to identify a groundwater body as a critical management area. Elsewhere, implementation would be possible if users request the engineer to take such action.

The transition to the proposed rights system for surface water systems might be implementable in areas where all rights holders agree to lease their rights to a company on the condition that transition proceeds in a manner consistent with the concepts presented in this blueprint.

Mining

Mining is widespread throughout the Humboldt Basin and, in some areas, mining is associated with significant dewatering arrangements to stop groundwater flowing into a mine. Where these arrangements are in place and the quality of the groundwater is acceptable, it may be possible for mines to return water to a surface water system or to get credit for storing it underground.

Mines would benefit from the opportunity to purchase shares, allocations, or both as needs arise.

The Humboldt Basin Water Resource Sharing Plan

While sharing systems are being established in each tributary, reach, and groundwater system, water-sharing arrangements for the entire basin should be developed. Consistent with knowledge emerging from the current groundwater study, rules for management of intended and unintended transfers between groundwater and surface water sources would be put in place. These rules must allow for the development of aquifer storage and recovery programs involving the return of surface water to a groundwater system where it can be stored. As a guiding principle, rules for resolution of tensions involving transfers should reflect, as far as possible, current use and should set a uniform timeframe for a return, if needed, to sustainable use.

State Legislation

Under existing legislation and as shown in Box 1 the state engineer could declare a groundwater resource to be a critical management area and could require preparation of and then implement a water resource sharing plan.

This power to declare a critical management area may not extend explicitly to surface water resources. If a groundwater resource area is in a critical state and can be shown to be connected to a surface water resource, it may be possible to argue that the critical management area declaration power extends to an entire basin.

Alternatively, under Chapter 416, the governor may

> devise contingency plans that provide for conserving, allocating, using, increasing the supply or taking whatever steps are necessary to prevent a water or energy emergency, or in the event of a water or energy emergency, to ensure the fairest and most advantageous use of water or energy or of any water or energy source or supply for the benefit of all the people of this state.

Prevention of an emergency such as the failure of an entire irrigation district may be sufficient to justify implementation of the proposed water rights system in the Humboldt Basin.

When the above-described preventative and declaration powers are combined, the state engineer would appear to have sufficient authority to pilot test the proposed rights system in the Diamond Valley and the Humboldt Basin.

Notwithstanding the strong support for this blueprint or a variant of it, new water planning and water allocation legislation could be needed. Such legislation should be generic in its form and should enable conversion to the new rights system on a water resource-by-water resource basis. Once this legislation has been passed, any group of water users should be given the opportunity to elect to test the new system and, if a significant majority are pleased with the outcome, to remain under it.

Rather than preparing a single integrated water resource bill for consideration by the Nevada's legislature, it may be more appropriate to prepare separate bills for

- Validation and conversion of existing rights into shares recorded on a Torrens Title-like registration system,
- Establishment of water allocation accounting systems, and
- Transition to a new water sharing system.

Box 1. Extract from Chapter 534 – Underground Water and Wells

NRS 534.110 Rules and regulations of State Engineer; statements and pumping tests; conditions of appropriation; designation of critical management areas; restrictions.

1. The State Engineer shall administer this chapter and shall prescribe all necessary regulations within the terms of this chapter for its administration.

7. The State Engineer:

(a) May designate as a critical management area any basin in which withdrawals of groundwater consistently exceed the perennial yield of the basin.

(b) Shall designate as a critical management area any basin in which withdrawals of groundwater consistently exceed the perennial yield of the basin upon receipt of a petition for such a designation which is signed by a majority of the holders of certificates or permits to appropriate water in the basin that are on file in the Office of the State Engineer.

The designation of a basin as a critical management area pursuant to this subsection may be appealed pursuant to NRS 533.450. If a basin has been designated as a critical management area for at least 10 consecutive years, the State Engineer shall order that withdrawals, including, without limitation, withdrawals from domestic wells, be restricted in that basin to conform to priority rights, unless a groundwater management plan has been approved for the basin pursuant to NRS 534.037.

NRS 534.037 Groundwater management plan for basin designated as critical management area: Petition; hearing; approval or disapproval; judicial review; amendment.

1. In a basin that has been designated as a critical management area by the State Engineer pursuant to subsection 7 of NRS 534.110, a petition for the approval of a groundwater management plan for the basin may be submitted to the State Engineer. The petition must be signed by a majority of the holders of permits or certificates to appropriate water in the basin that are on file in the Office of the State Engineer and must be accompanied by a groundwater management plan which must set forth the necessary steps for removal of the basin's designation as a critical management area.

Source: https://www.leg.state.nv.us/NRS/NRS-534.html.

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Recommended Reading

There is a growing literature on the design of water abstraction regimes that focus on the Australian experience. To help improve the Australian system, much of this literature is critical of one or more dimensions of the many changes that have and that are still are being made. None of the authors would recommend a return to the system that was in place in the 1970s and 1980s.

Explanation of how the Australian system works nationally:
Australia's National Water Initiative (www.nwc.gov.au)

Explanation of how the Australian system works in each state:

- Victoria (http://www.depi.vic.gov.au/water/governing-water-resources/water-entitlements-and-trade)
- New South Wales (http://www.water.nsw.gov.au/water-licensing)
- Queensland (https://www.dnrm.qld.gov.au/water)
- South Australia (http://www.environment.sa.gov.au/managing-natural-resources/water-use/water-planning)

Reports prepared by Australia's National Water Commission (www.nwc.gov.au):

- *Strengthening Australia's Water Markets*
- *Water Markets in Australia: A Short History*
- *Australian Water Markets: Trends and Drivers 2007–08 to 2011–12*
- *Water Management and Pathways to Sustainable Levels of Extraction*

Papers, books, book chapters, and reports helping inform people about the Australian approach:

- OECD. 2015. *Water Resources Allocation: Sharing Risks and Opportunities.* Paris: OECD.
- Young, M.D. 2015. "Unbundling Water Rights as a Means to Improve Water Markets in Australia's Southern Connected Murray Darling Basin." In *Use of Economic Instruments in Water Policy: Insights from International Experience,* edited by Manuel Lago, Jaroslav Mysiak, Carlos M. Gómez, Gonzalo Delacámara, and Alexandros Maziotis. London: Springer.
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- Garrick, D. 2015. *Water Allocation in Rivers under Pressure.* London: Edward Elgar.
- Bennett, J. 2015 "Doing Better with Less: Lessons for California from Australia's Water Reforms." Reason Foundation Policy Brief No. 129, July 2015
- Young, M. 2014. "Designing Water Abstraction Regimes for an Ever-Changing and Ever-Varying Future." *Agricultural Water Management* 145:32–38.

Reports and papers with a significant impact on the development of the Australian approach:

- Wentworth Group of Concerned Scientists. 2003. Blueprint for a National Water Plan. World Wide Fund for Nature, Sydney.
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Appendixes

Appendix A: Glossary

This glossary is adapted from Australia's National Water Initiative (www.nwc.gov.au) and modified to reflect circumstances in Nevada.

beneficial use approval: A permit or other similar regulatory approval authorizing the taking or capture of water from a defined resource in a manner consistent with the conditions set out in a water resource plan. Such an approval should allow only the taking and use of water in ways that are of net benefit to society.

carry over: With adjustment for losses and storage capacity limitations, the practice of transferring water allocated to a water account from one time period to the next.

consumptive pool: The proportion of a defined water resource that may be assigned to shareholders under the rules of the relevant water resource sharing plan. In a surface water system, it is normal to have two, three, or four consumptive pools each of priority.

consumptive use: Use of water for private benefit consumptive purposes, including irrigation, industry, urban, and livestock, and domestic use.

environmental and other public benefit outcomes: Environmental and other public benefit outcomes are defined as part of the water planning process and are specified in water resource sharing plans. They may include *environmental outcomes* such as maintaining ecosystem function (e.g., through periodic inundation of floodplain wetlands), biodiversity, water quality, and river health targets as well as *other public benefits* such as mitigating pollution and protecting public health (e.g., by limiting noxious algal blooms), indigenous and cultural values, recreation, fisheries, tourism, navigation, and amenity values.

environmental manager: an expertise-based function with clearly identified responsibility for the management of environmental water so as to achieve the environmental objectives of statutory water resource sharing plans. The institutional form of the environmental manager will vary from place to place, reflecting the scale at which the environmental objectives are set, the degree of active management of environmental water required, and the proportion of water set aside primarily for the production of environmental benefits through allocation rules and the proportion of water access entitlements held in the environment's interest. The environmental manager may be a separate body or an existing basin, catchment, or river manager, provided that the function is assigned the necessary powers and resources, potential conflicts of interest are minimized, and lines of accountability are clear.

environmentally sustainable level of extraction: The level of water extraction from a particular system that, if exceeded, would compromise key environmental assets or ecosystem functions and the productive base of the resource.

exchange rate: The rate of conversion calculated and agreed to be applied to water to be traded from one trading zone, or one jurisdiction, or both to another.

extraction rate: The rate in terms of unit volume per unit time that water can be drawn from a surface water or a groundwater system. (Used in in the context of a constraint that might exist due to the impact of exceeding a particular extraction rate at a particular point or within a specified system.)

irrigation district: An area or district that is primarily supplied with irrigation water through water service infrastructure.

metropolitan: Water and wastewater services provided in metropolitan urban areas.

over-allocation: Situations in which the total volume of water that could be extracted by *entitlement holders* at a given time exceeds a system's *environmentally sustainable level of extraction*.

over-use: Situations in which the total volume of water actually extracted for consumptive use in a particular system at a given time exceeds the system's *environmentally sustainable level of extraction*. Over-use may arise in systems that are over-allocated, or it may arise in systems in which the planned allocation is exceeded due to inadequate monitoring and accounting.

reliability: The frequency with which water allocated under a *water access entitlement* can be supplied in full.

rural and regional: Water and wastewater services provided for rural irrigation and industrial users and in regional urban areas with fewer than than 50,000 connections.

seasonal allocation: A specified volume of water that may be taken from a water resource within an irrigation season and, if not used, with adjustment for storage and other losses carried forward for use in a subsequent year.

sharing delivery capacity: An approach to sharing of an irrigation supply channel capacity (supplemented systems) or a water course capacity (unsupplemented) held by an *entitlement holder* and specified as a percentage share or volumetric supply rate at a particular time.

surface water: Water that flows over land and in water courses or artificial channels and that can be captured and stored and supplemented from dams and reservoirs.

termination fee: A fee payable to an operator by a holder of a right of access for terminating access or surrendering a water delivery right.

trading zones: Zones established to simplify administration of a trade by setting out the known supply source or management arrangements and the physical realities of relevant supply systems within the zone. Trade of shares or allocations within a zone can occur without redefinition of the share or allocation. Trade between trading zones may occur at exchange rates other than one for one and, in some circumstances, may require a time delay until the re-assigned water arrives in the new zone and for compensating arrangements to take effect.

unbundling: The process of separating an existing water right into shares, seasonal allocations, and the approvals necessary to make the works necessary to take and use water from a defined water resource.

validation: The process of identifying and confirming an existing water right, identifying all the people and legal entities with an interest in the right, and acceptance of the surrender of the right on the understanding that an equivalent or better right will be recorded in a water right register of state-guaranteed integrity.

water share: A perpetual or ongoing entitlement to exclusive access to a share of water from a specified *consumptive pool* as defined in the relevant water resource sharing plan.

water account: A government-guaranteed record of the maximum volume of water that may be used within a defined period, transferred to another water account, or both.

water allocation: The specific volume of water allocated to water access entitlements in a given season, defined according to rules established in the relevant water resource sharing plan.

water irrigation district: The area under control of an individual water service provider (e.g., an irrigation corporation, cooperative or trust, or water authority).

water plan: A statutory plan for surface water systems, groundwater systems, or both and developed in consultation with all relevant stakeholders on the basis of best scientific and socio-economic assessment to provide positive ecological outcomes and resource security for users.

water system; A system that is hydrologically connected and described at the level desired for management purposes (e.g., sub-catchment, catchment, basin or drainage division, groundwater management unit, sub-aquifer, aquifer, groundwater basin).

works approval: An approval to make and maintain the physical infrastructure needed to take water from a water resource.

water tagging: An accounting approach that allows a traded *water access entitlement* to retain its original characteristics when traded to a new jurisdiction or trading zone, rather than being converted into a form issued in the new jurisdiction or trading zone.

Appendix B: Guidelines for Water Registries and Water Accounts

These guidelines are adapted from Australia's National Water Initiative (www.nwc.gov.au) and are modified to reflect circumstances in Nevada.

Water registers should be established under state legislation and should

- Be of guaranteed integrity.
- Contain records of all water access entitlements or shares in a water resource region that have been validated.
- Contain protocols for the protection of third party interests that

    - Require the holder of a registered security interest, such as a mortgage, to be notified prior to any proposed dealings in relation to the water right and require the consent of such interests to any proposed transfer.
    - Allow only authorized dealings.
    - Require the registration of permanent transfers of the water right and encumbrances that affect the right such as mortgages and other security interests.
    - Prioritize competing dealings and interests.
    - Manage time lags between date of lodgement for registration and actual registration of dealings, as such time lags may affect priorities.
    - Allow for the discharge of the security interest, in conjunction with the transfer of the entitlement, to a new registered holder.
    - Ensure that lenders are only affected by a subsequently registered interest when the lender has consented to the subsequent dealing.

- Be publicly accessible, preferably over the Internet, and include information such as the prices of trades and the identity of entitlement holders.
- Link to water accounts that record all allocations made to the holder of a water right.
- Be organized by the water resource region to which each water access entitlement refers.
- Anticipate that the boundaries of a water resource management region might need to be changed and, in such circumstances and following due process, allow adjustment of the register in a way that preserves the interests of all parties.
- Following due process, allow for the separation of any beneficial use and other conditions from the water right or water access entitlement.
- Allow for the conversion of a water right into unit shares in a manner that is consistent with a statutorily approved water resource sharing plan, legislation, or both.

Appendix C: Guidelines for Preparation of Water Resource Sharing Plans

These guidelines are adapted from Australia's National Water Initiative (www.nwc.gov.au) and are modified to reflect circumstances in Nevada.

- Each plan should state the
    - Water source or water sources covered by the plan (i.e., its geographic or physical extent).
    - Current health and condition of the system.
    - Risks that could affect the size of the water resource and the allocation of water for consumptive use under the plan, in particular, the impact of natural events such as climate change and land use change or limitations to the state of knowledge underpinning estimates of the resource.
    - Means by which risks are to be managed and party responsible for risk management.
    - Number of sharing tiers to be established and the process to be used when unbundling an existing water right and converting it into shares and use approvals.
    - Overall objectives of water allocation policies.
    - Knowledge base on which decisions about allocations and requirements for the environment are being made and steps for improving it during the course of the plan;
    - Uses and users of the water, including consideration of indigenous water use.
    - *Environmental and other public benefit outcomes* proposed during the life of the plan and the water management arrangements required to meet those outcomes.
    - Estimated *reliability* of the water access entitlement and rules for deployment of the consumptive pool among categories of entitlements within the plan.
    - Rates, times, and circumstances under which water may be taken from the water sources in the area or the quantity of water that may be taken from the water sources in the area or delivered through the area.
    - Conditions to which entitlements and approvals having effect within the area covered by the plan are to be subject, including monitoring and reporting requirements, minimization of impacts on third parties and the environment, and compliance with site-use conditions.
    - Conditions that must prevail before a plan is suspended, parties that may decide to suspend a plan, and actions that must occur during the suspension period.
- The relevant plan should specify a pathway to correct *over-allocation* or *over-use*.
- Plan duration should be consistent with the level of knowledge and development of the particular water source.
- A review process should allow for changes to be made in light of improved knowledge.
- Where appropriate, plans should include mechanisms to deal with
    - Relevant *regional natural resource management plans* and cross-jurisdictional plans, where applicable.
    - The level of connectivity between surface water systems (including overland flow) and groundwater systems.

    - Impacts on water users and the environment that the plan may have downstream (including estuaries) or out of its area of coverage, within or across jurisdictions.
    - Water interception activities, including the construction of farm dams and other structures that in one way or another slow the rate of overland flow, groundwater recharge, or both.

- Water planning processes should involve

    - Consultation with stakeholders, including those within or downstream of the plan area.
    - Application of the best available scientific knowledge and, consistent with the level of knowledge and resource use, socio-economic analyses.
    - Adequate opportunity for consumptive use, environmental, cultural, and other public benefit issues to be identified and considered in an open and transparent way.
    - Reference to broad regional natural resource management planning processes.
    - Consideration of, and synchronization with, cross-jurisdictional water planning cycles.
    - Adequate opportunity for the potential impacts of water-sharing arrangements and trading rules among connected water bodies to be identified and considered in an open and transparent manner.

Appendix D: Principles for Regulatory Approvals of Beneficial Water Use and Works

These principles are adapted from Australia's National Water Initiative (www.nwc.gov.au) and are modified to reflect circumstances in Nevada.

- Regulatory approvals enabling water use at a particular site for a particular purpose will

    - Be consistent with water legislation and related natural resource development and planning legislation at the federal and state level.
    - Be consistent with relevant water management plans and water accounting protocols.
    - Take into account environmental, social, and economic impacts of use, including on downstream users, and seek to ensure that water is put to its highest and best use.
    - Clearly state the conditions relating to the approval, including the circumstances and processes relating to variations or terminations of the approval.
    - Minimize application and compliance costs for applicants.
    - Allow for applications to be assessed at a level of detail commensurate with the level of the proposed activity's potential impact.
    - Ensure that full consideration is given to aquifer drawdown, supply congestion, water quality and other local effects.
    - Establish transparent and contestable processes to establish whether a proposed activity is to be approved.
    - Establish avenues for appealing approval decisions.
    - Ensure that every approval to take water from a defined water resource is linked to a nominated water account in a manner that facilitates account deduction as water is used.

- The authority responsible for regulatory approvals must

    - Be separate from water users and providers.
    - Possess the necessary legal authority and resources to monitor and enforce the conditions of a water use or works licence.
    - Periodically benchmark its practices against the practices of peer authorities in other jurisdictions.

Appendix E. Principles for Trading Rules

These principles are adapted from Australia's National Water Initiative (www.nwc.gov.au) and are modified to reflect circumstances in Nevada.

Water trading rules should be established and be consistent with these principles:

- Water access entitlements may be traded permanently through lease arrangements or through other trading options that may evolve where water systems are physically shared or where hydrologic connections and water supply considerations would permit water trading.
- All trades should be recorded on a water register or water account as appropriate.
- Restrictions on extraction, diversion, or use of water resulting from a trade can only be used to manage

    - Environmental impacts, including impacts on ecosystems that depend on underground water;
    - Hydrological, water quality, and hydrogeological impacts;
    - Delivery constraints;
    - Impacts on geographical features (such as river and aquifer integrity); or
    - Features of major indigenous, cultural heritage, or spiritual significance.

- A trade may be refused on the basis that it is inconsistent with the relevant water resource sharing plan.
- The adjustment process associated with trading should be encouraged and should not be taxed as a means to claw back or reduce the total amount of water that may be taken from a defined water sourced.
- Where necessary, water authorities should facilitate trade by specifying trading zones and providing related information such as the exchange rates to be applied to trades in water allocations to (1) adjust for the effects of the transfer on hydrology or supply security (transmission losses) or reliability and (2) reflect transfers between different classes of water sources, unregulated streams, regulated streams, supplemented streams, groundwater systems, and licensed runoff harvesting arrangements.
- Water trading zones, including groundwater trading zones, should be defined in terms of ability to change the point of water extraction and to protect the environment. The volume of delivery losses in supplemented systems that provide opportunistic environmental flows should be estimated and taken into account when determining the maximum volume of water that may be traded out of a trading zone.
- Exchange rates and trading rules should not be used to achieve other outcomes, such as altering the balance between economic use and environmental protection or reducing overall water use.
- Trades should not generally result in a net increase in the volume of water being consumed. That is, trades should generally not cause an increase in the net amount of water being taken from a suite of connected water sources.
- Trade in water allocations may occur within and between connected aquifers or surface water flow systems consistent with water resource sharing plans.

- Trade from a licensed runoff harvesting dam (i.e., not a small farm dam) to a river or aquifer may occur subject to

    - Reduction in dam capacity consistent with the transferred water entitlement,
    - Retention of sufficient capacity to accommodate evaporative and infiltration losses, or
    - Conditions specified in water resource sharing plans to protect the environment.

- Exit or termination fees may be set by an irrigation district to recover reasonable costs to other irrigators of water transfers out of a district.

Nicholas Institute for Environmental Policy Solutions

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