

Idaho's Water: Supply and Quality in a Time of Growth



Andrus Center for Public Policy



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Idaho's Water: Supply and Quality in a Time of Growth

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Arrow Rock Dam is one of three dams in the Upper Boise Basin that provide flood control and water storage.

Executive Summary

- While the Treasure Valley is water rich, the East Snake River Plain has used collaborative governance to curb decreasing aquifer levels. Collaborative governance allows all stakeholders a seat at the table, supporting the development and involvement of these groups could be a useful mechanism for representing the perspectives and interests of all Idahoans.
- Water supply might change in the future, particularly the timing of peak streamflow. This has major implications for irrigation in the valley.
- We do not currently have enough data and information to confidently determine how growth of the urban area and loss of agricultural land will impact total water needs in the Treasure Valley. Density of urban growth and associated urban outdoor water use are major factors of uncertainty.
- Creative market solutions could be a valuable tool for trading water, but they need sufficient oversight in their development to decrease the risk of rural communities losing their water to urban growth. There are examples of these markets being successful in other growing western cities.
- Water quality has been improving in some areas due to innovative solutions and stakeholder engagement.

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Introduction

Water is critical to the future of Idaho's Treasure Valley. A rapidly growing population and changing climate pose dual challenges to the sustainability of the region's large urban centers and vibrant agricultural sector. To address this important topic, the Andrus Center hosted Idaho's Water: Supply, Quality in a Time of Growth in April of 2018. This conference identified an important question that will shape the water security future of the Treasure Valley: *Will the ongoing and rapid displacement of irrigated agricultural lands by urbanization increase or decrease water needs for the region?* There is considerable *disagreement* about the answer to this question, largely due to a lack of data that constrains the several research efforts addressing the topic locally. However, the conference explored the unique characteristics of Treasure Valley's water resource system and established the importance of more definitively answering this question. Participants articulated two conflicting views, some arguing that urbanization should result in more available water, while others arguing that our water needs will remain the same, or increase, with urbanization. Below we summarize some of the key outcomes of the Andrus conference on this important topic. In order to provide background about the history of water in the Western United States and its uses, we asked a number of speakers to provide context for the question framed above. The perspective of those speakers is presented first. In addition, there was a panel discussion on urbanization and water quality, itself an important issue.

Our Water Past

Patricia Limerick, Director of the Center of the American West at the University of Colorado, and Roland Springer, the Snake River District Manager of the Bureau of Reclamation, stressed the importance of understanding how we approached Western water in our past. Limerick, an eminent western historian noted,

"The practices that we know as conservation, the considered careful use of resources, the thought of longer horizons in time, the process of trying to think what would benefit the majority, what kinds of tradeoffs and sacrifices must people make to be part of this enterprise, those practices of conservation originated in very centralized regimes of power." (Idaho's Water, Limerick, pg 76).

Those practices came to us in the Progressive Era at the turn of the last century when there was wide-spread support for constructing infrastructure to build the economic base in the American West. Roland Springer noted this in a reference to President Theodore Roosevelt's 1901 State of the Union Address:

"It is as right for the National Government to make the streams and rivers of the arid region useful by engineering works for water storage as to make useful the rivers and harbors of the humid region by engineering works of another kind." (Idaho's Water, Roland, pg 42)

Just a year later, the Reclamation Act was passed (1902) initiating "The era of improbable comfort made possible by a truly astonishing but taken-for-granted infrastructure" (Idaho's Water, Limerick, pg 77). Limerick then highlighted that managers are trying to respond to the needs of local constituents when historically, solutions were more easily implemented in a top-down fashion from the central government (Idaho's Water, pg 77).

Springer commented on these challenges:

*“sometimes old policies and old contracts and old laws get in the way... so we have to be really creative as a community in dealing with these issues. We all have a goal of managing water well and we have to figure out what our constraints are and how to work through those constraints. We have lots of constituents now... who have a lot of interest, and we work to meet those interests, and sometimes we don’t meet them equally and people aren’t happy with us. But we really try to meet the needs of economics and nation-building and other values that have been created since then in relation to environment and fisheries and those kinds of things. So we need solid policy analysis, we need people that know the issues, but we also need people that understand why and how we got where we are. **And through coming to meetings like these and sharing these thoughts, we can start to understand each other’s perspectives.**”* (emphasis ours) (Idaho’s Water, pg 50).

Will the ongoing and rapid displacement of irrigated agricultural lands by urbanization increase or decrease water needs for the region?

“Idaho has a significant amount of water, an embarrassment of riches.”
(Idaho’s Water, David Robbins, pg 30)

“These social issues about what happens when cities grow into rich agricultural areas and chew up that land and change how the water moves around, that’s difficult. And that’s really where a lot of people in the West struggle.” (Idaho’s Water, Doug Kenney, pg 26).

Box 1

Supply: Precipitation that falls as rain or snow, stored in reservoirs or in groundwater aquifers.

Demand: Water that irrigators, domestic and industrial users require for their needs. *This term is used differently across sectors - irrigation districts often refer to diversions as demand, while others consider demand to be the consumptive use.

Consumptive use: Water that leaves the system from evaporation off of surfaces (such as soil or pavement), or from plants transpiring water through photosynthesis (grass and crops).

Return flow: Once water is applied to a surface, whatever does not evaporate or transpire seeps into the soil. This either supports the local groundwater table or is routed through ditches and drains to other locations to be reused and/ or eventually returned to the river.

Why this question is important:

The population in the valley is projected to increase from 625,000 today to up to 1.75 million by 2100. Tripling the population could result in a tripling of total water use, but conservation strategies, and smart urban development could reduce the per capita water use (Petrich 2016, Western Resource Advocates, 2003). The increasing population of the Treasure Valley has also resulted in rapid displacement of irrigated agricultural land by urbanization. This land use change is accompanied by uncertainty in whether the urban landscapes will use more or less water than their agricultural counterparts.

Forecasted changes in water supply for the Treasure Valley

Planning for future growth requires an understanding of how the water *supply* might change. Incorporating future hydrologic change into our water resources plans will allow us to build resiliency into our community. Research done at Boise State University has shown that the peak streamflow delivered from the Upper Boise Basin could occur 13-17 days earlier than the 1980 -2009 average date of peak of April 22nd (Figure 1, reproduced from Steimke et al., 2018). This shift in timing of peak streamflow would change how much surface water is available later in the growing season. This has important implications for people with surface water rights because the *day of allocation*³ could occur 11-33 days earlier by the end of the century (Appendix Figure 1). So, there could be higher streamflow, but earlier in the season than when people need it for outdoor water use and irrigation. Forecasting how water availability could change in the future will be a necessary and valuable tool for local and statewide water resources planning.

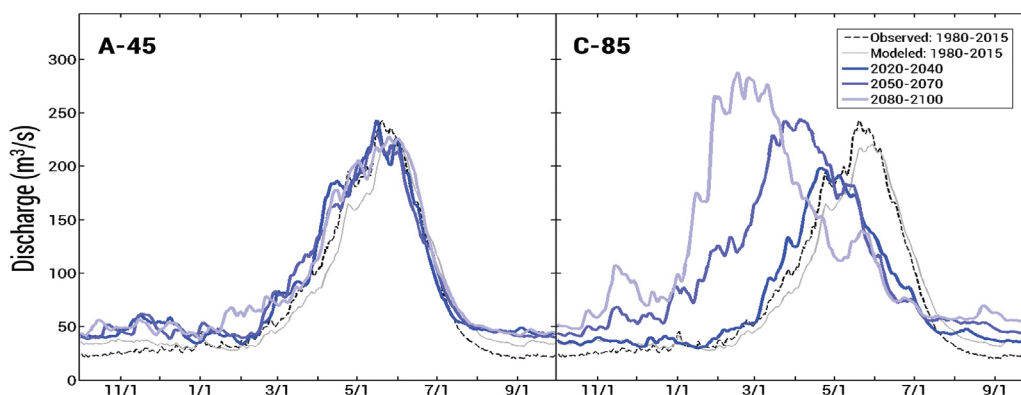


Figure 1. Boise River streamflow averaged over 2-decadal timespans for scenarios predicting the least amount of change (A-45) and the greatest amount of change (C-85) from historical records. Used with permission from Stiemke and Flores 2018.

- 3 Spaceholders in the federal on-stream reservoirs receive their annual storage allocation only after the *day of allocation* has passed, the day of allocation occurs after: (1) the last day of reservoir accrual to reservoir water rights has occurred in the water right accounting; (2) water right diversion demand is equal to or greater than the available natural flow in the river; and (3) the reservoirs have reached their maximum physical total system content. The day of allocation is the demarcation date between water use being met primarily by natural flow and water use being met primarily by storage water releases.

Distinct Characteristics of Treasure Valley Water Resources

In comparison to other western states, Idaho is relatively water rich, but it is operating under a unique set of institutional constraints and environmental conditions. The dominant use of surface water in the Treasure Valley (and across the state) is for irrigation. Groundwater is the main source for drinking water and other domestic/urban uses. These sources are intrinsically connected, when water is applied to fields and lawns, some of it seeps into the shallow groundwater system (Figure 2). Increased efficiencies in agricultural water use has allowed irrigators to apply less water to their fields, while lining of canals with concrete diminishes leakage into this shallow groundwater “pool”.

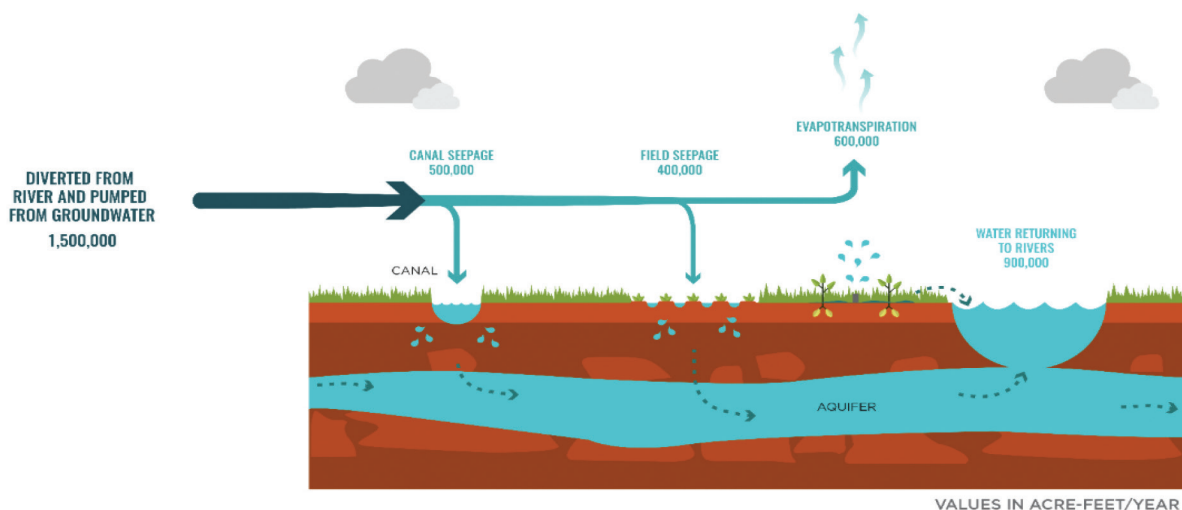


Figure 2. Quantity of water moving through the Treasure Valley. Although 900K ac-ft is “lost” to seepage, it is re-used up to 7 times before leaving the valley (Andrew Waldera used the example that many of the senior water rights below the Star Bridge depend on these return flows (Idaho’s Water, pg 10)).

One distinctive aspect of water use in the Treasure Valley is associated with urbanization of agricultural land. When new subdivisions are developed within irrigation districts, the delivery system used to service agricultural fields are outfitted with pressurized irrigation systems, making them reliant on the delivery of surface water from the irrigation entity (Figure 3). This is a progressive move for the irrigation delivery entities on many fronts, subdivisions in these delivery areas use untreated water for outdoor use rather than using much more expensive treated municipal water. Continuing to deliver irrigation water to lands after they have urbanized is very important for irrigation in the Treasure Valley because the existing irrigation systems generally rely on gravity-based delivery of water, meaning that there has to be enough water in the irrigation ditches to provide water to downstream users. This sets a stage for potential conflict, when long-standing irrigation delivery entities deliver inexpensive water (stored and delivered in expensive infrastructure) to properties where the use has changed from irrigating agricultural land (where water rights owners prioritize conservation) to irrigating green spaces and lawns (with little incentive to conserve water).

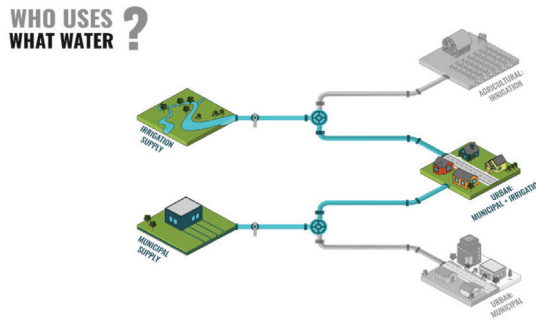


Figure 3. Schematic of the water source for different users in the Treasure Valley. Some new subdivisions have pressurized irrigation water for outdoor water use, while older developments primarily rely on municipal water from groundwater sources.

“I think part of the problem, or part of the opportunity, is people aren’t quite used to paying the appropriate value or cost of water.... They’re frustrated not so much that the water’s not there. The water’s not there at a price they’re willing to pay for it.” (M. Weaver, IDWR, pg 23)

Conflicting Views on the Impact of Urbanization on Water Quantity

Will the ongoing and rapid displacement of irrigated agricultural lands by urbanization increase or decrease water needs for the region?

1. The acres being irrigated are decreasing, so water demand should be less.
2. Diversions are equal to historical diversions, so demands are equal.
3. Suburban landscapes use similar amounts of water than agricultural land, so demand should increase with growth.

Part of the challenge with synthesizing these viewpoints is due to the use of the term “demand”. Irrigators often consider demand to be equivalent to diversions, while others consider demand to explicitly mean the water that leaves the landscape to the atmosphere (consumptive use, Box 1, above). Additionally, there is not sufficient evidence to exclude any of these alternatives, because each is grounded in observations or data that provide incomplete and often only indirect constraint on the water balance.

Available data shows no change over time in diversions from the river (Andrew Waldera, Attorney, Sawtooth Law), but this does not reflect total water demand. The population in the Treasure Valley has more than tripled since 1970, but the increased water use might largely be supplied by groundwater rather than surface water diversions. The area of irrigated agricultural land is decreasing, but much of that water is now used to irrigate in subdivisions. Although there is less area to be irrigated (because of roofs and roads),

those individuals might not be motivated to conserve water because the cost is low. While, farmers are often very conservative with water in low water years, and have the option to select crops that require less water to grow.

Additionally, although the “use it or lose it” mentality exists in western water law, Idaho courts have demonstrated their aversion of water right forfeiture which could occur if an individual does not use their entire water right.⁴

The questions then become, once land becomes urbanized, do they need and/or use as much water, and from which source? How do we incentivize conservation and regulate waste?

Next Steps

“We ought to have a data set that actually puts aside all of the impassioned breast-beating arguments that we go through where the facts actually matter so that we can make good rational public decisions about how we should move forward.” (Idaho’s Water, David Robbins, pg 37)

The Treasure Valley water demand forecast from Idaho Water Resources Board (IWRB) suggests that we might need to triple the amount of water available for domestic use by 2065. While this is a useful benchmark, other growing western cities have grown without increasing water demand (Keystone Policy Center, 2018). There is no one-size-fits-all solution in water management and planning, but other western cities have implemented “Smart Development” plans where they implement water conservation strategies and determine appropriate housing densities to manage outdoor water use with growth (Western Resource Advocates, 2003).

Data needs

The nuances in regard to spatial and temporal variability of consumptive use has driven the IDWR to try to determine if urbanization actually results in a change in water demand. In 2016 the legislature funded the development of a groundwater model for the Treasure Valley through the IWRB. This work will quantify the consumptive use (evapotranspiration) of water in the Treasure Valley from 1986 on using various remote sensing datasets. This is one step towards quantifying the water budget and its change over time. The IWRB and IDWR plan to devote further efforts to refine methods to estimate future water needs in the state, but additional data would certainly be beneficial. Potentially useful data could come from water meters on pressurized systems in suburbs, measurements of canal and field seepage, and measurements of evapotranspiration from urban areas.

4 Historically and currently, neither the State of Idaho or the IDWR actively look for cases that would require forfeiture. Forfeiture matters arise when (1) a water right owner takes some action with IDWR that forces our review of the historical consumptive use of water under a water right; or (2) more commonly, a neighbor requests a forfeiture enforcement action from IDWR against a neighbor.

What are other mechanisms to supply water to a growing population?

Currently, there are a variety of methods for individuals to retain or transfer their water right(s) in a willing seller/willing buyer situation. This can be done by permanently changing the elements of a water right (e.g. changes in water use, place of use, season of use, etc) via the statutorily authorized transfer process, or by temporarily acquiring a water right or changing the elements of a water right through the IWRB's state-wide water supply bank and associated local rental pools (Idaho's Water, Weaver), or by changing rate structures via water markets (Idaho's Water, Creamer). While the IWRB and IDWR provide various mechanisms to trade water, some argue that more flexibility in water markets could incentivize conservation. For example, we could create alternative pricing structures to incentivize conservation, yet as Doug Kenney noted:

“people have this love-hate relationship with markets. There's this idea that, you know, as a country we believe in markets, we believe in capitalism, we believe this is an efficient way to the extent that some water needs to be reallocated, we believe that's the way- markets are the way to do that. But markets are feared, especially in the very arid parts of the West. Markets are feared as a way for cities to take advantage of agriculture and to take whole communities and essentially wipe them off the map.” (Idaho's Water, pg 27)

Colorado has appeared to deal with this fear in several ways, through Alternative Transfer Methods and statutes such as the Agriculture Protection Act. Alternative water transfers include a range of activities that transfer water on a temporary basis, primarily from agriculture to other uses (WestWater Research, 2016). The general goal of these frameworks is to support coordination between urban and agricultural areas to result in joint benefits such as the long-term viability of farming, improved streamflow for both recreational and environmental reasons, and a means for cities to decrease uncertainty in future water supplies. The Agricultural Protection Act permits agriculturalists to change the beneficial use of their water right to include municipal and industrial uses, such that they can rent or lease their water for these other uses, while protecting their right to retain the beneficial use of water for agriculture. There are many statutes in place to mitigate potential disadvantages to local communities, through mitigation-transition payments, additional payments for the communities that aren't receiving revenue from fallowed fields, and statues about water quality (Idaho's Water, David Robbins, 32). As described by Doug Kenney:

“These are transfers that are more about managing the risk of running out of water than about actually increasing an urban area's water supply, because most growing areas, as I say, don't necessarily need more water, but they need more reliability of the water supply they have...There's no net increase in the amount of water used in those deals, but it's shifted in at least that given year between farm and city. But the farms still stay in business, again, it's rotational, it moves from one farm to the next, one plot of land to the next, there's various schemes. A lot of things like that are happening in the West.” (Idaho's Water)

Do we need to develop collaborative governance organizations to provide a more holistic view of water management in the state?

Thus far, Idaho has made substantial efforts to support collaboration across stakeholders (Matt Weaver, Andrew Waldera). The best example is the Snake River Basin Adjudication, it took over 35 years, but we now have a digital inventory of all the water rights and the legal establishment of the quantity of water associated with each water right across the majority of the state.⁵ Without the legal basis of the water right, we cannot administer water rights in times of short supply, yet there are very few states that have an equivalent database. Idaho also created dedicated water rights for groundwater withdraws through the Groundwater Act (1951), while, for example, California just passed the Sustainable Groundwater Management Act in 2014.

There have been multiple comprehensive aquifer management plans that have been developed across the state. These have brought together a range of stakeholders, including irrigators, municipalities, environmental entities and state agencies to set goals for maintaining the sustainability of our aquifers. For example, the IWRB and IDWR are currently developing a Treasure Valley Groundwater-Flow Model and have convened a “technical advisory committee that’s made up of a cross-section of cities and other stakeholder groups water user communities, that are guiding the development.” (Matt Weaver). Interestingly, Weaver notes that the IDWR and IWRB are often asked “to do things that they don’t have the statutory authority to do” (Idaho’s Water, Weaver, pg 22). He highlights that we should consider what statutory changes need to occur, or authorities that need to be put in place in order for full collaboration to be successful.

Forward thinking and collaborative governance will be instrumental in preventing conflicts before they arise. Previously, collaborative work has brought experts from different sectors and stakeholders together, but from the perspective of IDWR, their stakeholders are those with water rights. With an increasingly urban environment, who is representing the people that will be dependent on a sustainable water supply, but don’t have water rights themselves? This is where a systems level examination of water management would be particularly beneficial, it would enable municipalities to have a seat at the table. One particularly interesting question we might ask a collaborative governance group of this sort would be - how do we want to expand? If we continue to transition from agricultural land to urban, our total consumptive use of water might not change very much, but if we begin to develop currently undeveloped land, consumptive use will increase. Urban growth plans will have a significant impact on how water is used in the valley for the coming century.

“... when we do collaborate, when we finally do sit down and start thinking about what we’re gonna do to meet the future needs, then all options need to be on the table and all stakeholders need to be there and we need to be committed to go get the information that we need. ... I think a collaborative process that uses all those tools takes advantage of the universities and their experts and the Department of Water Resources and looks at all options and answers all the questions we need to make an informed decision is the way to go.” (Idaho’s Water, Michael Creamer, pg 22)

5 Adjudication still not completed for Priest River, Pend Oreille River, Kootenai River, and Bear River basins.

Background and Status of Local Water Quality

The Clean Water Act is the federal law that regulates water pollution. This sets the Total Maximum Daily Load (TMDL), which is essentially “a pollution budget for the river” (Idaho’s Water, Stone, pg 57). One challenge with the Clean Water Act is that agricultural areas are exempt; this precludes our ability to regulate those sources of pollution very well. Discharge from Water Renewal Facilities (wastewater treatment) is often high in phosphorus and is a point source of pollution. Because the pollution comes from one source, there can be negotiations about how to manage that pollution. Agricultural settings are non-point sources that are exempt from the Clean Water Act.

The most widespread surface water pollutants in the Treasure Valley are sediment, E.coli, phosphorous and other nutrients (Idaho’s Water, Stone, pg 55). These are “almost entirely non-point source, making them more challenging to manage” (Idaho’s Water, Stone, pg 57-58), yet we are seeing significant improvement in phosphorous and oxygen levels in reservoirs and downstream reaches (Idaho’s Water, Myers, pg 57). Myers noted that some of these successes are due in part to the “willingness and interest of other groups and stakeholders to be involved in water quality improvement projects” (Idaho’s Water, Myers, pg 57). And although there are successes like this, there is always room for improvement, particularly given interactions between constituents like temperature and nitrogen which has led to increases in nuisance algal blooms.

Box 2

Clean Water Act: Federal law that regulates water quality in the United States.

Total Maximum Daily Load: The maximum amount of a pollutant that can be in waters of the US.

Non-point Source: Pollution that comes from many sources, such as streets and yards.

Point Source: Pollution comes from one location (e.g. pipe out of factory or wastewater treatment facility (water renewal facility)

National Pollutant Discharge Elimination System: federal water quality permitting program for waters of the U.S.

Waters of the US: Federally designated water bodies protected under the Clean Water Act. The scope of this designation is currently under litigation with the EPA.

Top water quality topics

Water Renewal

Water renewal is a new way of thinking about wastewater treatment. Rather than simply treating the water, we can use byproducts for various (profitable) uses and renew the water back to drinking water standards. One way that the City of Boise has innovated to manage nutrients in the river is through the development of the Dixie Drain Phosphorus Removal Facility. The Dixie Drain collects ground and surface water 34 miles downstream of Boise’s primary water renewal facilities. It was a cost-effective solution that removes an

additional 1.5 pounds of phosphorus for every 1 pound removed at the upstream facility. The City of Boise uses the Dixie Drain phosphorus removal as a non-point source offset for its water quality permit (NPDES). They sell a form of this phosphorous, called Struvite to be processed into a commercial fertilizer. This facility is an example of a mechanism that can be used to manage non-point sources of pollution associated with urban growth, while developing a product that can help recover some of the costs associated with treatment (Idaho's Water, Burgos, pg 63). Steve Burgos hopes we re-envision the possibilities for waste water in the future. He used the renewed water from Orange County as an example of another community that is trying to break down the "ick" factor to get the most use out of their water supplies.

"...when I start thinking about urbanization, it's almost like we need to break down barriers between these different silos that we have created for ourselves." (Idaho's Water, Burgos, pg 58)

Growth and Storm Water Management

Storm water management plans are another requirement of the Clean Water Act. These might include various types of green infrastructure that can decrease runoff into the streets by allowing water to infiltrate. The goal of these projects is to have the urban environment work more like a natural one, where water is slowly filtered

through the soil, essentially getting treated before entering waterbodies. Density of urban growth has a big impact on storm water management, and from Burgos' point of view, increased housing densities can create better water quality outcomes (58). One concern, is the cost associated with new infrastructure development that would coincide with growth, but Burgos is encouraged because Boiseans continually show their support for water quality. About 72% of Boiseans surveyed are willing to pay more for the infrastructure necessary to have clean water, both now, and in the future with a higher population (Idaho's Water, Burgos, pg 66).

The panelists also stressed the role of education as we move forward as a community. Boise Environmental Education is a partnership between multiple agencies to provide programming to inform both children and adults about our environment and ways to live sustainably. While, this is an important outreach tool, Stone noted the importance of learning from other water users, developing collaborations, and having regulators and advocates continuing to learn about the system and ways to move forward (Idaho's Water, pg 65).

"I think it's an opportunity now to be proactive and not wait for a crisis to hit us. Let's get ahead of it so we can actually say, "Hey, we got a plan moving forward to actually deal with growth, to deal with this urban ag interface." I think the opportunity is now." (Idaho's Water, Burgos, pg 71)

The Link Between Water Quantity and Water Quality

In the Treasure Valley, surface water quality is strongly influenced by our water resource

management system, which is designed to ensure we have sufficient water quantity. Most dramatically, the return flow of irrigation water is the primary contributor to flow on the Boise River in the summer months; contributing about 1,000,000 acre feet of flow annually. While that water provides needed in-stream flows, it also delivers contaminants (sediment, phosphorus and nutrients) to the river. With changing climatic regimes and urbanization displacing irrigated agriculture, there are likely to be substantial changes to the amount and quality of water returning to the river. We do not know enough about how changes will propagate through the system to make predictions about the future impacts on water quality, except to say that it is likely alter the system away from the current state.

References

The Treasure Valley Water Atlas (<https://cid.boisestate.edu/tvwa>) is an additional source of information for those that would like to know more about water law, how water moves through the Treasure Valley, how we use it, and implications for an increasingly urbanized landscape.

Idaho's Water: Supply, Quality in a Time of Growth. 17 April, 2018. Andrus Center for Public Policy Transcript. https://d25vtythmttl3o.cloudfront.net/uploads/sites/135/files/2018/01/Why-Public-Lands-Matter_verbatim-transcript.pdf

Keystone Policy Center. (2018), Colorado Water and Growth Dialogue, Final Report. http://www.keystone.org/wp-content/uploads/2018/10/CO-Water-and-Growth-Dialogue-Final-Report_September-2018.pdf

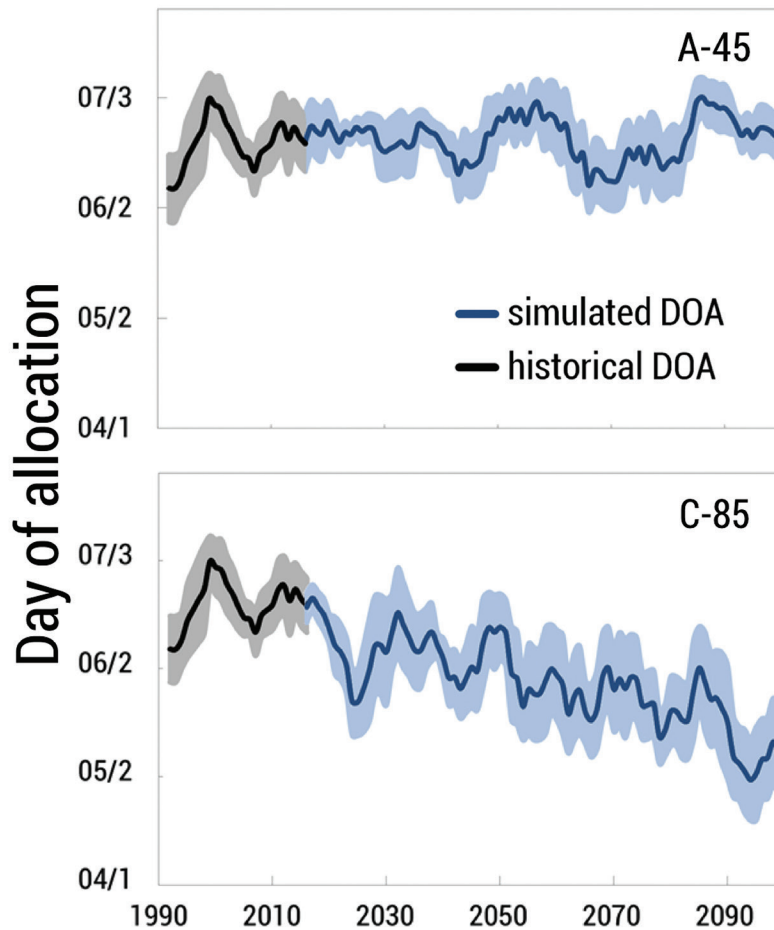
Petrich, C. (2016). Treasure Valley DCMI Water-demand Projections (2015-2065). Retrieved from <https://www.idwr.idaho.gov/files/publications/20160808-OFR-Treasure-Valley-Water-Demand-2015-2065.pdf>

Steimke, A. L., Han, B., Brandt, J. S., & Flores, A. N. (2018). Climate change and curtailment: Evaluating water management practices in the context of changing runoff regimes in a snowmelt-dominated basin. *Water*, 10(10). <https://doi.org/10.3390/w10101490>

Western Resource Advocates. (2003). Smart Water: A Comparative Study of Urban Water Use Efficiency Across the Southwest, 178. Retrieved from <http://www.westernresourceadvocates.org/water/smartwater.php>

WestWater Research. (2016). Alternative Water Transfers in Colorado. Retrieved from edf.org/ATMreport

Appendix



Appendix Figure 1: Historic (1986-2014) and modeled (2010-2099) day of allocation (DOA) under two climate change scenarios, with A-45 being the least amount of change, and C-85 being the most amount of change. Shaded areas show the standard deviation of 7-year moving average values. Of the scenarios tested, the DOA could occur 11 - 33 days earlier by the end of the century. Used with permission from Stiemke and Flores 2018.

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