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Science and Values on the High Desert: Dams and Irrigation on the Deschutes River, Oregon

Zander E. Albertson

Western Oregon University, zalbertson10@mail.wou.edu

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**Science and Values on the High Desert:
Dams and Irrigation on the Deschutes River, Oregon**

By

Zander E. Albertson

An Honors Thesis Submitted in Partial Fulfillment
of the Requirements for Graduation from the
Western Oregon University Honors Program

Dr. Mark M. Van Steeter,
Thesis Advisor

Dr. Gavin Keulks,
Honors Program Director

Western Oregon University

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Abstract

More than a century of irrigation water withdrawals, reclamation, and the construction of the Pelton-Round Butte hydroelectric complex have altered the Deschutes River in central Oregon. An examination of these human impacts in the Deschutes Basin finds the geomorphic and hydrologic impacts downstream of the hydroelectric complex to be less substantial than typically expected, while irrigation water withdrawals in the upper basin remain a serious issue. Mitigation and restoration efforts have achieved success in the larger context of the status quo of water rights and water use in the American West, though much work remains before anadromous fish reestablish a presence in the Deschutes Basin.

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Science Finds,
Industry Applies,
Man Conforms
-Motto of 1933 Chicago World's Fair¹

INTRODUCTION

Dams and river regulation have become inextricable elements of our modern society. Dams are constructed because they provide many benefits, including cheap electricity, navigable rivers, flood control and water storage. In the last two decades, a new understanding has emerged regarding the consequences of dams. Regulated rivers are fundamentally different from their untamed counterparts. Physical and biological components are altered, drastically in some cases. Fish migration is hampered or blocked entirely. Natural flow regimes, riparian vegetation and channel quality are changed as well. Society now faces the choice of managing rivers solely for anthropogenic interests, or to integrate intrinsic environmental and ecological values. Our choices in river management are intertwined with and influenced by social, economic and scientific forces.

In his classic work on the American West, *Crossing The Next Meridian*, Charles Wilkinson introduces the forces he describes as the “lords of yesterday.”² These “lords” are central to understanding issues facing the West, issues that can be understood as “wicked by design.”³ These issues are difficult to solve due to the fact that they go beyond any one scientific, public policy or economic analysis, and instead mix all three

¹ McCully, 2001

² Wilkinson, 1992

³ Nie, 2008

aspects of analyzing and solving problems. These issues are compounded by the involvement of long standing political institutions, laws and public policy. By nature, these issues are not as easily definable as those in the natural sciences, since they cross into many fields.

The lords of yesterday, while creating enormous economic opportunities and providing for great freedom to develop resources in the West, carry forward a legacy of law from yesterday that dictates public policy today. Utilitarianism is the fundamental principle that drives the lords of yesterday. Lords of yesterday are not people, but “laws, policies, and ideas” from the last century that play a central role in governing natural resources in the West. These laws, combined with government policies and paradigms of another era, do not align with the modern West’s shifting cultural, environmental and social values. Yet they play an extraordinary role in shaping land and resource management in the West, creating a number of issues that are wicked by design: among them are the issues of dams, irrigation and water rights.

Westerners often refer to a way of life that is under attack: mill closures in recent decades are just one example. “The language of scarcity is ubiquitous in public land conflict,”⁴ and this can be seen as water users compete for limited water, and those championing the environmental cause fight for an increasingly scarce population of fish in scarce flows of water. The Western way of life is rooted in the same period as the origin of the lords of yesterday, and “The old times influence, and in many cases determine, our actions today.”⁵ The long-standing traditions of water rights and water management have been written into today’s law, affecting both rural and urban users, as

⁴ Nie, 2008

⁵ Wilkinson, 1992

well as the true users of our waters, the fish and other riverine inhabitants. The nature of dams, irrigation and water rights exemplify issues that are wicked by design: they are deeply entrenched in our society and our choices regarding these issues are tangled in public policy, values, laws, institutions, economics and ethics.

Humans have constructed dams for at least two millennia; Egyptians built dams upstream of Cairo 5,000 years ago.⁶ Dams of old were necessarily restricted by technology, and until the 18th century small dams had a limited influence on rivers.⁷ Water-powered mills were commonplace in the 18th and 19th century in East Coast watersheds, and run of the river dams were used for transportation purposes.⁸ Medium and large dams for hydroelectric, irrigation and municipal supply were constructed in the late 1800s and 1900s, and the largest of dams were not built until the 20th century.⁹ With the arrival of heavy machinery and the ambitions of a growing, developing society, the rate of dam construction in the United States peaked between 1935 and 1965¹⁰, and the closing of Hoover Dam in 1936 began a new era in dam building.¹¹ A quarter of all of the currently existing dams in the United States were built in the 1960s alone. Investments and economic development by public and private investors made the 20th century the dam building era, and by the end of the century, 80,000 dams had been constructed.¹²

Hoover and Grand Coulee dams were completed before World War II and Glen Canyon dam in the Grand Canyon was completed in 1963. The formation of the Tennessee Valley Authority set the precedent for managing water over an entire basin,

⁶ Graf, 2005

⁷ Graf, 2005

⁸ Graf, 2005

⁹ Graf, 2005

¹⁰ Collier, et al., 1996

¹¹ Graf, 2005

¹² Graf, 2005

expanding the conceptual and real scale of water management and control in the U.S. Currently, there are more than 75,000 dams over 5 feet tall in the U.S.,¹³ and 60% of the nation's entire river flow can be stored at any given time.¹⁴ To underscore this, dams on the Colorado River can store 4 years of typical flow.¹⁵ The scale of damming in the United States pales in comparison to China, where 22,000 large (>15 meters high) dams exist, compared to the United States' 6,575.¹⁶ The pace of dam construction has slowed in the United States because of the lack of developable sites and changing views on river development.

Today, every large river in the United States has been fragmented: once free flowing systems have been partitioned and disconnected.¹⁷ More than 75,000 dams dot the landscape, and all watersheds larger than 750 square miles have some dams.¹⁸ Most of the dams are small, but much of the storage capacity (63%) resides with a small number (3%) of structures.¹⁹

Dam removal increased in popularity in the mid-1990s as a growing awareness of the issues posed by dams began to shift public opinion. Interestingly, an understanding that ecosystem changes are related to dam installation has existed for more than two centuries. As early as 1784, legislators attempted to thwart construction of dams on East Coast rivers that would disrupt fish migration. Rules were not enforced, and by 1825 most East Coast rivers were blocked by dams of some kind.²⁰ Throughout the 19th century, observations on both the West and East Coasts noted the role of dams in

¹³ Bednarek, 2001

¹⁴ Collier, et al., 1996

¹⁵ Collier, et al., 1996

¹⁶ McCully, 2001

¹⁷ Graf, 1999

¹⁸ Graf, 1999

¹⁹ Graf, 1999

²⁰ Graf, 2005

restricting fish migrations, and while unregulated fishing was partly responsible, dams played a role as well. Henry David Thoreau concluded dams impaired migration, and “advocated the removal of the structures with crowbars.”²¹ In the mid 1920s, researchers recognized the correlation between dams and declining salmon numbers by making vast upstream areas inaccessible for spawning. Though there was some limited awareness of dam impacts in the early 20th century, the effects of many large dams did not become obvious until the 1970s and 80s, primarily because the 1960s was the time of peak dam construction.²²

A brief look at societal views surrounding our relationship with rivers is illustrative. Today, a free-flowing river is generally attractive to Americans since it appeals to positive values regarding nature. This appreciation comes at the end of a period of shifting values and is different from previous periods when Americans viewed rivers with a strict utilitarian eye: rivers were generators of wealth, and should be fully utilized. In the early 1800s, rivers and canals were the primary means of transportation, and therefore central to business and economics. Rivers have also caught the eye of resource managers who place an economic value on each unit of water, and beginning in the late 1800s rivers generated electricity for public and private customers alike. Through the mid 1950s, rivers were “free” waste disposal systems for industry, municipalities and farms. The construction of dams was seen as a sign of “progress”, and undammed rivers were considered to be “loafing streams”.²³ By the end of the 20th century, these values had shifted to consider a broader range of uses for rivers, including recreation, esthetics and environmental and ecological values.

²¹ Graf, 2005

²² Graf, 2005

²³ Graf, 2005

This shift in perception is important because many of the current social values conflict with inherited values from earlier in the 20th century, leading to inherent contradictions in debates regarding river management and restoration. The essential tradeoff is one of economics v. environment. Dams made possible much of the economic development of rivers, but the cost of this development has been in the area of environmental quality. Many environmental changes resulting from dams have sets of competing and or opposing values. Fish species, recreation, and property values are prominent examples.²⁴ A dam might impede the migration of native fish, but dams also allow for the maintenance of popular sport fisheries. Dams disrupt whitewater recreation but create flatwater recreation opportunities on reservoirs. Looking at property values, the creation of a reservoir may flood valuable agricultural land, but create even more valuable lakeshore property.²⁵

Has society benefitted from regulating rivers? Viewed from an anthropocentric perspective, the answer is yes. They provide cheap and efficient power generation, flood control, irrigation, navigation, and recreational opportunities. Through the control of rivers, humans are able to control a variable of the environment that makes living easier and, in some cases, possible in the first place; cities can exist in otherwise impossible locations and humans can irrigate and cultivate previously marginal lands.

Hydroelectric plants on the Columbia River provide 75% of the Pacific Northwest's electricity, and flood prevention has certainly saved many lives and improved property values.^{26, 27} Stepping outside of human benefits, the presence of dams

²⁴ Graf, 2005

²⁵ Graf, 2005

²⁶ Bednarek, 2001

²⁷ Collier, et al., 1996

is problematic for riverine ecosystems. When water is released from a dam, it is often done at times and rates different from natural rhythms. In addition, the water that is released is typically different in its quantity, temperature, nutrient levels, and sediment load. These changes interrupt and alter most of a river's important ecological processes.²⁸ In some rivers, dams have drastically reduced sediment transport, and greatly reduced or eliminated floods, with the effects reaching hundreds or thousands of miles.²⁹

Every river is unique in terms of its flow regimes, the landscapes it flows through and the species it supports, so the impacts and operating pattern of every dam is unique. While the majority of the world's dams have already been completed, some of the environmental effects of a dam may not be realized or understood for decades or centuries.³⁰ A dam can therefore be seen as a "huge, long-term and largely irreversible environmental experiment without a control."³¹

THE ENVIRONMENTAL IMPACT OF DAMS

"You people are very skillful in getting these fish into cans. Cannot you be just as skillful in getting these fish raised over a dam?"

-Comment at public hearing for the first dam on the Columbia River, 1924³²

There are two broad categories of environmental impacts of dams: those which are directly related to dam construction and those which are related to the operation of the dam. They are outlined in detail in the box below. The most significant result of these impacts is that they produce complex and interconnected environmental disruption through the fragmentation of the river ecosystem. Populations of species up and

²⁸ Ligon et al., 1995

²⁹ Graf, 1999

³⁰ McCully, 2001

³¹ McCully, 2001

³² McCully, 2001

downstream of the dam are isolated and migrations are cut off. Because almost all dams serve to control floods, they also fragment ecosystems by removing the river from its floodplain, and the elimination of flooding is perhaps the single most ecologically damaging impact of a dam.³³

The Primary Environmental Impacts of Dams

A. DIRECT IMPACTS OF DAM AND RESERVOIR

1. Upstream change from valley to reservoir
2. Changes downstream in geomorphology of bed and banks; delta, estuary and coastline altered due to sediment load change
3. Water quality changes: temperature, nutrient load, turbidity, dissolved gasses (particularly dissolved oxygen)
4. Reduction of biodiversity due to blocking of natural organism movements and woody debris, and because of changes listed above.

B. IMPACTS OF DAM OPERATION

1. Changes in downstream hydrology:
 - a. Change in total flow volume
 - b. Change in seasonal timing of flows
 - c. Short-term fluctuations in flows
 - d. Change in extreme high and low flows, including elimination of floods
2. Changes in downstream geomorphology due to altered flow regimes
3. Changes in downstream water quality and temperature due to altered flow regimes
4. Reduction or change in riparian habitat, particularly because of flood elimination

Adapted from McCully, 2001

Depending on the purpose of the dam, the magnitude and duration of flow releases from above the dam will vary. A flood control dam keeps its reservoir low or empty, while a water supply reservoir should be full as long as possible.³⁴ At some dams, all or almost all of the water is withheld from the downstream reach, and only secondary sources such as tributaries, seepage, groundwater and springs provide water to the lower

³³ McCully, 2001

³⁴ Collier, et al., 1996

reach. On the other extreme, large water releases may occur relatively frequently depending on irrigation and hydroelectric needs as well as reservoir capacity. Whatever the release pattern, the flow regime is almost certainly different from natural flows.³⁵ In the words of Wallace Stegner, “a dammed river is not only stoppered like a bathtub, but it is turned on and off like a tap.”³⁶ Because of these variables, no one generalization can be made about the specific impacts of dams on flow regimes, except that flood peaks will be reduced,³⁷ yet it is clear that flow alterations have a multitude of environmental consequences. Erosion rates of both the riverbed and riparian area are increased and the river is stripped of natural woody debris and vegetation, which are an important source for food and habitat.³⁸

All rivers carry sediments from the rocks and soils they pass over, and all dams and reservoirs trap at least some of this sediment. By trapping this sediment, the river downstream is starved of its normal sediment load. Large dams and reservoirs will typically trap more than 90%, and sometimes almost 100% of inbound sediment.³⁹ The clear, sediment-free water released from the dam is said to be “hungry”, and will seek to regain some of its original sediment by eroding the bed and banks of the river. Over time, all the easily erodible material on the riverbed downstream from the dam will be removed, leaving the bed “armored” with rocks. This armored bed does not provide the gravels needed for spawning of fish and habitat for river-bottom invertebrates such as insects and crustaceans. It is not uncommon for riverbeds to be eroded up to 10 feet

³⁵ Williams and Wolman, 1984

³⁶ McCully, 2001

³⁷ Williams and Wolman, 1984

³⁸ McCully, 2001

³⁹ McCully, 2001

within a decade of dam installation.⁴⁰ Over time, the major impact on the downstream river will be to narrow and deepen the river channel, turning wide, meandering rivers with gravel bars and beaches into relatively straight, deep and narrow channels with little complexity.

Dams store water in reservoirs for at least a short period, and even short-term storage has detrimental effects on water quality. The effects are dependent on how deep the reservoir is and the length of storage. Water released from deep in a reservoir behind a high dam is typically colder in summer and warmer in winter than river water, while water released from the upper portion will be warmer year round.⁴¹ Warming or cooling of the natural river water changes the amount of dissolved oxygen present in the water, which is vital for the health of organisms including fish. Temperature changes, when viewed in a seasonal framework, disrupt lifecycles of aquatic creatures including their breeding, hatching and metamorphosing.⁴²

Nutrient load changes also result from dams, since dams act as traps for nutrients moving downstream. During warm weather, algae proliferate near the surface of reservoirs, feeding off of the eutrophic reservoir. The algae photosynthesize and consume nutrients and produce large amounts of oxygen. This means that surface reservoir releases, particularly in the summer, tend to be warm, nutrient depleted and loaded with algae. The heavy algae load can provide food for fish, but also coats gravel beds and greatly reduces water quality for irrigation and municipal purposes.⁴³

⁴⁰ McCully, 2001

⁴¹ McCully, 2001

⁴² McCully, 2001

⁴³ McCully, 2001

Salmon and steelhead are anadromous fish: they are born in freshwater and migrate to the ocean to mature before returning to their home rivers to spawn. Salmon always return to the same reach where they hatched; dam obstruction of migration to home spawning reaches means that out of the original 400 salmon and steelhead stocks of the Pacific Northwest, only 214 remain. One hundred sixty nine are at moderate or high risk of extinction.⁴⁴ While modern modifications to dams such as fish ladders allow for fish to negotiate their way upstream, downstream migration remains problematic. Migration of juvenile salmon, or smolts, is often fatally hampered by the time to swim and negotiate reservoirs. For example, during years of low flows or excessive water withdrawal, smolts on the upper Snake River can now take up to 39 days to reach the ocean, compared with less than three days in the pre-dam environment.⁴⁵

Dams and Irrigation

One of the primary benefits that dams have to offer is associated with watering the West: irrigation. By controlling water flows and storing water for release year-round, dams fit hand in hand with the distribution of irrigation water. Irrigation diversions remove water from the primary river channel and divert it to the end user where it is either distributed or stored for use later in the season. Reducing the amount of water in the main river channel has a variety of implications including water quality issues such as increased water temperatures as well as reduced riparian vegetation.⁴⁶ Irrigation diversions are directly correlated with warmer water temperatures: as diversions increase, instream flow is reduced, leading to a greater warming of the remaining water.

⁴⁴ McCully, 2001

⁴⁵ McCully, 2001

⁴⁶ Houston, 2008

Downstream warming is natural in most rivers, but it is exacerbated greatly by water withdrawals.⁴⁷ Irrigation withdrawals have direct impacts on fish: low flows when some or all water is diverted may strand fish by leaving the riverbed dry. Even when a flow of water remains, increased temperatures hamper fish spawning and reduce essential nutrient levels including dissolved oxygen.⁴⁸

The prior appropriation doctrine dictates the way in which water is distributed across the West. The doctrine states that water rights are hierarchical in nature, meaning that the earlier a right was issued, the more senior it is. Consequently, senior water rights holders receive priority access to water. The doctrine is based on the premise of “first in time, first in right.”⁴⁹ Water rights seniority becomes especially important in drought years and in areas where rights are over allocated.⁵⁰

The prior appropriation doctrine for managing water rights came about from miners in the American West who diverted water for their mining operations. They used a simple rule for water capture: “first in time, first in right.” If one or two men arrived and diverted an entire stream, so be it. They needed it and depended on it, so they had rights to it. Without the confidence provided by a water supply, how could a miner operate confidently to maximize his economic benefit?⁵¹ Though the water was free for the taking, after the initial appropriation the water right was akin to a piece of property meaning it could be leased or sold. The water laws of the miners were first tested by the California Supreme court case *Irwin v. Phillips* in 1855. The prior appropriation system was upheld, cementing first in time, first in right as the standard in California. The

⁴⁷ Houston, 2008

⁴⁸ Houston, 2008

⁴⁹ Wilkinson, 1992

⁵⁰ Yake, 2003

⁵¹ Wilkinson, 1992

decision was understandably driven by “inexorable social, economic, equitable, and pragmatic forces... It was, as the opinion put it, a matter of ‘a universal sense of necessity and propriety.’”⁵² Prior appropriation doctrine spread throughout the West, where newly arriving farmers adopted and depended on it, and California courts followed the trend. Prior appropriation was the law in the courts because it had already become the law of the miners and farmers.⁵³

Later developments added some conditions that were consistent with the utilitarian outlook of the miners who devised the system. To obtain a water right, an appropriator needed to divert water from the watercourse, and that water needed to be put to “beneficial use.” Beneficial uses of the period merely fell in line with the extractive mindset of the time and had little resemblance to our modern definition of a beneficial use where multiple uses are at times acknowledged. Such uses of the time included mining, agriculture, industrial, municipal, domestic, stock-raising and hydropower.⁵⁴ This meant that instream uses could not qualify, nor did using water to protect wildlife or maintain a waterfall. “In-stream uses were doubly disqualified”, on the grounds that any water flowing by without utility was effectively wasted.⁵⁵ The concept of multiple uses or instream flows beyond human extractive uses simply did not exist. Colorado announced such a philosophy plainly in its constitution, but all states practice it: “The right to divert... shall never be denied.”⁵⁶ Prior appropriation made sense when it was implemented: Western water was there and free for the taking, and property once it had

⁵² Wilkinson, 1992

⁵³ Wilkinson, 1992

⁵⁴ Wilkinson, 1992

⁵⁵ Wilkinson, 1992

⁵⁶ Wilkinson, 1992

been claimed. The prior appropriation today is an example of a lord of yesterday that dominates water in the West, to the detriment of many involved.

Attitudes of old die hard. Interviewing a farmer in Oregon, American West professor Charles Wilkinson asked the farmer what he thought about the instream flow that had been set by the State upstream. “I don’t like it,” he said firmly. “I don’t like it at all. It can’t do me any harm and maybe it would help me some... And maybe it would help the fishing. But I don’t care about any of that. I just don’t believe in those things.”⁵⁷

Unlike any other federal resources used for private interests such as mining, grazing, and timber harvest, water is free. One pays nothing to obtain a water right. Admittedly, hard work may be invested initially to set up a diversion canal, and one might pay an irrigation district to operate and maintain the system. But the water itself, arguably the most precious resource in the West, is free: “you pay no fee, tax, charge or royalty, not even a token payment like the \$5 per acre fee for taking a lode claim to patent under the hardrock mining law.”⁵⁸ Yet while free, a valid water diversion is transformed into a full property right the moment the water is diverted. When another user such as a state or conservation organization wishes to buy the water right and convert it into an instream use, it must pay full market value. Senior water users have free, superior and unregulated rights, making it difficult to establish much less maintain instream flows. Given that junior rights holders have a tentative position at best for obtaining water in some areas, the problem with obtaining instream flows lies not just in obtaining a water right that yields “real”, flowing water, but also overcoming the attitudes expressed by the Oregon farmer, who just cannot comprehend dedicating a single drop of

⁵⁷ Wilkinson, 2006

⁵⁸ Wilkinson, 2006

water to the river itself. The result: “A near-paranoia pervades nearly aspect of instream flow policy.”⁵⁹

An instream use is defined to be “any use that supports benefits derived from keeping water flowing in-channel. Most often the term describes the public users defined... [as] recreation, pollution abatement, navigation, and an array of environmental purposes, including fish and wildlife preservation. Instream uses are eligible for protection through instream water rights.”⁶⁰ An instream water right is a water right typically held by the state in the interest of instream uses as outlined above.

Even once an instream right has been set, its legitimacy is called into question in any time of water shortage. A few cubic feet per second generates great debate when it is for fish or kayakers but is defended when for human utilitarian use.⁶¹ Bridging this issue requires a combination of financing to fund the purchase of water rights to reserve the instream flows, a mechanism for which to purchase the water rights, and a local constituency that understands the need for a balance between human withdrawals and reserved flows. Until the outdated prior appropriation doctrine and the value-laden attitudes that follow it can be adjusted and updated to fit the needs and responsibilities of a changing American West, conflict between users of water, both human and aquatic, will remain.

The following case studies of selected major rivers in the American West illustrate the detrimental environmental effects of dams in action.

⁵⁹ Wilkinson, 2006

⁶⁰ Bastasch, 2006

⁶¹ Wilkinson, 2006

The Snake River

“In little more than one generation, Man has harnessed the tremendous water power of the Columbia Basin... He has tamed flood, improved navigation, and turned deserts into rich farmland... Production of low cost electricity has been a major factor in the Pacific Northwest’s transition from a regional economy based on agriculture and lumber to a more balanced, widely diversified economic and social structure.”

– Bonneville Power Administration⁶²

Hydroelectric power is one of the most important and valuable benefits of river regulation. The Snake River is the most extensively dammed river in the West, and hydroelectric power generation is the overriding priority of the Hells Canyon Complex, which consists of three dams on a 35-mile stretch of the Snake. Twenty-five dams lie on the Snake between its headwaters in Yellowstone National Park and its confluence with the Columbia River 1,000 miles downstream. The Snake is a major tributary of the Columbia, and this powerful river is considered a “working river” to Idaho farmers.⁶³ Irrigation diversions rely heavily on the river, reducing instream flow to as little as 200 cfs in places.⁶⁴ This water irrigates more than 3 million acres, mostly potatoes – an area roughly the size of Connecticut. Upon seeing the usually dry Shoshone Falls standing in contrast to the farms using Snake River water for irrigation, one observer recalled, “I wondered where the water had gone and stood puzzled, feeling that nature had been warped in a sinister way, as if I had seen a three-legged deer or a toothless squirrel.”⁶⁵

Dams on the Snake block salmon migration paths to spawning runs, and frequent high releases have caused depletion of sandbars downstream. Five to fourteen percent of adult salmon are killed at each of the eight dams standing between them and the end of

⁶² Collier, et al., 1996

⁶³ Collier, et al., 1996

⁶⁴ Collier, et al., 1996

⁶⁵ Collier, et al., 1996

their migration run, and those that do survive must also negotiate reservoirs.⁶⁶ Fish ladders and other bypass systems have been constructed at the Hells Canyon Complex, but all were unsuccessful: no salmon migrate above Hells Canyon Dam. In addition to the loss of historic salmon runs, the physical composition of the river has changed as a result of river impoundment.

The three dams composing the Hells Canyon Complex act as large sediment traps. The velocity of moving river water slows as it enters Brownlee Reservoir, allowing the previously suspended sediment to drop to the bottom of the lake. The small amount that does remain suspended and passes through is trapped behind the other two reservoirs directly downstream. Because the vast majority of sediment has settled behind the reservoirs, water released from the complex is usually clear and sediment-free. No significant sediment sources join the Snake until the confluence with the Salmon River, 60 miles downstream. The artificial removal of sediment from the river system has resulted in shrinking beaches in Hells Canyon by 75%.⁶⁷ With each flood, additional sand is scoured from the beaches, but with no upstream sediment supply, beach regeneration is nonexistent. Beaches between Hells Canyon Dam and the Salmon River show the most degradation, while it appears that the Salmon is reintroducing enough sediment to maintain beaches below the confluence.

Commercial river runners and recreationalists alike argue that this change matters, as they are more likely to be forced to camp in rocky, poison ivy-riddled sites off of the river. There is an aesthetic and ethical element to the change too – how much is an intact, complete river system worth? How does one assign a value to inconvenienced river

⁶⁶ Collier, et al., 1996

⁶⁷ Collier, et al., 1996

recreationalists, the value of society's need for energy, the value of preserving the landscape? It is unlikely that Hells Canyon will recover its beaches, and equally unlikely that salmon runs will flourish on the Snake River. Alternative management options exist, the least sophisticated and realistic of which is the dismantling of the dams. Changing the flow regime through patterned releases may mitigate the flow problem but introduce other issues, and would be costly to the Idaho Power Company and its shareholders. Retrofitting the dams to allow for sediment passage is another alternative, but would carry a hefty price tag, and may not be effective enough to preserve the beaches.⁶⁸ In the big picture, none of these management alternatives offers a balanced solution to the river impacts of the Hells Canyon Dam. The Snake River and its dams illustrate the collision of human needs and natural systems, as well as our assessment of relative values and environmental tradeoffs.

The Colorado River

“We’re on their tail, sir. We have a good idea who they are, how they operate and what they’re planning next.”

“But not where they are.”

“No sir, not at the moment. But we’re closing in.”

And just what the hell are they planning next?”

“You won’t believe me.”

“Try me.”

Colonel Grumbo points a finger to the immediate east. Indicating *that thing*.

“The dam?”

“Yes sir.”

“Not the dam.”

“Yes sir, we have reason to think so.”

“*Not* Glen Canyon Dam!”

“I know it sounds crazy. But that’s what they’re after.”

-Edward Abbey, *The Monkey Wrench Gang*⁶⁹

⁶⁸ Collier, et al., 1996

⁶⁹ Abbey, 1975

Any discussion of water in the West will inevitably bring about the Colorado River and Glen Canyon Dam. The Colorado River runs through the heart of the Grand Canyon in Arizona, and is a major desert river that has historically shaped its environment. Diverting and storing Colorado River water for human activities including agriculture, hydropower and urban uses is vital for the seven states served by the river. In the nineteenth century, the rivers of the Colorado River system were altered by a series of diversions and small dams, and large dams were built on the Colorado and its tributaries in the twentieth century to provide a reliable supply of water and ensure storage. These dams have radically altered the flow of the river system and the system is now highly regulated.⁷⁰

The closure of Glen Canyon Dam in 1963 changed the Colorado River and the Grand Canyon forever. Glen Canyon dam was to be the keystone component of the Colorado River Storage Project, composed of six dams on the Colorado, Green, San Juan and Gunnison Rivers. In combination with Hoover Dam 355 miles downstream, Glen Canyon Dam would provide irrigation water, flood control, hydroelectric power and municipal water supplies for California, Nevada and Arizona.⁷¹ The dam formed Lake Powell, which would provide recreation opportunities for millions of people per year. The original impetuous for dam construction was that each state through which the Colorado, San Juan and Green rivers flow was eager to reserve as much water as possible for their own use. Today, Glen Canyon Dam acts as a spigot releasing water to those states – 8.23 million acre-feet per year.

⁷⁰ DiDonato, 2011

⁷¹ Collier, et al., 1996

The large dams on the Colorado have fundamentally altered environmental and ecological processes, the primary of which is the resulting highly unnatural flow and temperature regime. Changes include reduced peak flows, higher base flows, and the absence of a spring flood.⁷² Under its natural flow regime, intermittent high flows and a large sediment supply allowed for great volumes of sand to be stored along the main channel during lower flow conditions.⁷³ During floods, the sand would be mobilized and deposited along higher terraces, forming sand beaches throughout the Canyon. In the pre-dam environment, these sand deposits were the foundation for trees that comprised the flood-level riparian zone and on which various plants and animals relied.⁷⁴ The flattened hydrograph resulting from the upstream dams mean that natural floods necessary to transport and deposit the sands no longer occur, and even when large releases are made, the cold, clear water carries little sediment to the lower reaches. The construction of Glen Canyon dam has controlled flooding and sediment deposition: the scale of high flows due to water release is now controlled by the elevation of the reservoir and amount of input as well as hydroelectric demand. Lake Powell traps nearly all of the sediment that would have been deposited downriver.⁷⁵ The width of the Colorado is narrowed in places due to debris fans, creating rapids. Large floods reworked these debris fans and moved debris from the rapids, but in the absence of flooding such rapids have narrowed and become difficult to navigate. Unvegetated sandbars were also a result of regular flooding, since they are subject to deposition during flooding and erosion after flooding.

⁷² DiDonato, 2011

⁷³ Collier, et al., 1996

⁷⁴ Collier, et al., 1996

⁷⁵ Schmidt et al., 1998

A lack of sediment means that 32% of large, high elevation sandbars in the Colorado decreased in size between 1973 and 1991.⁷⁶

A major effect of the dams has been the fragmentation of the river system. Water is held behind reservoirs and then released, migrating fish have truncated ranges, and sediment is trapped in reservoirs, starving downstream reaches. Processes that once spanned the entire basin, 1800 miles long, are now constricted to just a few hundred miles.⁷⁷ Native Colorado River system fish, evolutionarily adapted to the warm and muddy waters of the Colorado, faced competition even before dam construction, including competition with fishing and non-native sport fish. After dam construction, the river environment changed severely from warm and sediment rich to cold and clear as a result of the dam system trapping sediment and altering water temperature through storage.⁷⁸ Pre-dam temperatures of the Colorado in Glen Canyon had wide seasonal variation, from highs near 26°C (80°F) to lows near freezing; now the water flowing through the intakes at the dam experiences minimal annual variations. As a result, the Colorado is too cold to support reproduction of native fish more than 200 miles below the dam.⁷⁹ Altered temperature extremes wreaked havoc on fish reproduction, and the temperature changes were compounded by the degradation of spawning habitat.⁸⁰

Fish native to the Colorado evolved in an environment that has changed. The highly varied streamflow, temperature fluctuation, sediment load and large input of organic material are conditions which no longer exist. Today, river temperature is dictated by the temperature of the reservoir and the level at which water is withdrawn.

⁷⁶ Schmidt et al., 1998

⁷⁷ DiDonato, 2011

⁷⁸ DiDonato, 2011

⁷⁹ McCully, 2001

⁸⁰ DiDonato, 2011

The chemistry of the water is also impacted by the temperature: the warmer waters below Glen Canyon have less nutrients than cold water does, and because of the releases of cold, clear water and reduced organic materials, the conditions for aquatic macroinvertebrates downstream have changed dramatically.⁸¹ This has in turn affected the food supply for fish. A lack of woody debris accumulated in eddies has also decreased the population of macroinvertebrates. The cold water releases also impede native fish reproduction, and at the same time as native fish populations have been in decline, competition and predation by exotic fish has increased.⁸²

Water that is released from desert reservoirs is more saline than the water entering the reservoir. In the arid, hot West, annual evaporative losses from reservoir surfaces range from 2 feet in the Pacific Northwest to 10 feet in the American Southwest. Evaporation from reservoirs not only loses water (the estimated total of the Southwest's evaporated water waste is 14.6 million acre-feet, more than the entire flow of the Colorado River), but also increases salinity since the concentration of solutes increases as water evaporates and leaves the solutes behind.⁸³ Though the sources of salinity in the Colorado River basin are roughly evenly divided between natural and anthropogenic, the latter are responsible for the increasing salinity in the Colorado: as development increases, so does salinity. Irrigation is easily the largest human-caused source of salinity, accounting for 37% at Hoover Dam.⁸⁴ Salts are leached out when irrigation water is applied to a field and the return flow causes an increase in river water salinity. Following irrigation, reservoir evaporation is responsible for 12% with water evaporating and the

⁸¹ Schmidt et al., 1998

⁸² Schmidt et al., 1998

⁸³ Wilkinson, 1992

⁸⁴ Fradkin, 1996

salts remaining.⁸⁵ High salinity levels cause problems. Agriculturally, crop yields decline and plant mortality increases with the application of saline water. Irrigation diversions and withdrawals have an enormous deleterious effect on the waters of the Colorado: the once-verdant delta at the Gulf of California is dry many years as there has been no regular flow since before 1960.⁸⁶ Irrigators in the West consume between 80 and 90% of all water in the West.⁸⁷

While the impacts of dams are most apparent immediately below the dams, the implications are far reaching. Hundreds of miles downstream riparian habitats are compromised, and floodplain habitats have been reduced as well. What begins as snowmelt in the Rocky Mountains, collecting sediment and nutrients along the way and supporting thriving fish populations now ends in the mudflats of the delta,⁸⁸ a majestic river no more but rather a saline mixture of agricultural runoff and wastewater that stagnates and evaporates before ever reaching the ocean. “To walk down a gravel road just south of San Luis Rio Colorado and watch what remains of the Colorado pass through rusted culverts, bringing not fertility but toxicity to the land, is to ask what on earth became of this stream so revered in the American imagination, and yet so despoiled that it today reaches the ocean a river only in name.”⁸⁹

Rivers are well regarded as lifelines for civilization, and this is particularly true in the arid desert regions that make up the American Southwest. The waters of the Colorado River basin provide many societal benefits to be sure: they irrigate agricultural lands from California to Colorado to Mexico, and provide drinking water to municipalities

⁸⁵ Fradkin, 1996

⁸⁶ Pitt, 2014

⁸⁷ Wilkinson, 1992

⁸⁸ DiDonato, 2011

⁸⁹ Davis, 2013

including Las Vegas, Phoenix, Denver and San Diego. Hydroelectric energy powers homes, businesses and untold air conditioners across the West. Yet despite their economic and utilitarian importance, development and dams on the Colorado River basin and the operation of the associated dams have had negative effects on fish habitats, water quality and quantity, riparian zones, beaches and sediment load. Mitigation of these issues has been attempted by various state and federal agencies with limited success. Because of society's dependence on the services provided by dams and the extent of changes in the balance to the natural environment, dam removal is likely not feasible economically or ecologically. As population growth continues and climate change compounds many issues already present in the Colorado River basin, the complex relationship between humans and the Colorado River will force difficult ethical, scientific and technologic issues to the forefront.

MITIGATION

Dam builders and operators have been required in recent years to make a number of changes to mitigate the harm of their projects. While some mitigation attempts can reduce portions of the negative impacts of dams, mitigation can be dangerous in that it misleads the general public into believing that the dammed river has been restored to a pre-dam condition, with the characteristics of a wild river and fishery. This is not the case. Mitigation can help to offset some of the damage done by impounding a river, but the glossy public relations campaigns waged by hydroelectric companies do not tell the whole story.

The most common mitigation technique used is to release large quantities of water from the reservoir, more than would be released under normal dam operations. These releases are typically intended to benefit fish downstream, but can also be released as “flushing flows” intended to agitate the bed of the river and mitigate armoring. The U.S. Federal Energy Regulatory Commission (FERC) now requires operators of hydroelectric dams to release flows as a condition of dam relicensing. While these required releases can be the essential difference between a previously dry reach of river and one with instream flow, they typically give little consideration to the importance of natural, seasonal flow variation – different quantities of water at different times of the year are fundamentally different from releases of the same quantity year round. Instream flow requirements also tend to ignore the need for exceptionally large flood flows that are an essential part of most healthy river systems. On the whole, managed releases can help to mitigate the effects of dams but cannot re-create the “essential variability and dynamism” of a wild river.⁹⁰

While the aforementioned mitigation techniques can help to minimize the impacts that humans have on the riverine ecosystem, it is important to remember that the simple existence of a dam fundamentally changes the physical and biological workings of the entire ecosystem. Mitigation techniques employed after dam construction can help to “slow the bleeding” but there will always be a price to pay for the benefits society reaps from dam construction. Despite the efforts of hydroelectric companies and reclamation projects to tout the benefits of river impoundments, dams will always carry a high price tag. The Bonneville Power Administration (operating most of the large dams on the Columbia River) spends \$350 million dollars *annually* on “fish and wildlife

⁹⁰ McCully, 2001

investments,” yet the number of adult wild salmon continues to plummet and genetic diversity continues its decline.⁹¹

It is important to keep in mind that the goal of restoring a river to its pre-dam condition through the use of mitigation techniques may be unrealistic. A more realistic goal may be to rehabilitate the ecosystem on the component level in parts of the river, and in other cases the best decision may be to do nothing at all.⁹² Component level restoration involves rehabilitating the condition of one riverine element at a time to a predetermined level to build toward improved health of the overall riverine environment.⁹³ This is complicated by the fact that the social, economic and political context in which an issue is analyzed is the key to success or failure of the involved interests, and determines which parts of society benefit. A healthy river requires a healthy watershed, and the two cannot be separated, meaning that restoration efforts must ultimately consider the entire watershed. For example, where watersheds are degraded by poor or unsustainable farming practices or irrigation, rivers will also be degraded. Addressing issues that are not considered by the public to directly be related to riverine health such as land use in the watershed requires the combined efforts of public policy makers, watershed councils and local governments to work with landholders toward a mutually agreeable solution. These factors come together to muddy the waters of those interested in improving the state of riverine ecosystems.

There is the common perception in river and ecosystem management that a return to the original ecological order is the most desirable objective, but this is not always the case. In the case of some large rivers, including the Colorado, restoration may be

⁹¹ McCully, 2001

⁹² Schmidt et al., 1998

⁹³ Gore, 1995

impossible because of the complex overlap of social, political and economic interests, as well as ecological concerns. If restoration is to be attempted, scientific and value judgments must be made regarding which ecosystem processes to preserve and which to alter or eliminate. In some cases, the status quo may be more desirable.⁹⁴ The situation on the Colorado River is one such example. Lake Powell holds 80% of the upper Colorado River basin's stored water and Glen Canyon dam produces roughly 75% of the complex's total power, which serves a six-state area.⁹⁵ It is no surprise, then, that many agencies have interests in the management decisions to be made, including fish and game departments, recreational, fishing and rafting users, the National Park Service, Native American tribes, and the users of water and electricity in the region including agriculture and municipalities. Any attempt to restore or adjust the Colorado River will require consideration of interests, the impact of the dam, as well as regional climate, geomorphology, human activities, sediment flows and tributary inputs.⁹⁶

Full restoration of the river is ambitious and may not even be possible. While some restoration goals might be met by removing Glen Canyon dam, a full restoration would involve removal of all upstream dams and diversions. Even if this were to happen, the river environment has changed: exotic species such as saltcedar, exotic fish and fish parasites are established and well distributed.⁹⁷ Only massive eradication on a regional scale could adjust this: such action would be highly infeasible and controversial. Potential unintended consequences could also set back restoration goals, with sediment releases

⁹⁴ Schmidt et al., 1998

⁹⁵ Schmidt et al., 1998

⁹⁶ Schmidt et al., 1998

⁹⁷ Schmidt et al., 1998

potentially damaging riparian marshes and other “post dam riverine resources.”⁹⁸ Hydro power and water transfer would have to be compensated for via conservation of generation elsewhere. It is clear that while the aforementioned approaches would benefit some resources and processes, it would have a detrimental effect on others.

Sandbars and riparian vegetation are two resources that would be greatly impacted since they are closely interrelated. The management goals of exposed sandbars and dense riparian vegetation are clearly mutually exclusive, so restoration of bare sandbars would occur at the expense of riparian vegetation. A similar situation exists for fish: “if flooding is crucial to the recovery of flood adapted species... but the absence of floods is crucial to the conservation of terrestrial endangered species... then managers face an intractable dilemma.”⁹⁹ Management options are further confused by longitudinal differences that result in differing geomorphology, flooding, populations of fish, food supply, and sediment deposition.

Choosing a management strategy is therefore perhaps most predicated on value judgments and whether society will accept proposed changes in addition to a detailed understanding of this complex ecosystem. These value-loaded choices include economic effects and other societal impacts in addition to their functional results on the river. While science can guide these decisions, “values, not science, underlie the choice of a management goal for the river.”¹⁰⁰

⁹⁸ Schmidt et al., 1998

⁹⁹ Schmidt et al., 1998

¹⁰⁰ Schmidt et al., 1998

THE DESCHUTES RIVER: A RIVER DIVIDED

“Water which is allowed to enter the sea is wasted.”
-Joseph Stalin, 1929¹⁰¹

The Deschutes River begins small and cold high in the Oregon Cascades from the flanks of Mount Bachelor, where it begins its journey that stretches 252 miles to its confluence with the Columbia River. The Deschutes, along with the tributaries Metolius River, Crooked River and numerous others, drains nearly 11,000 square miles in central Oregon, making it the second largest watershed in the state. Bordered on the west by the Cascades, the watershed’s topography ranges from high mountain peaks to arid high desert landscapes, with canyons, fields and pastureland in between. With the exception of the westernmost part of the basin that includes the eastern slopes of the Cascades, the Deschutes watershed is composed of dry, arid high desert with hot, dry summers and cold, harsh winters.¹⁰²

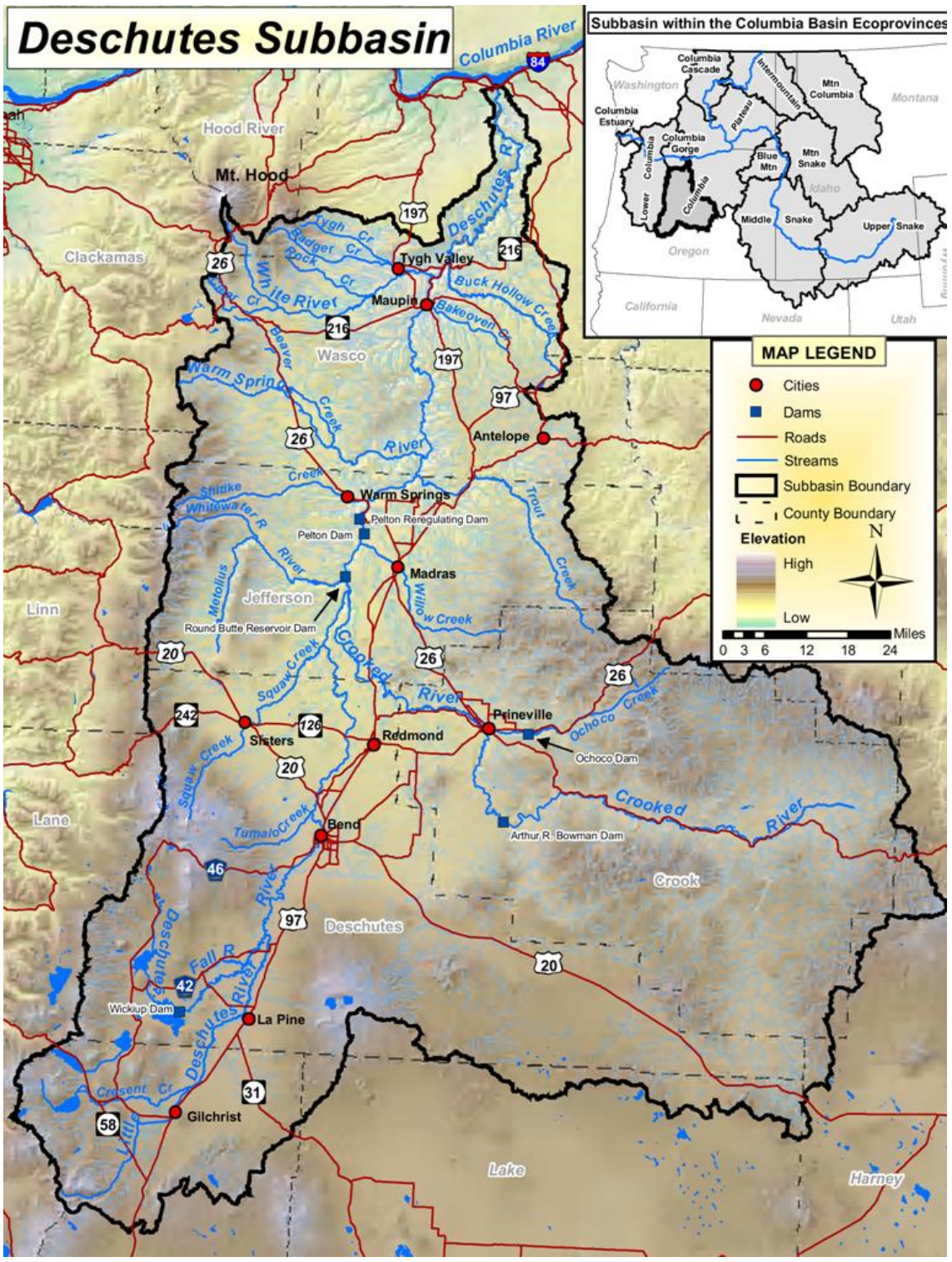
Through this high desert region cuts the Deschutes River, which has historically provided habitat for healthy, world-class runs of anadromous fish, and sustained the region’s indigenous people for millennia.¹⁰³ It has been said that the Deschutes is the “lifeblood of central Oregon, and salmon once were its soul.”¹⁰⁴ Hydroelectric development of the Deschutes has disconnected much of the historic spawning grounds for anadromous fish, and irrigation withdrawals continue to threaten water quality standards of both instream flow and water temperature. Today, restoration efforts are at work to return the soul of the Deschutes, but much work remains.

¹⁰¹ McCully, 2001

¹⁰² Judd, 2006

¹⁰³ Judd, 2006

¹⁰⁴ Judd, 2006



The Deschutes Basin with urban centers and highways.¹⁰⁵

¹⁰⁵ Northwest Power and Conservation Council, 2005

After flowing from the headwaters, the Deschutes flows south through meadows and forests before reaching the first of many impoundments: Crane Prairie Reservoir. Below Crane Prairie the Deschutes increases in power, flowing through a basalt canyon before entering neighboring Wickiup Reservoir and turning north. The river increases in size before entering the city of Bend, the largest population center in Oregon east of the Cascades. Several dozen miles downstream of Bend, major tributaries of the Deschutes, the Metolius River and the Crooked River, join the Deschutes and combine to form Lake Billy Chinook behind the Pelton Round Butte hydroelectric complex. Below the reservoirs formed by Pelton Round Butte including Lake Billy Chinook, Lake Simtustus and the reregulation reservoir, the Deschutes River flows as a “classic, brawling steelhead river through a deep ochre canyon”, providing some of the most popular fishing and recreation in the state.¹⁰⁶ Yet the Deschutes is really two rivers; like so many rivers, the Deschutes is a river that is divided. Below the Pelton-Round Butte Complex is a recreational hub supporting anadromous fish, while above the dams the river no longer supports once thriving populations of salmon and steelhead and nearly runs dry during summer months.

The Upper Deschutes

The upper Deschutes River is one of contradictions. Its headwaters remain mostly untouched and provide popular recreational opportunities and quality habitat for rainbow trout. Two major impoundments, Crane Prairie and Wickiup reservoirs provide irrigation water for agriculture and pasture downstream. Through the city of Bend, the river is popular among kayakers and fishermen, though the river nearly runs dry some months of

¹⁰⁶ Judd, 2006

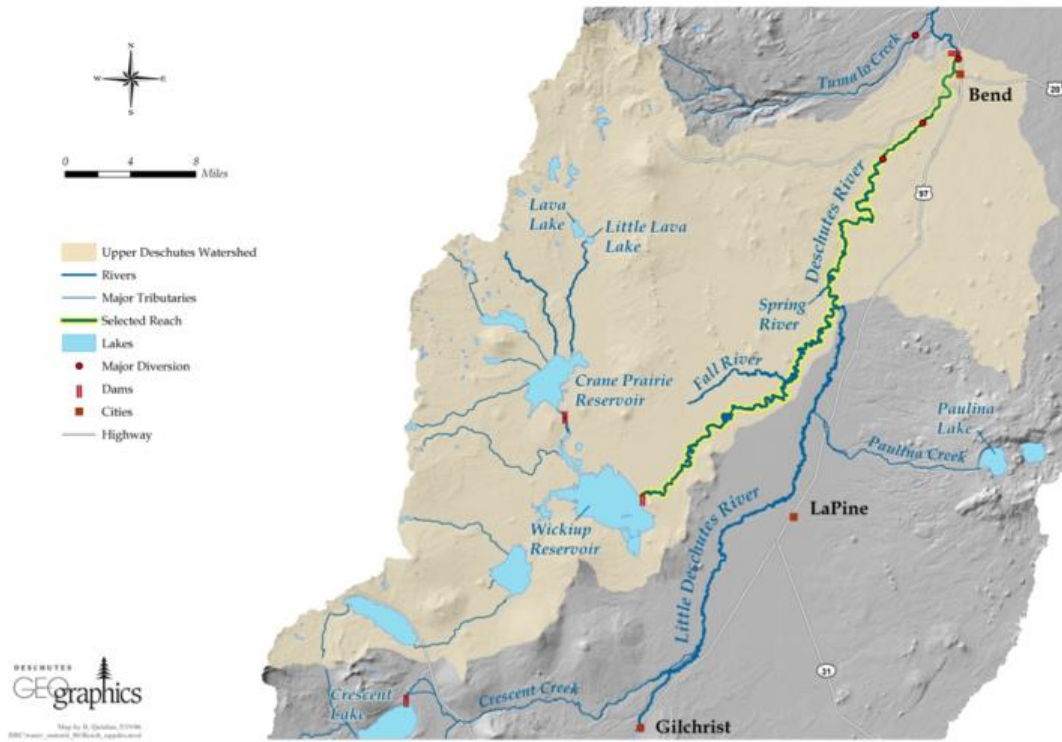
the year downstream of Bend.¹⁰⁷ Further downstream, springs near the confluence with Whychus Creek boost the flow. Congress designated over 70 miles above the Pelton-Round Butte complex as scenic and recreational under the Wild and Scenic Rivers Act in 1988. Prior to dam construction, anadromous fish were able to navigate the upper Deschutes to Big Falls, 132 miles from the confluence with the Columbia River and 14 miles upstream from Lake Billy Chinook. Precise numbers of fish that spawned in the upper Deschutes prior to dam construction are not known, though there is “strong evidence that a significant population of steelhead and spring chinook did occupy the river.”¹⁰⁸ A pioneer rancher describing her experience living alongside the Deschutes River at Bend in 1887 remembered, “The Deschutes River was literally full of fish of all sizes. We could stand on the log and throw fish into the frying pan.”¹⁰⁹ Whychus Creek, a Deschutes tributary north of Bend with headwaters in the Three Sisters Wilderness, was historically a major producer of steelhead and chinook as well. Today, the Upper Deschutes has large reaches that are water quality impaired as a result of extensive irrigation water withdrawals.

¹⁰⁷ Oregon Environmental Council

¹⁰⁸ Judd, 2006

¹⁰⁹ Deschutes River Conservancy, 2012

Upper Deschutes River



The Upper Deschutes Basin¹¹⁰

The Lower Deschutes

The lower Deschutes River is incredibly popular among recreationalists, offering excellent steelhead and trout fishing, whitewater rafting, hiking and camping. Large numbers of recreationalists contribute substantially to the economy of the area.

Biologically, the relatively cool and stable flow of the lower Deschutes River provides excellent habitat for anadromous fish. In this section, the Deschutes behaves more like a small spring-fed creek than a large river due to large groundwater infusions from the porous volcanic bedrock. During the hot summer months, this reach serves as a temperature refuge for fish. The lower Deschutes and some of its tributaries provide

¹¹⁰ Deschutes River Conservancy, 2012

habitat for the threatened bull trout, steelhead and chinook. Congress designated the entire one hundred mile stretch from the base of the reregulating dam to the Columbia River as recreational under the Wild and Scenic Act.¹¹¹

Beginning with the arrival of settlers in the mid-1800s, habitat degradation produced a drastic decline in the numbers and health of fish in the upper Deschutes Basin. Irrigation withdrawals, small power dam construction and livestock grazing resulted in severe reductions of historically abundant populations, with some nearing extinction. While the Pelton Round Butte Complex is the most visible and most significant factor in the story of fish in the Deschutes, human impacts prior to the dams should not be understated.

Human Impacts in the Deschutes Basin

Despite the recognition of the biological and recreational richness that the Deschutes has to offer, commercial irrigation and hydropower interests have utilized the river for over a century. The first irrigation diversion on the Deschutes was in place in 1892, and in 1910 the Bend Water, Light & Power Company installed the first hydroelectric dam on the Deschutes to power the city's streetlights. Diversions were in place even earlier on the Crooked River (1866) and Whychus Creek (1871), tributaries to the Deschutes.¹¹² In 1914, water rights claims on the Deschutes above Bend exceeded average available streamflow by 40 times.^{113,114} By 1920, irrigation diversions caused portions of the Deschutes River as well as major tributaries to run dry. The situation was

¹¹¹ Judd, 2006

¹¹² Lichatowich, 1998

¹¹³ Judd, 2006

¹¹⁴ Lichatowich, 1998

compounded by the completion of several large Bureau of Reclamation storage dams in the 1920s.¹¹⁵ In addition to riverbed dewatering, diversions dams blocked passage for fish and water losses altered water temperature to fatal temperatures.¹¹⁶ By the time additional storage reservoirs and reclamation upgrades were completed in the 1955, all but 20 cubic feet per second was diverted from the Deschutes above Bend.¹¹⁷

State salmon managers knew of the issues associated with irrigation as early as 1900, noting that the decline in salmon populations “must be attributed to the settler. This part of the country being dry, requiring irrigation during the summer months, dams have been built on nearly all the streams, water being taken from them... thus destroying much of the best spawning grounds.”¹¹⁸ Interest in developing hydroelectric generation facilities on the Deschutes began prior to the major dam building era of the 1930s-1970s. As early as the turn of the century, Oregon’s state engineer placed hydropower as the “primary goal of water development on the Deschutes,” and the Department of the Interior agreed, stating that “every drop of water [in the Deschutes Basin]... can and eventually will be put to beneficial use.”¹¹⁹ This attitude reflects the valuation of riverine systems as commodities that should adhere to the idea of “no waste”, for any water flowing unused by humans is “wasted”. A study conducted in the 1920s established that a hydroelectric project on the lower section of the Deschutes could generate 500,000 horsepower,¹²⁰ applying the utilitarian values of the time period to the Deschutes and setting the stage for river development.

¹¹⁵ Judd, 2006

¹¹⁶ Lichatowich, 1998

¹¹⁷ Lichatowich, 1998

¹¹⁸ Lichatowich, 1998

¹¹⁹ Lichatowich, 1998

¹²⁰ Lichatowich, 1998

Growing regional demand for cheap hydroelectric power prompted the Northwest Power Supply Company to apply in 1949 for a license to build a two dam complex on the lower Deschutes River.¹²¹ In 1951, a license was granted to PGE (who assumed control of the project), authorizing construction of Pelton Dam for power production and a smaller dam to reregulate flows. The State of Oregon objected loudly to the license, arguing that the project would decimate anadromous fish runs above the proposed site. Oregon also argued that the project could not proceed without the necessary state permits, which had not been granted. The Federal Power Commission (FPC, later FERC: Federal Energy Regulatory Commission) rejected the challenge, determining that state law cannot impede a federal project if the project “would be of unmistakable public benefit.”¹²² The Commission’s position was that such a benefit existed because the region had a lack of a dependable power capacity, which could be partially remedied by the project. Incredibly, the commission concluded, “existing fish runs would likely be maintained or increased.”¹²³

In 1954, the Ninth Circuit overruled the FPC and discarded the license, concluding that the state, not the federal government, should control the waterway. In 1955, the Supreme Court reversed the 1954 decision, arguing that the Federal Power Act authorized the issuance of licenses “upon any part of the public lands and reservations of the United States,”¹²⁴ meaning that the state could not prevent a federally licensed project from proceeding.¹²⁵ Construction began shortly after the *Federal Power Commission v. Oregon* decision. PGE began construction of Pelton Dam and the reregulating dam in

¹²¹ Judd, 2006

¹²² Judd, 2006

¹²³ Judd, 2006

¹²⁴ Judd, 2006

¹²⁵ Lichatowich, 1998

1956, and by 1958 the project was operational. In 1960, PGE obtained a license amendment to add a new, larger dam to the complex upstream from Pelton Dam. The completion of Round Butte Dam in 1964 greatly expanded the scope of the project, creating a 4,000 acre reservoir capable of storing approximately 500,000 acre-feet.¹²⁶

In 1964, Portland General Electric (PGE) completed construction on the Pelton-Round Butte Complex. The complex has wreaked havoc on fish migration, completely eliminating anadromous salmon and steelhead from the upper basin and impeding the movement of resident fish species including bull trout and rainbow trout. The project is responsible for an array of environmental and ecological problems in both the upper and lower Deschutes basins, most obvious of which is the extirpation of anadromous fish from the upper basin. Water quality problems exist throughout the basin as well.¹²⁷

Originally, all of the dams were equipped with fish passage mechanisms¹²⁸ as required by Oregon water law.¹²⁹ To facilitate upstream migration, PGE installed fish ladders at Pelton and the reregulating dam, and a trap and haul facility for passage over the much larger Round Butte Dam because the steep canyon upstream precluded a fish ladder. Skimmers were used to provide for downstream migration. Skimmers are surface collectors designed to collect smolts migrating downstream. Following capture, fish were piped or trucked downstream. The skimmers had a poor success rate, likely due to inadequate attraction flows. While many fish could navigate the maze of fish ladders upstream, issues remained with downstream migration.¹³⁰

¹²⁶ Judd, 2006

¹²⁷ Judd, 2006

¹²⁸ Judd, 2006

¹²⁹ Bastasch, 2006

¹³⁰ Judd, 2006

In the mid 1960s, the Fish Commission of Oregon (the predecessor to the Oregon Department of Fish and Wildlife) determined that the “Project’s fish passage facilities were incapable of sustaining the runs due to problems with juvenile downstream migration.”¹³¹ The downstream migration issue is due to a series of disorienting, swirling currents in Lake Billy Chinook (the first reservoir formed by the complex) due to the mixing of different temperature waters in the lake.¹³² The waters of the Metolius River are much colder than those of the Crooked and Deschutes, leading to swirling currents and temperature differentials. Fish from the Metolius arm of the reservoir were essentially trapped deep in the lake, while fish from the Crooked and Deschutes Rivers rode warmer currents into the Metolius arm of the lake, away from downstream passage facilities. This led to smolts entering the lake deeper than necessary to be successfully trapped and transported downstream.¹³³

¹³¹ Judd, 2006

¹³² Tillman, 2010

¹³³ Judd, 2006



Map of the dams composing the Pelton Round Butte hydroelectric complex and resulting reservoirs. Swirling currents in Lake Billy Chinook resulting from temperature differentials between Deschutes and Crooked River water meeting colder Metolius River water hamper fish passage.¹³⁴

Failure of downstream fish passage systems prevented runs of steelhead, sockeye, spring chinook and lamprey from reaching their historic spawning grounds. In total, the Pelton Round Butte Complex erased several hundred miles of habitat for anadromous fish, including 225 miles of previously highly productive tributaries. Of note is that the complex led to the end of the Suttle Lake sockeye run, one of just two such runs in Oregon. The Federal Power Commission linked the dam site with irrigation impacts,

¹³⁴ PGE (n.d.)

noting that the relatively low numbers of fish migrating past the dam site is due to “irrigation diversions in the headwaters [that] have almost completely depleted the upper reaches of the stream.”¹³⁵ In 1968, the Oregon Fish Commission made the decision to replace wild steelhead and chinook with hatchery production. Though hatchery fish provide recreational fishing possibilities, hatchery stocks fail completely in replacing biologically important sockeye populations. Further, the genetic pool for Deschutes fish is compromised as a result of hatchery introductions.^{136, 137}

In addition to blocking access to spawning grounds, the complex is also responsible for preventing the movement of woody debris with widely acknowledged importance for providing habitat complexity, providing shade and forming islands and side channels.¹³⁸ The project also flooded aquatic, riparian, wetland and forest habitat. Roughly 41 miles of riverine habitat was lost, as well as over 4,000 acres of habitat that served as migration corridors and breeding grounds. Studies indicate that operation of the complex will continue to “fragment habitat and impede dispersal patterns of amphibians, certain birds, and small mammals.”¹³⁹ Most notable, however, is the fragmentation of anadromous fish habitat and the river system resulting from the complex.

While the Pelton-Round Butte Complex is chiefly responsible for preventing anadromous fish migration, irrigation in the watershed is one of the key factors that will hamper restoration efforts. Western water development is represented most prominently by large “megaprojects” such as Hoover Dam on the Colorado, but a second, less visible impact of the same magnitude can be seen across the West. The millions of small dams,

¹³⁵ Judd, 2006

¹³⁶ Lichatowich, 1998

¹³⁷ Judd, 2006

¹³⁸ Judd, 2006

¹³⁹ Judd, 2006

stream diversions and groundwater pumping stations used by farmers, agricultural and irrigation districts, cities and corporations share the same origins and result in the same problems as the large, visible impoundment projects.¹⁴⁰ This is an important, yet often overlooked component when considering restoration efforts on a basin-wide scale, because even the outright removal of a major dam may not necessarily equate to the reestablishment of habitat connectivity in the river system. Applied to the Deschutes, this means that even with ideal fish passage facilities at the Pelton Round Butte complex, considerable numbers of smaller diversion dams will act as impediments for spawning fish.

Irrigation in the Upper Deschutes Basin

Upstream of the Pelton Round Butte complex, irrigation complicates the reintroduction of fish. Irrigation withdrawals create water quality problems for many reaches above the complex, and irrigation withdrawals in the upper basin “are the single most important factor contributing to habitat degradation.”¹⁴¹ Key water quality issues are water temperature and flow. As the river flows downstream from its headwaters and encounters the impoundments near Bend, temperatures begin to rise above the state water quality criteria.¹⁴² The figure below illustrates major storage reservoirs in the Deschutes Basin.

¹⁴⁰ Wilkinson, 1992

¹⁴¹ Lichatowich, 1998

¹⁴² Jones, 2006

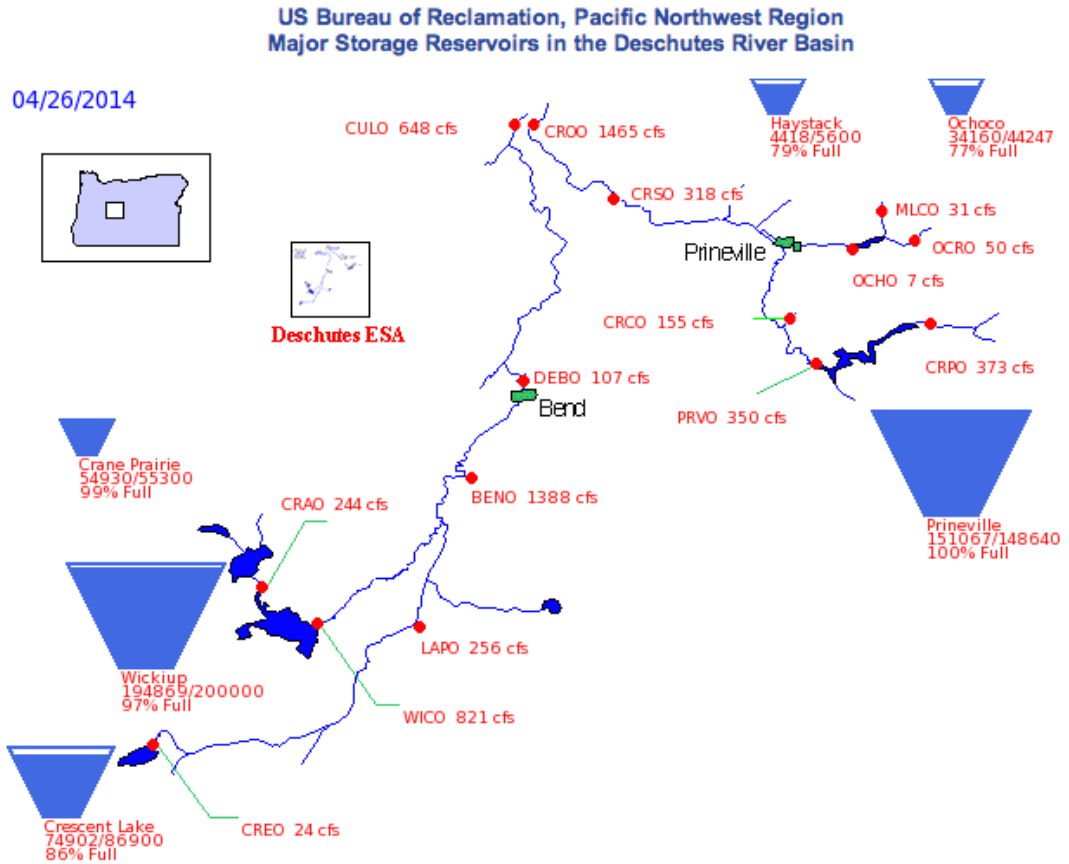


Diagram representing locations of major storage projects in the Deschutes Basin.¹⁴³

Water resource issues have come to the forefront in recent years, as additional demands have been placed on an essential resource that has been largely maxed out. Surface water rights are fully allocated in the basin, and water diversion and storage by irrigation districts has resulted in the dewatering of several reaches of the Deschutes River and their listing as “water quality impaired” under the Clean Water Act for violating temperature and flow standards.¹⁴⁴ “The most dramatic modifications are clearly seen in terms of low flows below irrigation district diversions in the Deschutes

¹⁴³ USBR, 2014

¹⁴⁴ Aylward and Newton, 2006a

Basin,”¹⁴⁵ and irrigation water diversions and storage can be correlated to water quality impairment. The upper Deschutes often does not meet flow standards in the winter due to reservoir storage, and storage and irrigation have “highly altered” flows in five of the seven water quality impaired reaches.¹⁴⁶ Summer flows in six of the seven impaired reaches are impacted by irrigation diversions, and many reaches basin wide experience low summer flows due to diversions.¹⁴⁷ Prior to recent restoration efforts, the quantity of water diverted during the summer was so excessive that sections of Whychus Creek and Tumalo Creek typically ran dry.^{148,149}

¹⁴⁵ Aylward and Newton, 2006a

¹⁴⁶ Aylward and Newton, 2006a

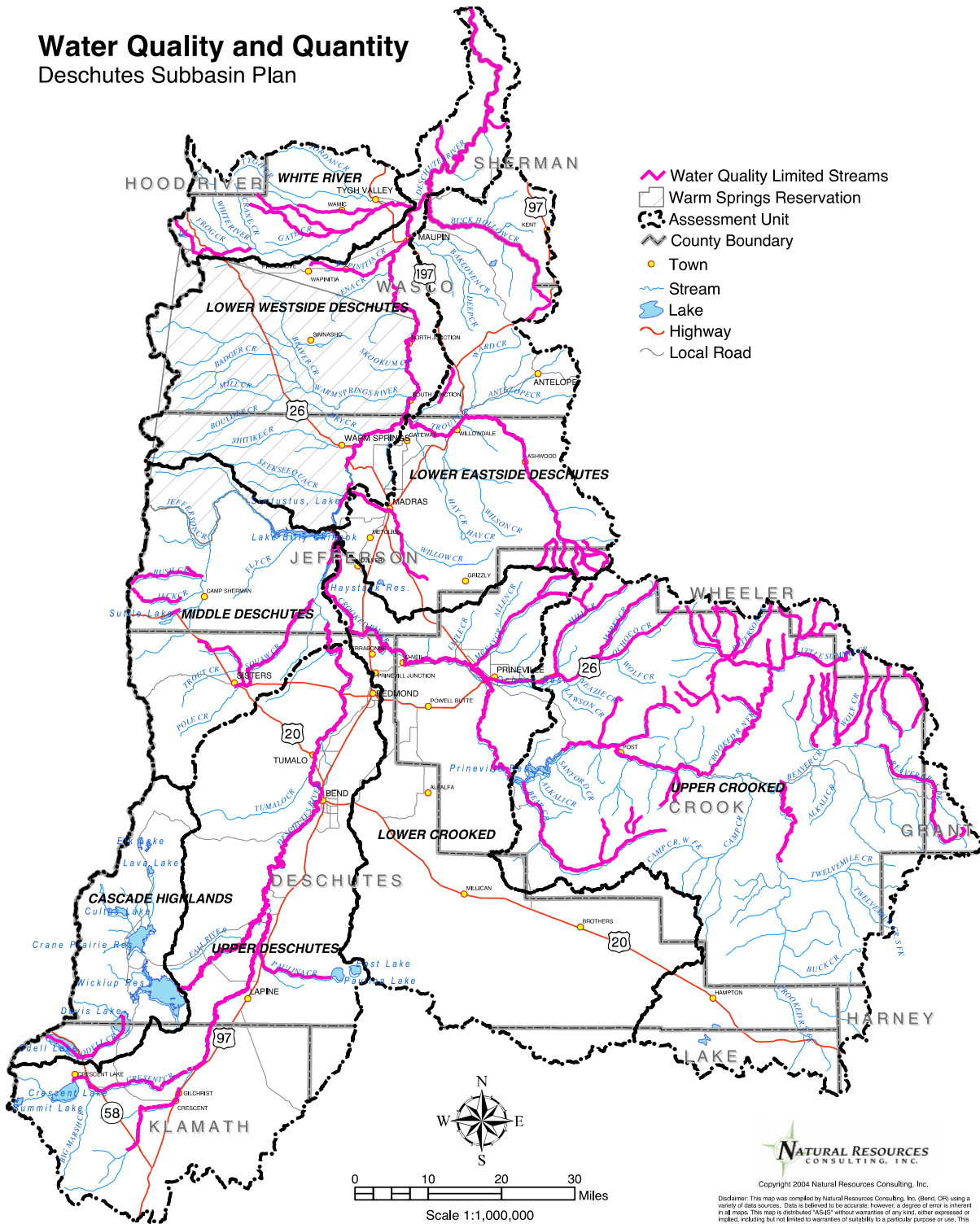
¹⁴⁷ Aylward and Newton, 2006a

¹⁴⁸ Aylward and Newton, 2006a

¹⁴⁹ Houston, 2008

Water Quality and Quantity

Deschutes Subbasin Plan

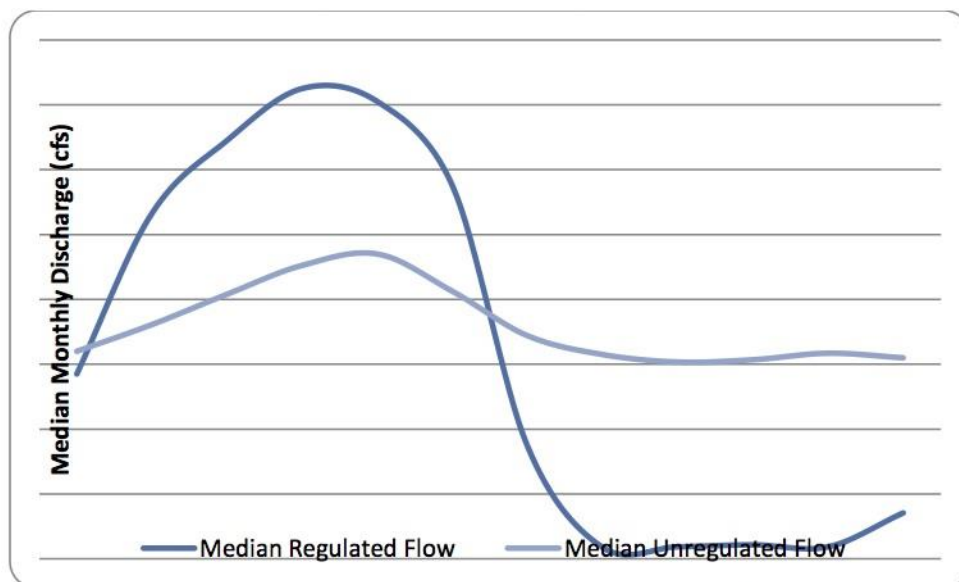


Data Source: 2002 Oregon DEQ 303d Listed Streams

Water Quality Impaired Streams, Deschutes River Basin.¹⁵⁰

¹⁵⁰ Northwest Power and Conservation Council, 2005b

Under natural conditions, flows in the Deschutes River were very stable. Winter flows below Wickiup Reservoir historically averaged 660 cfs and summer flows 730 cfs.¹⁵¹ Under regulated conditions, the minimum flow requirement below Wickiup Reservoir is 20 cfs, just 4% of the natural low-flow.¹⁵² The following figure illustrates the flattening of the hydrograph as a result of reservoir storage and release on the Upper Deschutes River.



Source: Regulated flow as measured at the Wickiup Gage (WICO) #14056500 (1983-2011)
Unregulated flow as measured at the Pringle Falls Gage ##14057000 (1916-1940)

Upper Deschutes discharge comparison before and after regulated reservoir releases. The Wickiup gage is located immediately below Wickiup Reservoir, and the now discontinued Pringle Falls gage location was just downstream of Wickiup Reservoir.^{153, 154}

These flow fluctuations mean that when winter water storage is occurring, streambeds and banks are dewatered and exposed to freeze-thaw cycles in the winter, and riparian vegetation loses its water supply. Fish and macroinvertebrate habitats are

¹⁵¹ Deschutes River Conservancy, 2012
¹⁵² Deschutes River Conservancy, 2012
¹⁵³ Deschutes River Conservancy, 2012
¹⁵⁴ Oregon Water Resources Department

damaged, and fish redds can be exposed to freezing temperatures.¹⁵⁵ Bank erosion also occurs as high flows increase the shear stress exerted on the banks; this degradation is compounded by the lack of riparian vegetation resulting from winter dewatering. A comparison of photographs between Wickiup Reservoir and Benham Falls from 1943-1991 reveals that the Deschutes widened by an average of 20% during the 48 year analysis period.¹⁵⁶ The erosion from banks destabilized by low flow period freeze-thaw cycles and removed by high flows results in steep, unstable cutbanks, high levels of turbidity, and the filling-in of riverbed gravel interspaces which is necessary for successful fish nesting.¹⁵⁷ Within the Bend city limits, The North Canal Dam and Diversion remove nearly all the water in the Deschutes, and flows remain very low until springs add more water miles downstream.¹⁵⁸ Wintertime low flows occur as reservoirs are filling capacity, while summer low flows are a result of water diverted to fill water rights not entirely satisfied by reservoir releases.

Gauge Station	April	May	June	July	August	September
Deschutes River at Benham Falls (RM 182)	1360	1890	2222	2330	2150	1810
Deschutes River below Bend (RM 164)	93	39	34	33	31	34
Percent of flow diverted	63	85	90	91	92	89

Adapted from Yake, 2003. Median Monthly Discharge in cfs of the Deschutes River measured at two gages, one above and one below major water diversions. The data are from periods 1970 to 2000. On average, 90% of the water is diverted from the Deschutes River during the high withdrawal months of June through September.¹⁵⁹ Benham Falls is located several miles upstream of Bend and the large North Canal Diversion.

¹⁵⁵ Deschutes River Conservancy, 2012

¹⁵⁶ Deschutes River Conservancy, 2012

¹⁵⁷ Deschutes River Conservancy, 2012

¹⁵⁸ Lichatowich, 1998

¹⁵⁹ Yake, 2003

There is an inverse relationship between instream flow and temperature: as water is removed from the river and flow volume decreases, temperature increases, sometimes to lethal levels for fish in the summer months.¹⁶⁰ From Tumalo Creek to the spring input some 22 miles downstream, stream temperatures on the Deschutes can reach 26.7° C, nearly 9 degrees warmer than the state temperature standard. This has caused the nearly complete elimination of redband trout in that section of river.¹⁶¹ The extent of water quality degradation is illustrated on a basin-wide scale below.

Historic Probability of Meeting Instream Flow Target*								
Month	Little Deschutes River	Upper Deschutes River	Middle Deschutes River	Tumalo Creek	Whychus Creek	Metolius River	Lower Crooked River	Lower Deschutes River
Jan	Very High	Low	Very High	Very High	Very High	Very High	Very High	High
Feb	Very High	Low	Very High	Very High	Very High	Very High	Very High	High
Mar	Medium	Low	Very High	Low	Very High	Very High	High	Very High
Apr	High	High	Medium	Low	Low	Very High	High	High
May	Low	Very High	Very Low	Low	Medium	Very High	Low	High
Jun	Low	Very High	Very Low	High	Medium	Very High	Low	High
Jul	Medium	Very High	Very Low	Low	Very Low	Very High	Medium	High
Aug	High	Very High	Very Low	Very Low	Very Low	Very High	High	Very High
Sep	Very High	Very High	Very Low	Very Low	Very Low	Very High	Very High	Very High
Oct	Very High	High	Medium	Medium	Very Low	Very High	Very High	Very High
Nov	Very High	Very Low	Very High	Very High	Very High	Very High	Very High	Very High
Dec	Very High	Low	Very High	Very High	Very High	Very High	Very High	Very High

*period of record varies for each reach

Instream flow depletion resulting from irrigation withdrawals on the Deschutes River and tributaries has been severe. The daily probability of reaching flow targets during each month is illustrated above.¹⁶²

Percent of Days Meeting Target	Historic Probability
80-100%	Very High
60-79%	High
40-59%	Medium
20-39%	Low
0-19%	Very Low

Impact of Pelton-Round Butte on Deschutes River Geomorphology and Hydrology

The lower Deschutes River below the Pelton Round Butte Complex has not seen any major geomorphological changes as a result of impoundment, making it a “unique

¹⁶⁰ Houston, 2008

¹⁶¹ Lichatowich, 1998

¹⁶² Aylward and Newton, 2006b

river” in the literature. Flow, stream temperatures and channel morphology did not undergo major changes as a result of dam construction,¹⁶³ though this uniquely intact environment below the dam is not without problems because of connectivity issues with upstream reaches. Research from several parties, including Oregon State University, has found that because the Deschutes River has an unusually stable flow regime and historically minimal sediment transport, dam construction did not result in the geomorphic changes typically attributable to dam construction.^{164, 165}

The Deschutes River has historically had very stable flows, with minimal fluctuation in daily, monthly, and annual flow.¹⁶⁶ A 1914 U.S. Reclamation Service report noted the Deschutes River as “one of the most uniform of all streams in the United States, not only from month to month, but also from year to year.”¹⁶⁷ This flow regime results from the hydrology of the basin: unlike rivers dominated by surface runoff, the Deschutes is fed by a large “hydrologic sponge”¹⁶⁸ composed of porous volcanic bedrock, “which makes the river behave much like a spring-fed creek.”¹⁶⁹ Greater drainage densities are responsible for the extensive groundwater system of the watershed acting as a buffer,¹⁷⁰ accepting excess water that would typically result in surface runoff and releasing water during the drier summer months. Most precipitation enters the groundwater system through the highly permeable volcanic fields to emerge months to years later as springs rather than draining on the surface in defined channels.^{171, 172} This

¹⁶³ Lichatowich, 1998

¹⁶⁴ O’Connor et al., 2003

¹⁶⁵ Fassnacht et al., 2003

¹⁶⁶ Yake, 2003

¹⁶⁷ Yake, 2003

¹⁶⁸ Duncan, 2000

¹⁶⁹ Duncan, 2000

¹⁷⁰ O’Connor et al., 2003

¹⁷¹ O’Connor et al., 2003

volcanic geology is also responsible for mitigating large changes in flow, and the low sediment transport rate of the river can also be traced to basin geology.¹⁷³ Near the Pelton Round Butte Complex, springs contribute a majority of total flow.¹⁷⁴ Because flows are relatively stable, the higher flows needed to transport larger amounts of sediment are rare, leading to low sediment movement rates.¹⁷⁵

Putting the basin's hydrologic stability in context, the average maximum flow in the Deschutes both before and after dam installation is roughly three times minimum low flow.¹⁷⁶ In other rivers, this ratio may be as large as 100 times.¹⁷⁷ Comparing the Deschutes with the John Day River basin, a nearby river with a similar-sized basin, and the Willamette River Basin in western Oregon further illustrates the peculiarity of the flow regime on the Deschutes: The John Day River has a mean monthly discharge in April that is more than thirty times greater than in September. For the Willamette, the mean monthly discharge for January is roughly ten times that of August. The Deschutes varies by just a factor of 1.5 between high and low flows.¹⁷⁸

¹⁷² Duncan, 2000

¹⁷³ Duncan, 2000

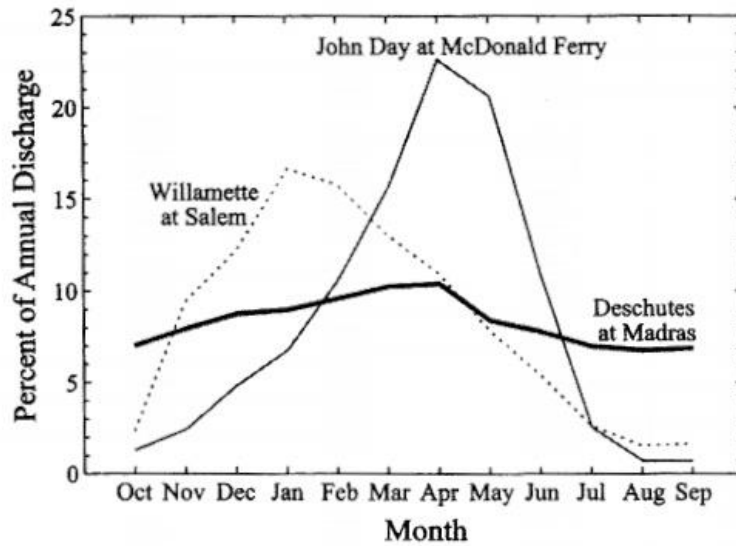
¹⁷⁴ O'Connor et al., 2003

¹⁷⁵ Duncan, 2000

¹⁷⁶ Fassnacht et al., 2003

¹⁷⁷ Duncan, 2000

¹⁷⁸ O'Connor et al., 2003



Mean Monthly Discharges for the John Day River, Willamette River and Deschutes River.¹⁷⁹

An analysis of the February 1996 flood on the Deschutes has confirmed these conclusions. A 100-year flood event, the flood “suggests that neither dam construction nor major flood events resulted in significant channel bed adjustments.”¹⁸⁰ Channel change following the flood event including channel migration or riverbed geometry was minimal,^{181,182} which suggests that even in times of flooding, sediment transport rates are modest. “Thus, the frequency of bed-mobilizing flows has been historically low and has changed little following impoundment. This further implies that there have been historically low sediment transport rates.”¹⁸³ This unique situation is a combination of geologically driven flow regime and lack of significant sediment sources. It is hypothesized that the young volcanic rock that dominates the region produces little

¹⁷⁹ O’Connor et al., 2003

¹⁸⁰ McClure, 1998

¹⁸¹ McClure, 1998

¹⁸² Duncan, 2000

¹⁸³ McClure, 1998

sediment, and those areas that are richer in sediment sources have limited surface drainage networks through which sediment may be transported.¹⁸⁴

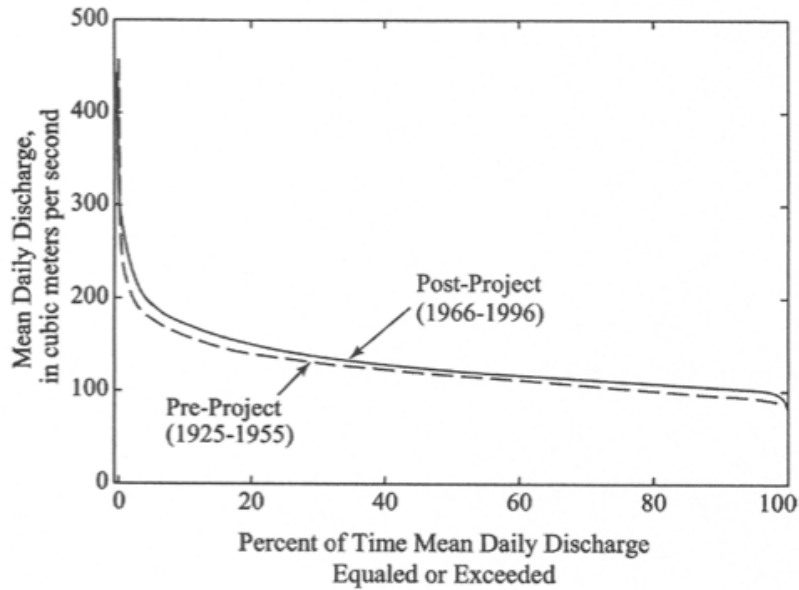
Compared with “normal” rivers, the Deschutes in its pre-dam condition experienced sediment-moving flows once every 5 to 10 years, compared to the two to three times per year that might be expected on a typical river.¹⁸⁵ This suggests that while the Pelton Round Butte complex may have some minimal downstream effects, because of the lack of sediment to be transported and the lower frequency at which it would be historically transported, downstream geomorphic effects of the complex are minimized. Using hydraulic modeling, Oregon State University researchers predicted that discharges of between 270 and 460 m³/s (cubic meters per second, a standard measure of discharge) would be required to stimulate bedload sediment transport. Flows of this magnitude have occurred less than 1% of the time during the 70 year record, which is “substantially less than on other alluvial rivers.”¹⁸⁶ The implications for the Deschutes are such that the installation of the Pelton Round Butte Complex has had a significantly lesser impact than might be traditionally expected. Putting the analysis of the Deschutes River in a larger context may suggest that rivers with low sediment transport rates as a result of flow regimes and or geology may not experience the channel morphology change and degradation that is expected on “normal” rivers.¹⁸⁷

¹⁸⁴ O’Connor et al., 2003

¹⁸⁵ Duncan, 2000

¹⁸⁶ Fassnacht et al., 2003

¹⁸⁷ Fassnacht et al., 2003



30-year flow duration curves for pre-dam (water years 1925-1955) and post-dam (1966-1996) periods on the Deschutes River.¹⁸⁸

That the lower Deschutes has not undergone typical geomorphic changes does not mean there are not issues resulting from the construction of the Pelton Round Butte Complex. The primary issue of habitat connectivity and migration remains; when combined with water quality issues resulting from irrigation in the upper basin, much work remains before fish can be reintroduced in the watershed. Restoration efforts in recent years have made remarkable progress, though it is likely that decades remain before the Deschutes watershed has overcome the fragmentation of the basin.

Deschutes Basin Restoration

Recognition of the need to restore Deschutes Basin fish habitat has gained traction in the last decade, as the understanding of watershed health has become more widespread and public interest in seeing fish in rivers has increased. Groundbreaking partnerships

¹⁸⁸ Fassnacht et al., 2003

between local, state, federal, private and non-profit organizations have allowed for collaboration rather than litigation. The primary effort is to successfully reintroduce anadromous fish to the basin, which means mitigating the disorienting currents in Lake Billy Chinook, providing functional fish passage at the Pelton Round Butte complex, removing irrigation dams and ensuring baseline instream flows to meet water quality standards for flow and temperature. To move these goals from concepts on paper to functioning in the real world requires untangling the complex web of water rights, economics, public policy and societal values. The progress made thus far is a testament to groups collaborating and setting aside previous differences to work toward a healthier river basin. Inherent in this collaboration is a recognition of the holistic, intangible benefits that a healthy ecosystem provides: while ecosystem services and species conservation have been acknowledged for some time,¹⁸⁹ only recently have attitudes and values shifted toward putting thought into action.

Restoring instream flow to ensure healthy temperatures and flows has been an ongoing process in the basin, with several approaches in use. Water conservation through efficiency improvements in the irrigation canal system is one such approach, as is “water banking.” Because surface water has been fully allocated, conservation is the best method for creating “new” water supplies.

Instream flow allocation and regulation can occur through various avenues: federal and state regulation, and voluntary, market-based approaches. Federal regulation can include the Clean Water Act and the Endangered Species Act, and state regulation approaches include the State Scenic Waterways Act as well as enforcing instream flow

¹⁸⁹ Ehrlich and Mooney, 1983

rights for aquatic life.¹⁹⁰ While there are legal precedents supporting the federal and state approaches, the voluntary, market-based approaches provide the best option for securing instream flows because they involve collaboration between irrigators, irrigation districts, municipalities and regulatory agencies.

There are great opportunities for water conservation in agriculture and irrigation, which accounts for more than 80% of water use in the West.¹⁹¹ In Oregon, irrigation is the largest water user.¹⁹² The Deschutes is tapped for irrigation use, which is no surprise given that nine of the top ten Oregon counties that irrigate are east of the Cascades. Given this, irrigation efficiency should be a top priority in the Deschutes Basin. One solution that has already been implemented on a limited basis by some irrigation districts in the Basin is piping irrigation canals to reduce water loss via seepage. While expensive, conservation is the solution toward making more water available in an environment where surface water rights are fully allocated.

Irrigation district assessments indicate that seepage losses in central Oregon canals used to deliver irrigation water experience an average transmission loss of 37%, with high losses in some areas and very low losses in others. Because of the highly permeable volcanic terrain underlying some areas, seepage loss is reported to be nearly 60%.¹⁹³ Overall, losses are significant, totaling nearly 600,000 acre-feet, indicating an opportunity to significantly increase water efficiency and reduce the volume of water withdrawn from the Deschutes and its tributaries for irrigation.¹⁹⁴ Piping of nearly a mile of a major irrigation canal in 2013 has resulted in the conservation of enough water that 5

¹⁹⁰ Aylward and Netwon, 2006a

¹⁹¹ Wilkinson, 2006

¹⁹² Bastasch, 2006

¹⁹³ Aylward and Newton, 2006a

¹⁹⁴ Aylward and Newton, 2006a

cfs will be transferred for instream flow for steelhead habitat improvement in the Crooked River, a Deschutes River tributary.¹⁹⁵

In 2004, several Deschutes Basin irrigation districts and the Deschutes River Conservancy established the Central Oregon Water Bank, with involvement from the cities of Bend and Redmond and the Confederated Tribes of the Warm Springs.¹⁹⁶ The water bank facilitates short and long-term leasing as well as permanent reallocation of existing water rights on a voluntary basis in order to reallocate surplus agricultural water rights to meet instream flow requirements.¹⁹⁷ Leased water is either donated by water rights holders or paid for by the Deschutes River Conservancy (DRC). When the DRC opts to pay to lease water, cost per acre-foot depends on the seniority of the water right and the source of the water.¹⁹⁸ Underlying the movement and leasing of water and water rights is an essential concept: water rights play a powerful, perhaps dominant, role in the West and in Oregon, especially in the arid Deschutes Basin. Conceptualizing new ways to use the deeply entrenched water rights system is a critical component of river restoration work in central Oregon.

The prior appropriation doctrine governs water laws in Oregon: first in time, first in right. This means that senior rights are commonly held by private landowners and irrigation districts; the relatively young or “junior” rights standing of water that has been purchased for instream flow may or may not be filled in a given year. The irrigation season runs from April 1 through October 31, with maximum demand from May 15 to

¹⁹⁵ Deschutes River Conservancy, 2013

¹⁹⁶ Aylward, 2006

¹⁹⁷ Aylward, 2006

¹⁹⁸ Aylward, 2006

September 15th, peaking in July and August.¹⁹⁹ Live streamflow typically satisfies senior water rights, with additional releases from reservoirs covering the balance.²⁰⁰ Of the approximately 50,000 surface water rights in Oregon, about 1500 of them are for instream uses. About 70% of them are in western Oregon, though the Deschutes Basin leads the east side of the state with roughly eight million acre-feet of instream rights.²⁰¹ Despite the apparent volume of instream rights, it is important to note that instream rights can only be fulfilled after those with more senior rights take their share, and these users have decades to a century of greater priority.²⁰² “The situation might be compared to a doughnut shop where the instream family of use, arriving 5 minutes before closing, has been given a coupon good for 20 dozen [doughnuts], but a [priority] number of 99 – and the sign at the counter says ‘Now serving number 15.’ Their order, compared to most others in line, is probably one of the biggest in quantity. However, the likelihood of getting their order filled in a timely fashion, or at all, is another matter.”²⁰³ Satisfying instream rights often depends on weather: rainy years or years with good snowpacks tend to mean more instream rights will have water.

For this reason, water banking becomes a valuable tool. Through the use of a water bank, a senior water rights holder that gets their rights filled first can reallocate a portion of their water right for a variety of uses, such as improving reliability of junior rights holders, groundwater withdrawal mitigation, and instream flow restoration.²⁰⁴ It is important to remember that the abstract concept of a water right translates into the very

¹⁹⁹ Deschutes River Conservancy, 2012

²⁰⁰ Deschutes River Conservancy, 2012

²⁰¹ Bastasch, 2006

²⁰² Bastasch, 2006

²⁰³ Bastasch, 2006

²⁰⁴ Aylward, 2006

tangible concept of water flowing for a particular use, and not flowing for another. Using the analogy above, application of senior water rights water to the instream flow problem effectively results in the instream family of use moving ahead toward the front of the line. In the real world, this means a higher likelihood that minimum flows of water will remain in creeks and rivers especially during dry years. The water-leasing program in central Oregon has grown in water leased and participants involved. In 2005, the Deschutes Basin experienced drought conditions, yet still had more participants in the program and more water was leased for instream uses than any previous year.²⁰⁵ As the program grows, more modest growth is to be expected, but water banking remains a powerful tool. In the broader perspective, avoiding conflict over water rights in the Deschutes Basin relies on the type of voluntary collaboration exemplified by the water bank, reallocating water rights from historic uses such as agriculture and irrigation toward the modern demands of urbanization and instream flows.²⁰⁶ Changing land use and population trends in the Basin, especially Deschutes County, means that the use of water for irrigation purposes is being reduced. This is reflected in the growth of water banking and the reallocation of traditional water rights.²⁰⁷

Despite the mitigation efforts thus far, temperatures in the Deschutes exceed the state temperature standard in approximately 9 miles of reaches above the confluence with Whychus Creek. Modeling suggests that the current instream water right flows for that section may be insufficient to meet the state temperature standard. While it may be

²⁰⁵ Aylward, 2006

²⁰⁶ Aylward, 2006

²⁰⁷ Aylward, 2006

difficult or impossible to meet the state temperature standard along every mile of river, increases in flow will still result in “substantial” ecological benefits.²⁰⁸

While the geomorphic change downstream of the complex has been minimal, PGE has installed an underwater “selective water withdrawal” tower in Lake Billy Chinook intended to mitigate the swirling currents that have confused migrating fish;²⁰⁹ the tower along with a redesigned fish collection facility constructed in December 2009 promises a move toward more successful passage around the project impoundments.²¹⁰ ²¹¹ The tower draws warm water off of the surface of the lake as well as colder depths to modify currents and draw fish into the collection facility.^{212, 213} In the collection facility, fish are sorted and piped to a fish handling facility where they are then transported downstream.²¹⁴ Over a million juvenile steelhead and chinook were released in 2007 in the Deschutes, Crooked and Metolius Rivers, to be transported around the complex and reintroduced downstream for migration. An ambitious radio tracking project has been launched to monitor the progress of migrating fish, and while the majority have been traced to the Metolius River, fish have been tracked to the Crooked and Deschutes as well.²¹⁵ While fish returns in recent years have been modest, the first sockeye salmon in 45 years was observed spawning in the Metolius River upstream of the complex;^{216, 217} overall, however, returns in 2013 were “disappointingly low.”²¹⁸

²⁰⁸ Mork and Houston, 2012

²⁰⁹ PGE (n.d.)c

²¹⁰ PGE, 2014

²¹¹ CBB, 2012

²¹² PGE (n.d.)b

²¹³ PGE (n.d.)c

²¹⁴ PGE (n.d.)b

²¹⁵ CBB, 2012

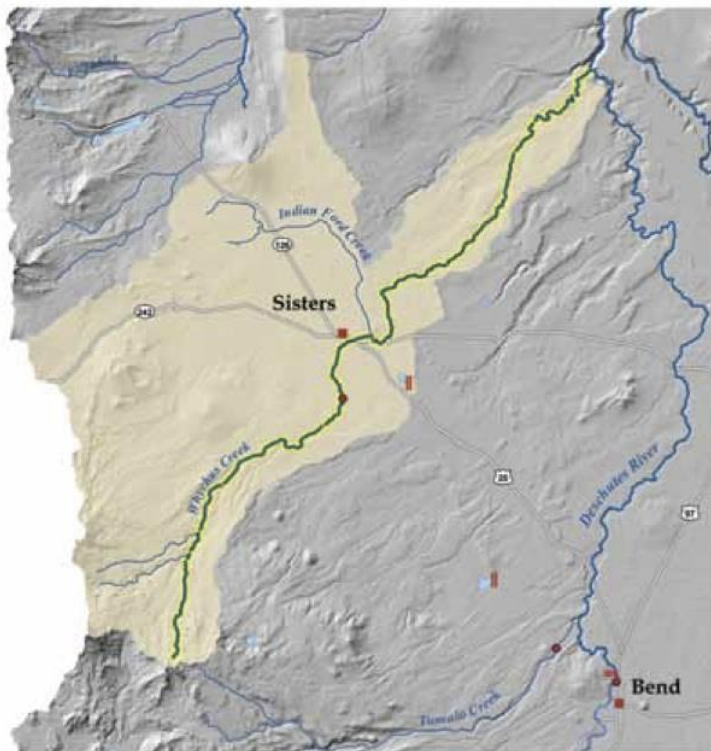
²¹⁶ Ratliff, 2012

²¹⁷ CBB, 2012

²¹⁸ CBB, 2013

Whychus Creek Restoration

Whychus Creek has been the subject of extensive restoration work including establishment of instream flows, dam removal, and irrigation diversion screening. The work on Whychus is illustrative because it is a testing ground for projects with applicability across the basin, but it also serves to demonstrate how anadromous fish restoration in the basin is contingent on many other factors besides fish passage at the Pelton Round Butte complex.



Whychus Creek's watershed begins at the crest of the Cascade Mountains and extends northeast, with the creek flowing through Sisters before its confluence with the Deschutes River approximately three miles upstream of Lake Billy Chinook.^{219, 220}

2007 survey data of Whychus Creek fish habitat indicated 0.0 miles of "good", 28.4 miles of "fair", and 6.8 miles of "poor" habitat.²²¹ Data collected in 2008 and 2009

²¹⁹ Tillman, 2010

²²⁰ Mork and Houston, 2012

indicate that ten miles of habitat have been reclassified as “good”,²²² but given that Whychus Creek was historically some of the best habitat for steelhead in the entire basin, these habitat surveys indicate the ongoing challenges of comprehensive basin restoration.²²³ A collaborative effort to improve habitat downstream of Sisters in Camp Polk Meadow has meant rehabilitating a section of river severely degraded by channelization beginning in the 1960s for flood control. The objective is to reintroduce the necessary complexity for spawning grounds, wetlands and a natural floodplain by constructing oxbows and side channels. This will improve habitat and slow streamflow, reducing erosion and allowing for improved riparian vegetation.²²⁴ Camp Polk Meadow was historically the highest quality spawning ground for steelhead on Whychus Creek, making it an important restoration target.²²⁵

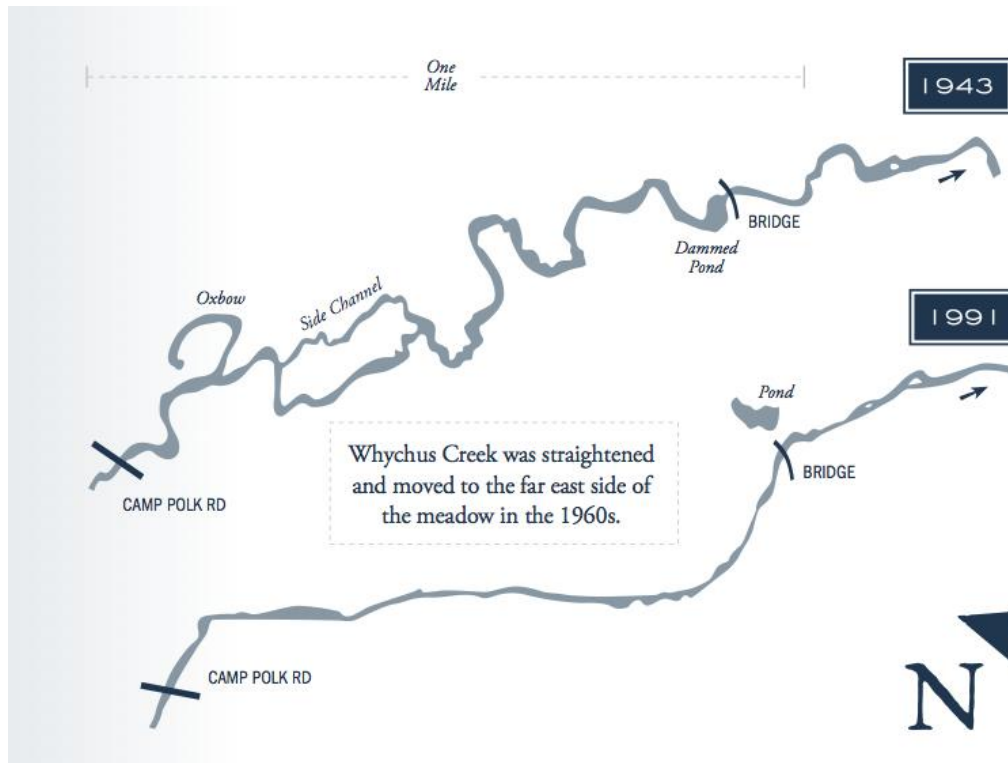
²²¹ Houston, 2008

²²² UDWC, 2009

²²³ Houston, 2008

²²⁴ Houston, 2008

²²⁵ Deschutes Land Trust



Channelization by the Army Corps of Engineers in the 1960s straightened Whychus Creek and caused significant losses in important habitat and channel complexity such as side channels and oxbows.²²⁶

Of the 13 irrigation diversions on Whychus Creek, none were screened until 2009. Four had been screened as of 2011, and all diversions are scheduled for screening or decommission by 2020.²²⁷ This is an important step for restoration since fish inadvertently swim or are drawn into irrigation canals where they often become stranded. Juvenile fish are most vulnerable to unscreened diversions because they mistake the canal for a side channel, and attempt to take shelter in it only to become lost in the irrigation canal system.²²⁸

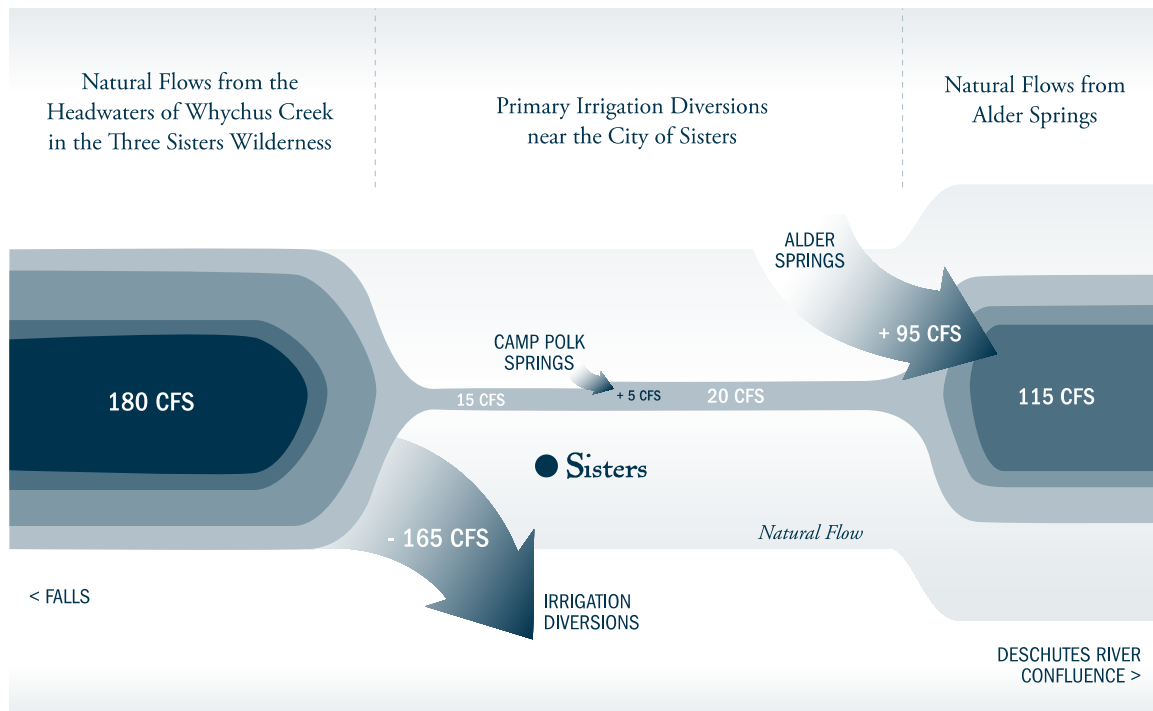
Perhaps the most important and significant Whychus Creek restoration project is the establishment of instream flows. For a creek that ran completely dry an average of

²²⁶ Houston, 2008

²²⁷ UDWC, 2009

²²⁸ UDWC, 2009

two out of three years between 1960 and 1999, the establishment of 20 cfs of instream flow is a significant step forward.²²⁹ Irrigation uses remove 90% of the water in Whychus Creek at several locations upstream of Sisters, and have historically diverted 100% of the flow during the peak demand months of summer.²³⁰



Irrigation diversions remove up to 90% of Whychus Creek’s streamflow, and the creek ran dry two out of three years between 1960 and 1999.²³¹

Through the piping of seepage-prone irrigation district canals and instream flow leasing projects, the Three Sisters Irrigation District and the Deschutes River Conservancy have been able to return nearly 30 cfs instream, meeting the state instream flow target.²³² In addition, collaboration between landowners of a local ranch, the U.S. Forest Service, and several river advocacy groups is resulting in permanent instream flows and the installation of a fish friendly diversion pump. The ranch’s concrete dam is

²²⁹ UDWC, 2009

²³⁰ Mork and Houston, 2012

²³¹ Houston, 2008

²³² DRC, n.d.

being replaced with a more efficient and fish-safe pump and the elimination of lost water though an unlined diversion ditch will allow for the establishment of a permanent senior water right of 1 cfs in Whychus Creek.²³³ That the water rights are some of the oldest in the basin underscores the notion that collaboration on a small scale can facilitate important progress.

This type of cooperative action, rather than litigation, offers the best way forward for restoration projects, but lasting solutions will require investment from all water rights holders and basin stakeholders for the construction of a strong foundation for basin watershed health. Results of a 2012 monitoring study found that Whychus Creek still experiences low flows during early summer and late summer/early fall when irrigation demands exceed water availability, but extreme low flows appear to be decreasing in frequency and magnitude during the summer months.²³⁴ With the removal of an outdated diversion dam, two miles of additional habitat have been reopened and instream flows have been greatly improved.²³⁵ Given the multitude of projects that are ongoing along Whychus Creek, it is not possible to quantify the impact of any one given restoration effort, but the sum of the work has been the reopening of several miles of habitat, increasingly established summer streamflows, and improved habitat.²³⁶

While heartening and newsworthy to see fish returning to spawn upstream of the Pelton Round Butte Complex after successful migration, the sober reality is the fish that do arrive upstream of the complex find a network of rivers and streams that remain blocked by countless small diversion dams in the basin. Even in those waterways that are

²³³ DRC, 2014

²³⁴ Mork and Houston, 2012

²³⁵ DRC, 2013b

²³⁶ Mork and Houston, 2012

not blocked by diversions, fish encounter water quality issues such as low to nonexistent instream flows. This means that while mitigation efforts thus far have been innovative and groundbreaking, they are no panacea for the still-degraded fish habitat situation in much of the Deschutes Basin; all components of restoration work including adequate streamflow, appropriate water temperature, healthy spawning habitat, and successful fish passage must come together for anadromous fish to complete their lifecycle.

Though recent research has indicated that none of the significant geomorphic changes typically expected downstream of dams have occurred on the Deschutes River, it is important to note that conditions upstream of the compound are far from ideal, and remain wholly inadequate in some reaches. The Deschutes largely still remains a river divided given that conditions in the Upper Deschutes Basin remain impaired, and while groundbreaking collaborations between water rights holders and conservation agencies are increasingly securing instream water rights, the dewatering of streams and rivers remains a constant threat basin-wide.

CONCLUSIONS

“In my view, nature is awful and what we do is cure it.”

-Camille Dagenais, former head of Canadian dam engineering firm SNC, 1985²³⁷

“It must be considered that there is nothing more difficult to carry out, nor more doubtful of success, nor more dangerous to handle, than to initiate a new order of things.”

-Niccolo Machiavelli, *The Prince*, 1532²³⁸

The rivers of the Pacific Northwest have been the focus of some of the most ambitious conservation efforts ever undertaken. Numerous initiatives have been proposed and enacted, and progress has been made in spite of great geographic scale, economic

²³⁷ McCully, 2001

²³⁸ McCully, 2001

stakes and biological complexity. That said, the pressures on fish and rivers remain substantial, and the likelihood is that even if fish runs begin to survive and regain strength, their position will remain tenuous and progress will be fragile at best. It is unlikely that the deeper changes necessary for fish to prosper and flourish will be undertaken due to the complex relationship the region has with its rivers. Water plays many roles for many users, and this will remain an intractable problem for some time until great changes are made in human morality and understanding. The choices of economics, development and energy in the Pacific Northwest will impact, directly or indirectly, the fish and our rivers.

The magnitude of human impact on the West's water is staggering. The Bureau of Reclamation has built 355 storage reservoirs and 16,000 miles of canals, 1500 miles of pipelines and 278 miles of subterranean tunnels. More than 100,000 miles of canals divert water to irrigators, where more than a million artificial lakes, ponds and reservoirs store nearly 300 million acre-feet: this is the equivalent of twenty-two Colorado Rivers. Such a volume of water is enough to flood Montana, Wyoming, Colorado and New Mexico, a north-south strip from Canada to Mexico, under a foot of water.²³⁹ The story of the development of rivers "is an unsettling story that speaks directly to the limits of technical expertise, the treacherous allure of the grandiose solution, and the consequences that can unfold when the government opens its checkbook and closes its regulation manual."²⁴⁰ While attitudes are shifting and societal views on what a river is and should be have become broader, the extent of water development and the attitudes and values associated present a formidable challenge for restoration efforts.

²³⁹ Wilkinson, 2006

²⁴⁰ Wilkinson, 1992

Today, proposed dam construction projects face heavier scrutiny than ever before, are seen as less efficient and more expensive using a traditional cost-benefit analysis, and must contend with many new kinds of costs that are not easily quantifiable.²⁴¹ In spite of its efforts, the reform movement in western water is young and its achievements are limited in scope. The monolithic mass of water rights granted prior to the concept of instream rights remain largely undisturbed; an instream right with a priority date of 1980 to protect wildlife gets nothing tangible when a priority date of 1880 or 1900 is needed to get real, flowing water. “First in time, first in right.”²⁴² Keeping this in mind when examining the Deschutes Basin is a reminder that while small volumes of instream flow are secured through initiatives such as water banking, every season senior water rights are filled for irrigation purposes and the junior instream flow rights go unfilled, leaving fish to deal with minimal flows. As recently as October 2013, more than 2,000 fish died when stranded in a Deschutes River side channel near Bend because of low flows.²⁴³ This event underscores the continuing tenuous balance between water storage and flows required to maintain fish populations in the upper basin.

Even after several decades of reexamination of laws and the addition of new ones, most of the water is still delivered to the beneficiaries of the prior appropriation doctrine: the low flows in the fall of 2013 resulted from reservoir filling upstream for the upcoming irrigation season. Resistance runs deep and profound in the old attitudes that lie with water developers and users: “It’s their water, and they’ll do with it as they please.”²⁴⁴ Taking an engineering approach to our rivers results in one-sided policies

²⁴¹ Wilkinson, 2006

²⁴² Wilkinson, 2006

²⁴³ Darling, 2013

²⁴⁴ Wilkinson, 2006

favoring development, utilitarian and extractive uses. It is clear today that “there is more in our rivers than we are allowed to see through the lens with which our policies view them.”²⁴⁵ What is required is deeper change in the thinking of all users of the river and its tributaries, and rethinking the role of humans in the basin. Science cannot solve all of our problems; it merely points the way for the ethical and value-laden questions we must answer. The science is established that fish need water flowing in streams at the proper temperature, healthy habitat for reproduction, and access to their full range for migration.

What society chooses to do with this information is where science and values meet: a decision must be made about what priorities are desired in the Deschutes Basin. Maintaining the status quo of filling senior water rights or choosing to transfer them to maintain instream flows is a value-laden choice, one guided by science but ultimately premised on a view that fish have as much right to rivers as do humans and that water flowing downstream in a river is not wasted but is infinitely valuable to the aquatic life it sustains. Extirpating the “lords of yesterday” that entrench the status quo of human dominance of rivers is key for the success of restoration work in the Deschutes Basin.

“The song of waters is audible to every ear, but there is other music in the hills, by no means audible to all... On a still night, when the campfire is low and the Pleiades have climbed over rimrocks, sit quietly and listen... and think hard of everything you have seen and tried to understand. Then you may hear it – a vast pulsing harmony – its score inscribed on a thousand hills, its notes the lives and deaths of plants and animals, its rhythms spanning the seconds and the centuries.”

-Aldo Leopold, *Sand County Almanac*, 1949²⁴⁶

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²⁴⁵ Wilkinson, 2006

²⁴⁶ Davis, 2013

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