# Upper Deschutes River Restoration Strategy

**October 7, 2008**

**Deschutes River Conservancy,**
**Upper Deschutes Watershed Council,**
**Oregon Department of Fish and Wildlife**

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## Vision

We envision a healthy river that supports high quality riparian and aquatic habitats and the processes necessary to sustain them.

## Purpose

The Upper Deschutes River Restoration Strategy (the Strategy) outlines the steps necessary to restore the structure and function of the Deschutes River between Wickiup Reservoir and North Canal Dam. The Upper Deschutes Watershed Council, Oregon Department of Fish and Wildlife, and Deschutes River Conservancy believe that restoring the river will require coordination between irrigation districts, non-profit organizations, public agencies, and private landowners. The Strategy identifies and prioritizes the suite of restoration actions necessary to achieve our vision.

## Geographic Context

The Deschutes River is one of the most well known waterways in the western United States. The river originates at Little Lava Lake in Oregon's Cascade Mountains and flows north, dropping 4,500 feet over 250 miles before emptying into the Columbia River. It provides water for the irrigation of agricultural lands, critical habitat for fish and wildlife, a rich history of culture, tradition and sustenance for Native Americans, power for generating electricity, and recreation benefits that draw sporting enthusiasts from all over the country.

Historically, the upper Deschutes River and its tributaries supported healthy populations of redband and bull trout. Stream flows were naturally stable and the river supported resilient wetlands and verdant riparian areas. Over the past 100 years, however, fish and wildlife have suffered as a result of basin-wide habitat degradation. Explosive population growth in the region and all that has come with it – municipal and residential development, irrigation of agricultural lands, logging, and recreation – has all contributed to a decline in habitat quality throughout the Deschutes Basin.

Flows in the upper Deschutes River were remarkably stable under natural conditions. Irrigation storage in Wickiup and Crane Prairie Reservoirs now largely dewaters this reach between October and April and artificially increases flow in the reach during the late spring, summer, and early fall. The shift from a naturally stable flow pattern to a highly variable flow pattern has limited fish populations in the Deschutes River. The 2004 Deschutes Subbasin Plan identified that "stream flow extremes, especially low or intermittent flows, are probably the most significant factors limiting fish production in much of the Deschutes River subbasin [sic] today." The Oregon Department of Fish and Wildlife identifies improving redband trout and whitefish populations and determining the feasibility of re-introducing bull trout as goals for the upper Deschutes River.

The upper Deschutes River can be divided into two reaches at Benham Falls. Upstream of the falls, the river meanders through pine forests and wet meadows. Healthy redband trout populations historically extended through this low-gradient reach, but habitat degradation associated with irrigation storage and release operations has reduced these populations.

Reservoir operations lead to huge seasonal flow fluctuations in this reach. Winter storage reduces flows as low as 20 cfs, and summer discharge raises flows up to 1,800 cfs. These fluctuating flows cause bank erosion, decrease water quality, and limit spawning habitat. The Oregon Department of Environmental Quality has listed this reach for not meeting several water quality standards (turbidity[1&2], temperature[1], chlorophyll A[1], and dissolved oxygen[1&2]) in large part due to flow fluctuations. Correspondingly, the Oregon Department of Fish and Wildlife has identified flow fluctuations as the greatest factor limiting fish abundance in the Upper Deschutes River.

Downstream from Benham Falls, the upper Deschutes River cascades over several natural falls before reaching irrigation diversions in the City of Bend. Redband trout populations improve from Benham Falls to Bend. This improvement in trout populations can be attributed to more stable winter streamflow. Upstream inputs from Fall River and Spring River combine with groundwater discharge into the Deschutes River to attenuate the flow fluctuations associated with areas immediately below Wickiup Reservoir. Nevertheless, spawning habitat is still limited spawning in this reach.

## Strategy Elements

The Deschutes River Conservancy, the Upper Deschutes Watershed Council, and the Oregon Department of Fish and Wildlife have identified a suite of activities to help us achieve our vision for the upper Deschutes River. We believe that a clear set of actions and recognizable outcomes will be necessary for success.

We believe that streamflow is the greatest limiting factor in the upper Deschutes River. Streamflow restoration and related actions have the greatest potential for improving ecological conditions in the long-term. However, improving intra- and inter-annual flow patterns alone will not be sufficient to achieve our vision.

We see a need for short-term, local scale habitat enhancement and long-term, reach scale channel reconstruction to complement streamflow restoration in the upper Deschutes River. These actions should be completed strategically based on their ability to build community support or improve ecological conditions. We do not believe that disconnected, local-scale actions should be a priority unless they have high amounts of private match funding or have been strategically selected for their social or ecological value.

We believe that comprehensive restoration effectiveness monitoring will help us to document current status and trends while improving our actions in the future. All monitoring should be tied to specific metrics related to ecological conditions. We also see the need for a research program to document emerging issues in the upper Deschutes River, including water quality issues related to plant growth and nutrient inputs.

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[1] RM 189 at Meadow Camp to RM 162 at North Unit Dam
[2] RM 222 at Pringle Falls to RM 189 at Meadow Camp

Following the work of other organizations, we have separated our strategy into different components (see Figure 1). We do not always explicitly identify these components in the narrative, but we do identify them in detailed tables following the narrative. *Goals* identify broad-scale impacts that that will help us to achieve our vision. Under each goal we specify measurable *objectives.* Objectives represent the desired changes that we hope to see in the upper Deschutes River system. We achieve our objectives through *actions*. Actions represent specific management activities intended to change some social, political, or ecological aspect of the upper Deschutes River. We have created *hypotheses* that link each action to a measurable objective. Our hypotheses allow us to determine whether our actions are having the intended effect on the system. We use *metrics*, or measurable components of the system, to test our hypotheses. In many cases, these metrics need to be refined and developed as part of the comprehensive monitoring plan discussed in this strategy. Different stakeholders in the upper Deschutes Basin have different *roles* under each goal. We identify confirmed or potential roles and outline some of the *tasks* involved in these roles. Some roles remain unfulfilled, and we acknowledge that no stakeholders currently plan to pursue some of the identified actions. We also roughly identify *timelines* for when an action should be completed. We know that some actions depend on other actions occurring first, and we expect that some actions will be easier to complete than others. Finally, we have prioritized our actions based on their ecological importance, social and economic feasibility, and timeliness. Actions that are ecologically important but rely on other actions occurring first may be listed as a lower priority. For example, we believe that a monitoring plan should be implemented as soon as it is established. Establishing the plan needs to come first, though, so implementing the plan remains a medium priority at this point.

**Figure 1.** Sample Action. We identified this action as a high priority action necessary to restore the upper Deschutes River. The action has a measurable objective, a testable hypothesis with associated metrics, appropriate benchmarks, an approximate timeline, and clear roles and responsibilities.

| Objective | Action | Priority | Hypothesis | Metrics | Benchmarks | Timeline | Roles & Responsibilities |
|---|---|---|---|---|---|---|---|
| Move the existing hydrograph towards the desired future hydrograph. | Identify desired hydrograph and benchmarks. | High | Desired hydrograph will be different from existing hydrograph. | Hydrograph elements (magnitude, timing, frequency, and rate of change of flows) | Funding secured; working group established; ecologically ideal hydrograph developed; socially feasible hydrograph developed. | 5 Years | Deschutes River Conservancy will facilitate hydrograph identification (pending funding) |

## Recommended Actions

We have organized this document by goals, objectives and actions. We have prioritized our recommended actions based on their ecological importance, timeliness, and feasibility (see Figure 2). A full narrative and detailed tables explaining the recommended actions follow this section.

**Figure 2. Summary of Recommended Actions.** We identified the following actions as contributing to our vision for the upper Deschutes River. Some actions appear twice, and an action may have a different priority depending on its context. We have not sorted the actions at each priority level because actions will be more or less appropriate at different times depending on their context. However, streamflow is generally acknowledged as the greatest limiting factor along the upper Deschutes River.

- High Priority Actions
  - Identify the desired dimension, pattern, and profile of the upper Deschutes River.
  - Identify target hydrograph and benchmarks.
  - Restore individual components of the hydrograph through temporary and permanent water transactions.
  - Identify high-value, at-risk riparian areas.
  - Establish a comprehensive monitoring plan.
  - Support community organizing and information sharing.
  - Establish a research program to study emerging water quality issues.

- Medium Priority Actions
  - Restore the dimension, pattern and profile through channel and bank restoration.
  - Add large wood [strategic].
  - Implement local channel and bank restoration projects [strategic].
  - Create the institutional framework necessary to more the existing hydrograph closer to the desired hydrograph.
  - Review and revise county, state, and city land use regulations.
  - Implement a comprehensive monitoring plan.

- Low Priority Actions
  - Create the infrastructure necessary to improve reservoir operations and meet target ramping rates.
  - Add large wood [stand-alone].
  - Implement local channel and bank restoration projects [stand-alone].
  - Clarify and communicate land-use regulations.
  - Establish regular communication with elected officials.
  - Add spawning gravel.

The partner organizations that developed the Strategy prioritized actions based on their feasibility and their ecological importance. We recognize that institutional capacity and resources vary and that agencies and organizations do not currently have the capacity to implement some high priority actions. We suggest that restoration partners review high priority actions in relation to other work in the basin as opportunities to implement them arise. Different actions will be more or less timely depending on the status of related actions. For example, we can improve minimum flows without identifying a target hydrograph. As flow restoration progresses, through, identifying the appropriate hydrograph becomes more important. We believe that some medium priority actions are necessary but will require additional work before they can be implemented.

The narrative in the following section provides the context for and the reasoning behind our prioritization. The narrative clearly identifies the steps necessary to implement each action. We suggest reviewing actions in the narrative before moving forward and implementing them.

## Narrative of Recommended Actions

The following narrative outlines the actions that we believe will move the upper Deschutes River closer to our vision. The narrative divides these actions into different sections based on the goals and objectives that they support (see Table 1). In spite of these divisions, we believe that they stand together as a suite of inter-connected activities necessary to restore the upper Deschutes River. Each goal and its associated objectives and actions appears in a separate section.

**Table 1. Goals and Objectives.** The Deschutes River Conservancy, Upper Deschutes Watershed Council, and Oregon Department of Fish and Wildlife identified four goals and eight objectives necessary to achieve our vision of a healthy upper Deschutes River.

| Goal | Objectives |
|---|---|
| By 2030, degraded ecosystem structures and functions will be improved in the Upper Deschutes River. | Restore the dimension, pattern, and profile of the upper Deschutes River |
| | Move the existing hydrograph towards the desired future hydrograph. |
| By 2030, existing ecosystem functions and processes will be maintained and protected from further degradation. | Enhance local instream habitat |
| | Protect areas with high ecological value |
| By 2030, the community will demonstrate greater stewardship of the upper Deschutes River. | Engage riparian landowners in protecting and restoring the upper Deschutes River. |
| | Engage community members in protecting and restoring the upper Deschutes River. |
| By 2030, the restoration community will have an increased understanding of the upper Deschutes River system. | Understand effectiveness of the suite of restoration actions. |
| | Understand emerging water quality issues related to land use and water management. |

## Goal: By 2030, degraded ecosystem structures and functions will be improved in the upper Deschutes River.

This strategy identifies two objectives and six actions under the goal, "By 2030, degraded ecosystem structures and functions will be improved in the upper Deschutes River" (see Table 2). The following sections describe the actions under each objective.

**Table 2. Objective and actions necessary to restore degraded ecosystem structures and functions.**

| Objective | Action |
|---|---|
| Restore the dimension, pattern, and profile of the upper Deschutes River. | Identify the desired dimension, pattern and profile. |
| | Restore the desired channel dimension, pattern, and profile through channel and bank restoration. |
| Move the existing hydrograph towards the desired future hydrograph. | Identify desired hydrograph and benchmarks. |
| | Create institutional framework to improve hydrograph through water transactions. |
| | Create the infrastructure necessary to improve reservoir operations and meet target ramping rates. |
| | Restore components of the hydrograph using temporary and permanent water transactions. |

### Objective: Restore the physical dimension, pattern, and profile along the upper Deschutes River.

#### Action: Identify the desired dimension, pattern, and profile.

Three physical characteristics define a river. The *dimension* describes the depth and width of the river channel as you look across it. The *pattern* refers to how the river moves across the landscape. Does it pass straight through in a straight line? Does it wander sinuously? The *profile* describes how the elevation of the river falls as the river flows from its headwaters to its mouth.

Seasonal flow patterns and local geology determine the dimension, pattern, and profile of a river. Winter reservoir storage and summer reservoir releases have changed flows patterns in the upper Deschutes River, and they have likely affected its physical form. We hypothesize that the dimension, pattern and profile necessary to improve the health of the Deschutes River is different from the existing dimension, pattern, and profile.

Identifying the desired dimension, pattern and profile is a critical first step towards restoring the upper Deschutes River. We cannot implement large scale physical habitat

restoration projects until we identify our desired river form. Based on their land ownership and their existing activities, the Deschutes National Forest will be the most appropriate lead partner for this action.

This high priority action can be completed within five years and should be funded accordingly.

**Action: Restore the dimension, pattern, and profile through channel and bank restoration.**

The upper Deschutes River corridor looks much different in the summer, when the river fills its channel, than it does in the winter, when the river recedes and leaves bare banks along most of the upper reach. The river's bare banks freeze during the winter and erode during the summer, sloughing off material that later travels downstream. Restoring the Deschutes River requires, among other actions, restoring its physical form. We hypothesize that, over the long term, we can change the river's dimension, pattern and profile from its existing form to our desired form through a combination of seasonal streamflow restoration and large scale channel and bank restoration projects. However, until the hydrograph more closely matches the desired condition (see below), our ability to restore the dimension, pattern and profile will be severely limited.

This action exemplifies the long-term approach necessary to restore the upper Deschutes River. We cannot restore the form of the Deschutes River until we identify the desired form (see above) and, correspondingly, the desired hydrograph (see below). While we agree that it is ecologically critical to implement this action, its success depends on completing other actions first. Once we have identified the proper form and its related hydrograph, we can incrementally restore the Deschutes River channel.

Based on their existing activities, the Deschutes National Forest and the Oregon Department of Fish and Wildlife will be the most appropriate lead partners for this action. The Upper Deschutes Watershed Council can provide funding but does not have the resources to implement the large-scale restoration required to reach our goals.

This action is a medium priority action that will require long-term investments. We expect to implement this action after five years because of its stated dependencies on other activities in this strategy.

**Objective: Move the existing hydrograph towards the desired future hydrograph.**

**Action: Identify target hydrograph and benchmarks.**

A river's *hydrograph* describes how the river's flow changes over time. It identifies the magnitude, duration, frequency, timing, and rate of change of streamflow in a river. The hydrograph affects the form of the river and how fish and wildlife behave in and around the river.

Under natural conditions, flows in the Deschutes River did not vary much between seasons. Groundwater discharge maintained a relatively steady flow in the river throughout the year, and it was one of the more stable flowing rivers of its size in the United States. Reservoir operations have changed the how much water flows through the upper Deschutes River each season, leading to unnaturally low winter and unnaturally high summer flows.

These changes are important because seasonal flow patterns drive the river's biological functions. Instream flow restoration efforts historically focused on identifying the minimum or optimum flows needed to support selected fish populations. As our understanding of river restoration has evolved, our understanding of instream flow needs has changed as well. Restoration practitioners have begun to focus on the whole hydrograph necessary to support fish, wildlife, channel structure, recreation, agriculture, and riparian vegetation. Instead of looking at minimum or optimum flows, they identify how each portion of the hydrograph supports river structure and function.

We hypothesize that the desired hydrograph in the upper Deschutes River will look much different from the existing hydrograph. We suggest identifying the desired hydrograph through a collaborative process that considers irrigation, recreation, and ecological needs.

The existing instream flow targets for the upper Deschutes River identify one component of the desired future hydrograph. The desired hydrograph identified through a collaborative process should account for the full suite of component (high flow events, low flow events, inter-annual variability, etc.) that define a river's hydrologic regime. We recommend moving beyond the single-value hydrograph approach and towards a collaborative approach that incorporates inter-annual and intra-annual variability.

The Nature Conservancy has pursued collaborative processes across the United States. They have expressed interest in working the Deschutes Basin, and may be able to provide technical support. We suggest establishing a multi-stakeholder working group to implement this process. The working group should first develop a summary of existing, appropriate research relating to streamflow, habitat structure, and river functions. After developing and sharing this information, they should convene a multi-day conference where a wide range of stakeholders meets and collaboratively develops the desired hydrograph.

The Deschutes River Conservancy will be an appropriate lead partner for this action given their current collaborative approach and experience working with streamflow restoration.[3] We consider this action to be a high priority for funding because of its relationship to channel restoration (see above). It can be completed within five years.

[3] Pending funding availability

**Action: Create the institutional framework necessary to move the existing hydrograph closer to the desired future hydrograph.**

The institutional framework governing how water moves through the upper Deschutes River consists of existing contractual arrangements, inter-district agreements, state statutes, and federal regulations. It defines who gets how much water from Wickiup and Crane Prairie Reservoirs, where they can use it, and what they can use it for. The existing framework makes it difficult to move water between willing buyers and willing sellers even when a transaction will benefit all parties.

The Deschutes River Conservancy currently uses a relatively obscure federal statue to temporarily restore winter streamflow.[4] This method works, but it involves a high transaction cost and does not provide the most benefits to instream or agricultural water users. We have provided examples of several changes to changes to reservoir management that could improve streamflow in the upper Deschutes River.

- *Allow Inter-annual Carry-over*. The Oregon Water Resources Department maintains accounts for each of the four irrigation districts that store water in Crane Prairie or Wickiup Reservoir. These accounts track how much water each district has available in storage. Currently, the Oregon Water Resources Department resets those accounts at the end of each irrigation season. An irrigation district does not necessarily benefit the following year if it has extra storage in its account at the end of the season. Instead of resetting district accounts, the Oregon Water Resources Department could allow them to carry stored water in their accounts through the following season.

- *Explicitly Operate Reservoirs Together*. Crescent Lake, Crane Prairie Reservoir and Wickiup Reservoir all leak water. They leak at different rates depending on how full they are. They also fill with different reliability. From a water-availability perspective, it makes sense to fill the leakiest reservoirs last and empty the most reliable reservoirs first. This change would allow districts to keep their storage accounts but physically store their water in different reservoirs.

- *Fill Reservoirs Vertically*. The Oregon Water Resources Department currently fills irrigation district accounts in Crane Prairie and Wickiup Reservoirs following a complicated set of rules set out in a 1938 inter-district agreement. Since the reservoirs fill account-by-account, we refer to them as filling 'horizontally.' We suggest that the Oregon Water Resources Department could instead fill the reservoirs vertically. Each district would receive a portion of the water entering the reservoir based on its relative priority date and total storage right. When combined with inter-annual carryover, this option may improve water use efficiency.

- *Reservoir Re-authorization.* The Bureau of Reclamation restricts the use of water in Crane Prairie and Wickiup Reservoirs. Wickiup Reservoir has the strictest

[4] 43 *CFR* 12.8 (2005)

restrictions. A Congressional re-authorization of these two reservoirs for multiple uses would allow for water to be stored and used for streamflow restoration.

- *Title Transfer.* The Bureau of Reclamation currently holds the titles to Crane Prairie and Wickiup Reservoirs. A title transfer from federal to irrigation district control would make it much easier to change how these reservoirs operate.

It will be much easier to move water between different users and uses if we adapt the existing institutional framework to allow these changes. We hypothesize that a new institutional framework will help us move towards the desired hydrograph without impacting existing water users and uses. We do not define which changes would be most appropriate. Instead, we acknowledge that several possible sets of changes would achieve our desired outcomes.

We consider this action to be a medium priority to be completed within 5-10 years. The Deschutes River Conservancy has demonstrated that short-term streamflow restoration can occur under the existing framework, albeit with a relatively high transaction cost. Any long-term solution will likely involve one or more of the changes described above. We suggest funding this action based on a long-term timeline.

**Action: Create the infrastructure necessary to improve reservoir operations and meet target ramping rates.**

The flow in the upper Deschutes River depends on the outflow from Wickiup Reservoir. Adjusting the flow in the Deschutes River requires manually adjusting the outflow from the reservoir. The desired flow pattern in the Deschutes River will likely have specific peaks, troughs, and rates of change. It will be difficult to create this flow pattern by manually adjusting flow in the river.

We hypothesize that installing new infrastructure to control the outflow from Wickiup Reservoir will allow water managers to more easily adjust the flow in the Deschutes River and move towards the desired hydrograph.

We consider this action to be a low priority relative to other actions and suggest that it be funded accordingly. The priority of this action should increase if the action can be leveraged against multiple purposes, such as the installation of a hydroelectric generating facility. We foresee this action being completed within a 10-15 year time period.

**Action: Restore individual components of the hydrograph through temporary and permanent water transactions.**

A *water transaction* moves water between users or uses through voluntary arrangements. Water transactions can be permanent or temporary. In the Deschutes Basin, they regularly occur between or within irrigation districts, municipal water providers, and environmental interests.

Oregon owns the water in the Deschutes Rivers. Individual entities own the right to use that water for specific purposes. Four irrigation districts own the right to store water in and use water from Wickiup and Crane Prairie Reservoirs. We hypothesize that water transactions with these irrigation districts will restore different components of the hydrograph.

We envision a three-tiered approach to water transactions in the upper Deschutes River. The first tier involves short-term, low-volume transactions. The Deschutes River Conservancy leased a small amount of stored water from Crook County Irrigation District #1 in 2006-2007 and 2007-2008. These two one-year transactions demonstrated that water transactions are a successful tool for streamflow restoration in the upper Deschutes River.

The second tier involves medium-term, higher volume water transactions. The Deschutes River Conservancy suggests maintaining a minimum flow of 50 cfs over a 5 year period as a next step. We have worked with the Oregon Water Resources Department to model the difference in irrigation storage availability under a 20 cfs base flow and a 50 cfs base flow, and we are confident that we can mitigate for the impacts of increased base flow on district storage availability during most years. Some districts use more of their stored water than others, and water can be temporarily moved between districts to improve reliability.

The third tier involves permanent water transactions implemented as part of a broad-scale restoration strategy. We expect that the long-term reallocation of water between uses and users will increase the volume and reliability of live flow available for diversion and will reduce the districts' reliance on stored water.

When we transfer existing irrigation rights instream, we increase the amount of water available for other irrigators to use in two ways. First, we do not transfer any storage rights instream. Most irrigation water rights have both live flow and stored water components. The Deschutes River Conservancy only transfers the live flow components, leaving the stored water in Crane Prairie and Wickiup Reservoirs to shore up irrigation water supplies. Second, we only transfer a portion of the live flow water right instream. Most water rights in the upper Deschutes Basin consist of two parts – a volume of water to be used on-farm and a volume of water to aid delivery through district canals. We only transfer the on-farm portion instream, theoretically leaving the delivery portion available for other water users to divert. These instream transfers increase the 'live flow' available to districts, reducing their reliance on stored water. In the long-term, the Deschutes River Conservancy hopes to contract with irrigation districts for a portion of the stored water that they may no longer need.

Some irrigation districts, such as North Unit Irrigation District, rely on storage more than others, such as Central Oregon Irrigation District. As irrigation districts with reliable live flow rights urbanize, we foresee the potential to trade their water rights for a combination less reliable live flow rights and stored water rights. A water rights switch of this type could permanently restore flow while having a minimum impact on irrigation districts.

## Goal: By 2030, existing ecosystem functions and processes will be maintained and protected from further degradation.

This strategy identifies two objectives and six actions under the goal, "By 2030, existing ecosystem functions and processes will be maintained and protected from further degradation" (see Table 3). The actions under this goal focus on maintaining existing functions. In some cases, such as adding spawning gravel, maintaining existing functions requires maintenance that would be considered restoration in other systems. We believe that these actions are not necessarily improving the system but are maintaining it at existing baseline levels. The following sections describe the actions under each objective.

**Table 3. Objective and actions necessary to maintain and protect existing ecosystem functions and processes.**

| Objective | Action |
|---|---|
| Enhance local instream habitat. | Add spawning gravel. |
| | Add large wood. |
| | Local channel and bank restoration projects. |
| Protect areas with high ecological value. | Identify at-risk, high value riparian areas. |
| | Implement land transactions to protect identified valuable areas. |
| | Review and revise city, county, and state land use regulations. |

### Objective: Enhance local instream habitat.

#### Action: Add spawning gravel.

Native fish need cool, clean water and suitable substrate to successfully spawn in the upper Deschutes River. *Substrate* refers to the material along the bottom of a stream. Redband trout spawn in areas with well-aerated gravel substrate. They form *redds*, places where they deposit their eggs, in these areas. Dams along the upper Deschutes River prevent gravel from entering the system from upstream tributaries. At the same time, sediments eroding off of the banks settle out and cover existing gravel areas. These changes limit the amount of clean, correctly sized gravel available for native fish spawning.

We hypothesize that adding spawning gravel in areas with the correct streamflow and riparian cover will reduce overall gravel embeddedness and increase the number of

redband trout redds. When coupled with channel dimension restoration, we expect that adding spawning gravel will improve native fish populations.

We consider this action to be a low priority for long-term restoration. Enhancing spawning gravel will maintain spawning grounds but will not restore additional functionality to the upper Deschutes River. However, we do believe that spawning gravel restoration provides short-term benefits for fish populations and should be funded accordingly. The Oregon Department of Fish and Wildlife will lead, implement, and monitor gravel enhancement projects.

**Action: Add large wood.**

The high summer flows and low winter flows described earlier limit the riparian vegetation growing along the upper Deschutes River. *Large wood* enters a river when trees or limbs fall along its bank. When we refer to large wood, we generally mean logs or whole trees measuring greater than 6 feet in length. Limited riparian vegetation means limited large wood entering the river.

Why does large wood matter? Large wood changes stream morphology. It increases pool formation, accumulates sediments and organic matter, and provides a substrate and energy source for stream-dwelling macroinvertebrates. Agencies and organizations have already completed several large wood projects along the upper Deschutes River.

The Deschutes River Conservancy commissioned a review of eleven bank stabilization projects along the upper Deschutes River in 2005. Several of these projects included large wood placement. The review suggested that placing multiple pieces of large wood in simulated debris jams was more effective than placing individual pieces of wood instream, and it recommended that future large wood placement projects emulate natural debris jams for more immediate results. According to the reviewers, large wood improved habitat at both low flows and high flows only when it was correctly placed in the channel. They suggested completing detailed pre-implementation site surveys and, where appropriate, integrating large wood placement with bank shaping projects. Randomly adding large wood increases organic matter in the system, but strategically adding large wood provides additional benefits for fish habitat, riparian vegetation, and channel form. We hypothesize that strategically adding large wood will bring both low flow and high flow habitat conditions closer to the desired conditions.

We consider adding large wood to be a low priority when project objectives do not extend beyond increasing organic matter in the stream. We rank large wood enhancement as a medium priority when it is strategically placed and coordinated with other local habitat enhancement actions.

**Action: Implement local channel and bank restoration projects.**

Water management and land use practices both affect local habitat conditions. We have discussed water management extensively earlier in this strategy. Land use practices,

particularly riparian development in the Sunriver-LaPine corridor, has also impacted the upper Deschutes River. The conversion of riparian areas to homes, lawns, and roads has altered riparian vegetation and likely exacerbated water quality impairments.

The Deschutes River Conservancy's review of upper Deschutes River restoration projects recommended that local habitat restoration projects could be most effective if they were implemented in areas where land management caused instream habitat or water quality degradation. For example, local habitat restoration may be effective in areas where development has encroached on the river channel and altered conditions. Local projects will restore local habitat condition if they are well planned and strategically designed to address multiple limiting factors. They should include detailed site assessments and be explicitly designed to improve habitat at both low and high flows.

Local channel and bank restoration projects will not restore the structure and function of the upper Deschutes River across the whole degraded reach because of the overwhelming impact of water management in the river. We recognize local channel and bank restoration as a medium priority for both funding and implementation when it follows the above recommendations. Some local restoration projects intend to improve community relations rather than meeting ecological objectives. These projects have value for different reasons, and we address them below.

The Oregon Department of Fish and Wildlife and the Deschutes National Forest both design, implement, and monitor local channel and bank restoration projects.

**Objective: Protect riparian and upland areas with high ecological value from encroachment.**

**Action: Identify at-risk, high value riparian areas.**

The upper Deschutes River flows through both public and private lands. Riparian areas along the upper Deschutes River provide wetlands that store and release water, habitat for wildlife, and shade for fish. Further development of these areas may affect how well they support a functioning Deschutes River.

We hypothesize that some ecologically important riparian areas are at risk for development. These areas may have been fully developed, or they may already be protected from development. Identifying these areas is the first step in protecting them from degradation.

Deschutes County has a pending grant application to identify and protect wetlands within its boundary. The Oregon Department of Fish and Wildlife will identify areas of importance for fish and wildlife in the upper Deschutes River corridor as funding allows. We suggest that these agencies leverage their limited funding and work towards a coordinated map of these at-risk areas.

We believe that this action should rank as a high priority, as preventing degradation is generally more effective and efficient than restoration. We recommend funding this type

of action accordingly if the proposed action has either very specific ecological goals or a broad, cross-agency scope. This action can be completed within five years.

**Action: Review and revise city, county, and state land use regulation.**

The existing patchwork of land use regulations offers varying levels of protection to riparian areas along the upper Deschutes River. Riparian road development, timber thinning and harvesting, and exurban property development have all affected the upper Deschutes River corridor. Development pressure will likely increase along this reach as the population of Central Oregon grows. Identifying where improved land-use regulations will protect high value ecological areas and revising those regulations accordingly may lead to additional riparian area protections.

We hypothesize that existing land use regulations are different from ideal land use regulations that balance urban and exurban development with environmental protection. We also hypothesize that improved land use regulations will prevent the degradation of more at-risk, high value ecological areas than current land use regulations.

Although traditional land use regulations often create tension between development and environmental interest, emerging non-traditional regulations allow opportunities for growth while protecting ecological functions. We support any reviews and improvements of land regulations as they pertain to Deschutes River protection. Future reviews should consider the different layers of protection offered at the local, state, and federal levels and ensure that their regulations are compatible.

Currently, Deschutes County is the only entity pursuing this action. They will be reviewing their comprehensive plan in the near future, and they will look at Deschutes River protection as part of their review.

We believe that this action should be a medium priority and funded as such. Its eventual success depends in part on completing the preceding action, identifying ecologically important areas. We expect that this action can be completed in five to ten years if agencies or organizations have the funding to pursue it.

**Action: Land transactions protect identified ecologically valuable areas.**

Land transactions have protected socially and ecologically important areas across the United States. The Deschutes Land Trust has pioneered land transactions in the Deschutes Basin, proving that land transactions can be important tools for conservation here in Central Oregon. Land values have increased in Deschutes County, though, and purchasing large areas of riparian land may be prohibitively expensive.

Targeted land acquisitions may be useful restoration tools along the upper Deschutes Basin. As experiences in southern Deschutes County show, lands along the Deschutes River may have a high water table and a potential to flood. These two factors may limit the development of existing open space in the future. We suggest using land transactions to protect ecologically important land that may be unsuitable for building.

We hypothesize that land transactions will be useful at protecting these ecologically important areas and preventing future degradation. Although the Wetlands Conservancy has expressed interest in this area in the past, no agencies or organizations are openly pursuing land transactions along the upper Deschutes River. We recommend funding these voluntary transactions as a high priority if and when an entity does pursue them.

## Goal: By 2030, the community will demonstrate greater stewardship of the upper Deschutes River.

This strategy identifies two objectives and four actions under the goal, "By 2030, the community will demonstrate greater stewardship of the upper Deschutes River" (see Table 4). The following sections describe the actions under each objective.

**Table 4. Objective and actions leading to improved community stewardship.**

| Objective | Action |
|---|---|
| Engage riparian landowners in protecting and restoring the upper Deschutes River. | Local channel and bank restoration. |
| | Clarify and communicate land use regulations. |
| Engage community members in protecting and restoring the upper Deschutes River. | Support community organizing and information sharing. |
| | Establish regular communication with elected officials. |

### Objective: Engage riparian landowners in protecting and restoring the upper Deschutes River.

#### Action: Implement local channel and bank restoration projects.

As described earlier, small scale channel and bank restoration projects will not restore the structure and function of the upper Deschutes River. However, riparian landowners provide entry points into local communities.

We hypothesize that small-scale projects will engage riparian landowners and increase their awareness of the interactions between riparian development and aquatic ecosystems. Over the long-term, an informed riparian landowner will help influence and motivate improved river management.

Strategic local restoration projects that follow the suggestions described earlier should be a medium priority for funding and implementation. Individual restoration projects without strong ecological goals or unique community goals should be a low priority for funding. We do see exceptions if local community members provide match funding for projects on private property.

#### Action: Clarify and communicate land use regulations.

A conglomeration of city, county, state, and federal regulations govern land use along the upper Deschutes River. This daunting collection of regulations is not user friendly for riparian landowners. Anecdotal evidence suggests that some landowners simply ignore land use regulations rather than trying to understand them.

We hypothesize that clarifying these regulations and communicating them in non-technical language will improve landowner understanding of and involvement in river stewardship. Creating an easy step-by-step explanation for riparian land owners to use when they develop their property will help us to protect the upper Deschutes River.

We view this action as a low priority and suggest that it be funded accordingly. While this action could improve land use practices along the upper Deschutes River, we suggest that this action be incorporated into any efforts to improve land use regulations. This action should be a medium priority when completed in conjunction with improvements in land use regulation or when completed as part of a larger landowner outreach and communication effort.

**Objective: Engage community members in protecting and restoring the upper Deschutes River.**

**Action: Support community organizing and information sharing.**

We hope to contribute to landowner education through community meetings and encourage landowner involvement in strategic restoration projects. Long-term success in restoring the Upper Deschutes will require an increased level of understanding, awareness and involvement among the stakeholders involved in the area.

We hypothesize that, through a committed, sustained and well-implemented community outreach program, we can improve community comprehension of the issues surrounding the upper Deschutes River. The Upper Deschutes Resources Coalition has been active in promoting river health. This group plays an important role in community restoration and should have a lead role in any organizing process.

We consider this action to be a high priority and expect it to be funded accordingly. The Upper Deschutes Watershed Council and the Oregon Department of Fish and Wildlife currently work with landowners on a limited basis. We suggest a coordinated approach that involves meeting with small groups of landowners in order to share the strategy and incorporate their needs into future actions.

**Action: Establish regular communication with elected officials.**

Elected officials do not always see the wide range of stakeholder view and values along the upper Deschutes River. At the same time, they do not always understand the ecological limitations along the river and how different agencies and organizations are attempting to address those issues. Partner organizations should communicate with officials in an organized, strategic manner that reveals how each organization and suite of activities contributes to community goals. We consider this action to be a medium priority but a low priority for funding. It should be incorporated into project financing and implementation and outreach efforts rather than being a stand-alone action.

## Goal: By 2030, the restoration community will have an increased understanding of the upper Deschutes River system.

This strategy identifies two objectives and three actions under the goal, "By 2030, the restoration community will have an increased understanding of the upper Deschutes River system" (see Table 5). The following sections describe the actions under each objective.

**Table 5. Objective and actions leading to an increased understanding of the upper Deschutes River.**

| Objective | Action |
|---|---|
| Understand effectiveness of the suite of restoration actions. | Establish a comprehensive monitoring plan based on recommended objectives and tasks. |
| | Implement comprehensive monitoring plan based on recommended objectives and tasks. |
| Understand emerging water quality issues related to land use and water management. | Establish and implement a research program based on our understanding of these issues. |

### Objective: Understand the effectiveness of the suite of restoration actions.

#### Action: Establish a comprehensive monitoring plan based on the recommended objectives and actions.

This restoration plan focuses on achieving ecological goals through specific objectives and actions. Effectiveness monitoring needs to account for both the individual actions and their cumulative effects.

Researchers classify restoration monitoring as one of two general types. *Status and trend monitoring* looks at how ecological conditions change over time. Ambient water quality monitoring provides one example of status and trend monitoring. It does not attempt to link actions with ecological outcomes. *Cause and effect monitoring* looks at whether a particular action led to a particular outcome. The adaptive management approach incorporates cause and effect monitoring. Traditionally, restoration programs monitor ecosystem status and trends but not cause and effect.

We acknowledge that determining cause and effect relationships for ecological restoration can be very difficult in the real world. Common techniques for evaluating management activities (such as paired watershed studies) do not necessarily work in the upper Deschutes River. We recommend a combination of status and trend monitoring and cause and effect monitoring to achieve this objective. We suggest the development of a strong conceptual model to support reach level status and trend monitoring. At the same time, we support project level cause and effect monitoring to determine whether individual projects have had local effects on the upper Deschutes River.

We hypothesize that we can design a monitoring program to identify whether individual actions achieve their objectives and whether the suite of actions improves ecological conditions. A programmatic monitoring plan that reaches across organizations and agencies will be more efficient and yield better outcomes than individual monitoring activities. It should be collaboratively developed and fully implemented prior to implementing restoration activities.

We recommend that this action have a high priority and be funded accordingly. Restoration literature and experience consistently emphasize that monitoring should be implemented at the earliest possible point in the restoration process. It should be completed within two years. The Oregon Department of Fish and Wildlife will lead the development of this plan with staff support from other agencies and organizations.

**Action: Implement a comprehensive monitoring plan.**

Establishing a coordinated, comprehensive monitoring plan depends on the interrelationships between different organizations and agencies. Implementing the plan will likely depend on these individual groups as well. An efficient monitoring plan will divide activities among different organizations and leverage each of their strengths.

We hypothesize that a comprehensive monitoring plan will identify whether individual actions have achieved their objectives and whether the entire suite of actions has improved ecological conditions. Again, the plan should be fully implemented prior to implementing restoration activities to demonstrate project and program effectiveness.

The Oregon Water Resources Department, the upper Deschutes Watershed Council, the Oregon Department of Environmental Quality, the City of Bend, and the Deschutes National Forest all monitor conditions in the upper Deschutes River. These agencies should collaborate to efficiently implement the monitoring plan developed under this strategy.

We recommend that this action have a high priority and be funded accordingly. It should be funded over a long time period to account for inter-annual variation in ecological conditions. Although this action depends on the preceding action, we rank it as a high priority due to its importance. It should begin with two years and continue as necessary.

**Objective: Understand emerging water quality issues related to land use and water management.**

**Action: Establish and implement a research program based on our existing understanding of these issues.**

A variety of water quality concerns have emerged in the upper Deschutes River. These concerns include temperature, dissolved oxygen, pH, sedimentation and algal growth. We have a general understanding of the relationship between these issues, their root causes, and potential restoration actions, but we have not documented cause and effect

relationships between management conditions (e.g., development, reservoir operations, etc.) and observed water quality conditions.

A long-term, comprehensive research program will allow us to collect and evaluate data in a way that can produce direct management recommendations. This effort will need to be adaptive so that emerging issues and new data are continually assessed. It will need to document both long-term trends and conditions and cause and effect relationships. In addition, research will need to occur over many years so that it can track long-term changes and account for short term climate variability.

A fundamental component of the monitoring plan will be the regular communication of results to natural resource managers, the community at large and the leaders of the restoration actions proposed in this strategy. This task will ensure that the monitoring results help support community understanding and lead to effective restoration projects.

We recommend this action as a high priority and suggest that it is funded appropriately. The joint Water Quality Monitoring Program led by the Upper Deschutes Watershed Council may be the proper venue for developing and leading this action. We foresee it being implemented within two years given appropriate funding.

## Matrices of Recommended Actions

The following pages include four tables identifying actions and their associated strategy elements. Actions include varying levels of detail. For some actions we know who will complete each task and we have the resources available to fully implement the action. For other actions, we know which tasks we need to complete but we do not have the capacity to complete them right now.

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**Goal: By 2030, degraded ecosystem structures and functions will be improved in the upper Deschutes River.**

| Priority | Hypothesis | Metrics | Benchmarks | Timeline | Roles & Responsibilities |
|---|---|---|---|---|---|
| High | Existing dimension, pattern, and profile are different from desired dimension, pattern, and profile. | Channel dimension, pattern and profile. | Options for desired dimension, pattern, and profile developed; stakeholders agree on desired dimension, pattern, and profile. | < 5 years | Deschutes National Forest will identifiy the desired dimension, pattern, and profile. |
| Medium | Physical restoration will restore the desired dimension, pattern, and profile. | Channel dimension, pattern and profile. | Resources available; restoration sites identifited; restoration implemented. | 10-20 Years | The Deschutes National Forest and the Oregon Department of Fish and Wildlife will implement habitat restoration. The Upper Deschutes Watershed Council will help fund habitat restoration. |
| | Restored dimension, pattern, and profile will improve riparian conditions. | To Be Determined | To Be Determined. | 10-20 years | |
| High | Desired hydrograph will be different from existing hydrograph. | Hydrograph elements (magnitude, timing, frequency, and rate of change of flows) | Funding secured; working group established; ecologically ideal hydrograph developed; socially feasible hydrograph developed. | 5 Years | Deschutes River Conservancy will facilitate hydrograph identification (pending funding). |
| Medium | Existing institutional arrangements are not adequate to restore flow. | Changes to management agreements, contracts, authorizations, etc. | Consensus among stakeholders regarding acceptable changes; changes initiated; changes completed. | 5-10 years | Deschutes River Conservancy will lead discussions about possible changes to institutional framework. |
| Low | New infrastructure will allow water managers to meet target ramping rates. Existing Infrastructure not adequate to meet target ramping rates. | Ramping rates | Infrastructure needs identified; funding secured; infrastructure created. | 10-15 years | To Be Determined. |
| High | Water transactions will restore low flow. | Legally protected instream flow; streamflow | Resources available; multi-year transaction developed; 50 cfs / up to 10,000 AF legally protected; 50 cfs 7-Day Average Minimum Flow | <5 years | Deschutes River Conservancy will develop funding, implement, and monitor transaction; Oregon Water Resources Department will process transaction and monitor streamflow. |

**Goal: By 2030, existing ecosystem functions and processes will be maintained and protected from further degradation.**

| Objective | Action | Priority | Hypothesis | Metrics | Benchmarks | Timeline | Roles & Responsibilities |
|---|---|---|---|---|---|---|---|
| Enhance local instream habitat. | Add spawning gravel. | Low | More spawning habitat after gravel enhancement. | Spawning habitat availability | Site identified; sites prioritized; sites enhanced; Ecological benchmarks to be determined. | < 5 years | Oregon Department of Fish and Wildlife will lead, implement, and monitor gravel enhancement projects. |
| | | | More redds after gravel enhancement. | Redband trout redds | | | |
| | Add large wood. | Low (Opportunistic), Medium (Strategic) | Low flow conditions closer to desired conditions after enhancement. | To Be Determined | Site identified; sites prioritized; sites enhanced; Ecological benchmarks to be determined. | <5 years | Oregon Department of Fish and Wildlife will lead, implement, and monitor large wood enhancement projects. |
| | | | High flow conditions closer to desired conditions after enhancement. | To Be Determined | | | |
| | Local channel and bank restoration projects. | Low (Opportunistic), Medium (Strategic) | Low flow conditions closer to desired conditions after restoration. | To Be Determined | Site identified; sites prioritized; sites enhanced; Ecological benchmarks to be determined. | <5 years | Oregon Department of Fish and Wildlife will lead, implement, and monitor local restoration projects. |
| | | | High flow conditions closer to desired conditions after restoration. | To Be Determined | | | |
| Protect areas with high ecological value. | Identify at-risk, high value riparian areas. | High | Some ecologlically important areas at risk for development. | Size of areas at risk; ecological functions served by areas at rish | Areas at risk for development identifiedl; ecolgoically important areas at risk for development identified; Coordinated map of at-risk areas and protection levels developed. | <5 years | Deschutes County will identify and protect wetlands within County boundaries (pending funding); Oregon Department of Fish and Wildlife will identify site-specific ecological functions at proposed restoration sites; Deschutes National Forest will identify ecologically important riparian areas within National Forest boundaries (pending funding). |
| | Implement land transactions to protect identified valuable areas. | Medium | Land transactions will protect some ecologically important areas. | To Be Determined | Initial resources secured; communication with landowner; transaction resources secured; transaction completed. | < 5 years | To Be Determined. |
| | Review and revise city, county, and state land use regulations. | High | Existing land use regulations differ from ideal land use regulations. | Size and ecological value of protected areas | Ideal land use regulations identified; Actual and ideal land use regulations compared; land use regulations revised closer to ideal. | >5 years | Deschutes County will revise its Comprehensive Plan in 2009. |

## Goal: By 2030, the community will demonstrate greater stewardship of the upper Deschutes River.

| Objective | Action | Priority | Hypothesis | Metrics | Benchmarks | Timeline | Roles & Responsibilities |
|---|---|---|---|---|---|---|---|
| Engage riparian landowners in protecting and restoring the upper Deschutes River. | Local channel and bank restoration. | Low (opportunistic), Medium (strategic) | Projects will engage riparian landowners. | Number of cooperating landowners | To Be Determined. | 5 years | Oregon Department of Fish and Wildlife will design, implement and monitor local restoration projects. |
| | | | Projects will increase comprehension of riparian-aquatic interactions. | Landowners' comprehension | | | |
| | Clarify and communicate land use regulations. | Low | Action willl increase landowner comprehension of land use regulations. | Landowners' comprehension | To Be Determined. | 5 years | To Be Determined. |
| Engage community members in protecting and restoring the upper Deschutes River. | Support community organizing and information sharing. | High | Community outreach will increase landowner comprehension of upper Deschutes River system. | Landowners' comprehension | Funding secured; outreach program developed; outreach program implemented. | 10 years | To Be Determined. |
| | Establish regular communication with elected officials. | Low | Regular communication will increase comprehension of issues and work being done to address them. | Elected officials' comprehension | To Be Determined. | 10 years | To Be Determined. |

**Goal: By 2030, the restoration community will have an increased understanding of the upper Deschutes River system.**

| Objective | Action | Priority | Hypothesis | Metrics | Benchmarks | Timeline | Roles & Responsibilities |
|---|---|---|---|---|---|---|---|
| Understand effectiveness of the suite of restoration actions. | Establish a comprehensive monitoring plan based on recommended objectives and tasks. | High | Monitoring program can be designed to identify if suite of restoration actions have improved ecological conditions.<br>Monitoring can be designed to identify if individual restoration actions have achived goals. | To Be Determined | Working group established; monitoring plan written; monitoring plan passes academic review; stakeholders accept monitoring plan. | 2 years | Oregon Department of Fish and Wildlife will develop fish and aquatic habitat monitoring; Deschutes River Conservancy will develop surface water monitoring; Upper Deschutes Watershed Council will develop water quality monitoring. |
| | Implement comprehensive monitoring plan based on recommended objectives and tasks. | High | Monitoring will identify that suite of restoration actions have improved ecological conditions.<br>Monitoring will identify that individual restoration actions have achieved goals. | To Be Determined | Resources secured; plan implemented. | 15 years | To Be Determined. |
| Understand emerging water quality issues related to land use and water management. | Establish and implement a research program based on our understanding of these issues. | High | A directed research program will allow us to inform future land and water management decisions. | To Be Determined | Hypotheses developed; Program designed; funding secured; program implemented. | 5 years | The Upper Deschutes Watershed Council will lead the development and implementation of this plan. |