FINAL
Deschutes Basin
Habitat Conservation Plan

Volume I: Chapters 1-12

Submitted by:

Arnold Irrigation District
Central Oregon Irrigation District
Lone Pine Irrigation District
North Unit Irrigation District
Ochoco Irrigation District
Swalley Irrigation District
Three Sisters Irrigation District
Tumalo Irrigation District
City of Prineville, Oregon

October 2020

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Habitat Conservation Plan

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Submitted to: US Fish and Wildlife Service – *Portland, OR*
National Marine Fisheries Service – *Portland, OR*

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Tumalo Irrigation District – *Bend, OR*
City of Prineville, Oregon

In Support of: Applications for ESA Section 10(a)(1)(B)
Incidental Take Permits

OCTOBER 2020

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DESCHUTES BASIN
HABITAT CONSERVATION PLAN

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1 – EXECUTIVE SUMMARY

1.1 Introduction and Background

Eight irrigation districts (Districts) in the Deschutes Basin of Oregon and the City of Prineville, Oregon (City) have prepared the Deschutes Basin Habitat Conservation Plan (DBHCP) to support the issuance of incidental take permits by the US Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS), collectively called the Services, under Section 10(a)(1)(B) of the federal Endangered Species act of 1973, as amended (ESA). The Districts and the City (collectively called the Permittees) utilize waters of the Deschutes River and its tributaries (Figure 1-1) where their activities have the potential to incidentally harm (take) one wildlife species (Oregon spotted frog) and two fish species (steelhead trout and bull trout) that are currently listed as threatened under the ESA. The taking of a listed species is prohibited under Section 9 of the ESA, but avoidance of take for these three species would require the Permittees to cease or significantly curtail a number of essential activities involving the use of water. The incidental take permits will allow the Permittees to continue their otherwise lawful uses of water without the threat of prosecution for the incidental taking. The DBHCP will be implemented to minimize and mitigate the impacts of the authorized taking. The incidental take permits and the DBHCP will have concurrent terms of 30 years.

The DBHCP also provides mitigation for the effects of the activities on one species that currently has no status under the ESA in the Deschutes Basin (sockeye salmon). In the event this unlisted species becomes listed under the ESA during the term of the DBHCP, the Permittees will receive incidental take coverage for it as well.

All eight Districts covered by the DBHCP are quasi-municipal corporations formed and operated according to Oregon law to distribute water to irrigators (patrons) within designated geographic boundaries. Collectively the Districts serve over 7,653 patrons and provide water to nearly 151,000 irrigated acres. Prineville is an incorporated city and the county seat for Crook County, Oregon. It operates City-owned infrastructure and provides essential services, including public safety, municipal water supply, and sewage treatment to more than 9,000 residents.

The Permittees have prepared this DBHCP to comply with the requirements of ESA Section 10(a)(2)(A), which requires an applicant for an incidental take permit to specify:

(i) the impact which will likely result from such taking;

(ii) what steps the applicant will take to minimize and mitigate such impacts, and the funding that will be available to implement such steps;

(iii) what alternative actions to such taking the applicant considered and the reasons why such alternatives are not being utilized; and

(iv) such other measures that the Services may require as being necessary or appropriate for purposes of the plan.

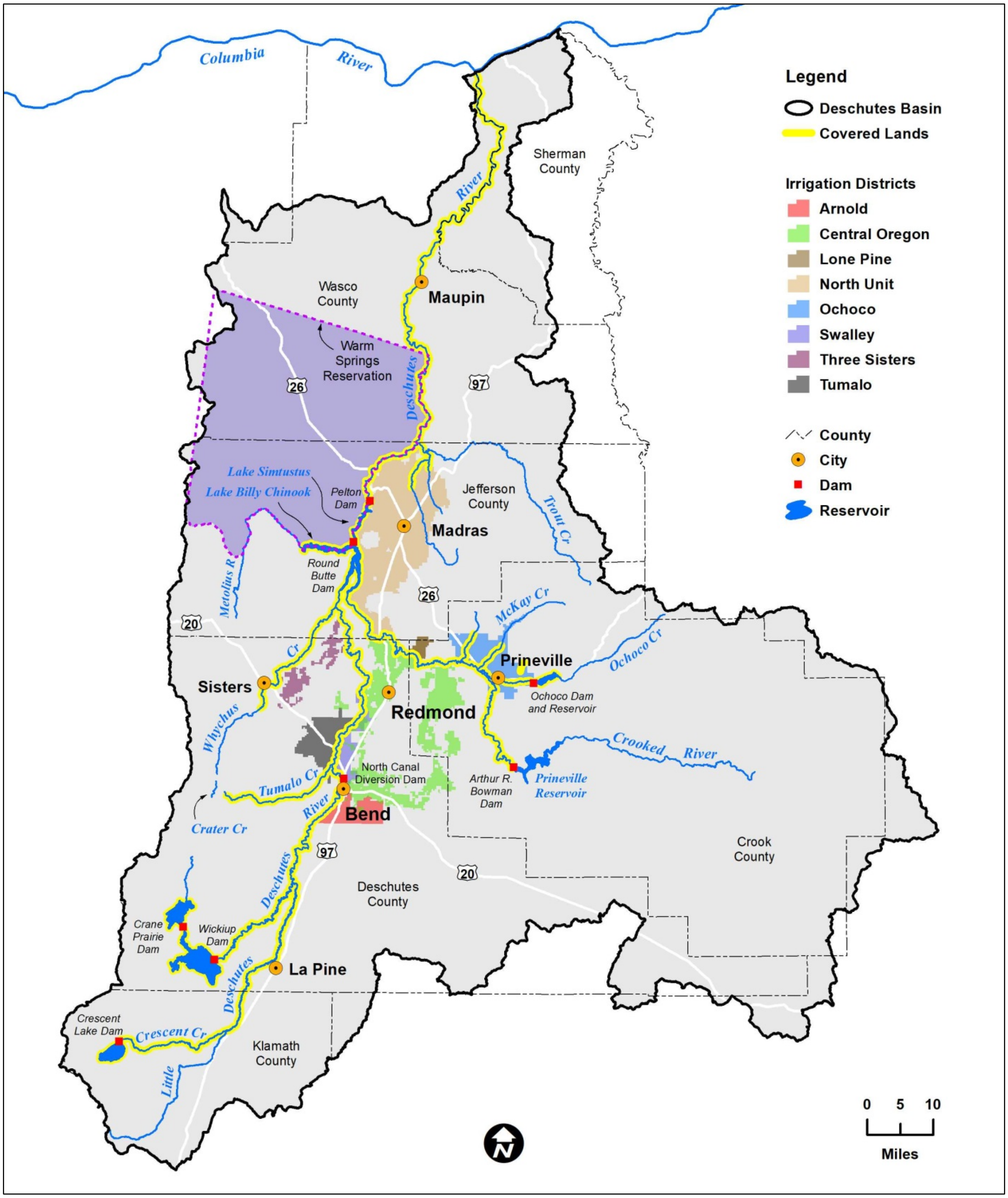

Figure 1-1. Map of the Deschutes Basin showing lands and waters covered by the Deschutes Basin Habitat Conservation Plan.

Before the Services can issue an incidental take permit, they are required by ESA Section 10(a)(2)(B) of the ESA to determine that:

(i) the taking will be incidental to otherwise lawful activities;

(ii) the applicant will, to the maximum extent practicable, minimize and mitigate the impacts of the incidental taking;

(iii) the applicant will ensure that adequate funding for the conservation actions necessary to minimize and mitigate the impacts of the incidental taking will be provided;

(iv) the incidental taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild; and

(v) any other measures considered necessary or appropriate by USFWS and/or NMFS will also be implemented.

This DBHCP is the result of several years of collaboration between the Permittees, the Services and multiple stakeholders within the region. In addition to providing habitat for fish and wildlife, the Deschutes River and its tributaries form the basis for most economic and recreational activities in Central Oregon. In recognition of the fact that few persons within the basin are unaffected by the river, the Permittees and the Services took a number of steps to incorporate public input to the development of the DBHCP. Governmental agencies and organized non-governmental groups with interests in the Deschutes River were invited to participate in the DBHCP Working Group beginning in 2008. The Working Group met up to four times a year throughout DBHCP preparation to help guide each step of the process. When specific technical issues were identified, Technical Working Groups were assembled from the members of the larger Working Group with specialized expertise to provide the Permittees and the Services with detailed input. In addition, a broader Stakeholder Group was created to keep the greater Central Oregon community apprised of DBHCP development and solicit their input. The Stakeholder Group, which met 11 times between 2008 and 2019, was open to anyone within the Deschutes Basin with an interest in the DBHCP.

The activities covered by the DBHCP modify the timing and magnitude of flow in the Deschutes River and a number of its tributaries through the storage, release, diversion and return of irrigation water. These changes in surface hydrology alter the quantity and/or quality of aquatic habitats for listed species in both positive and negative ways. The approach of the DBHCP is to modify the covered activities to reduce the negative effects on aquatic habitats while preserving the positive effects. The negative effects of the covered activities cannot be eliminated altogether without complete cessation of the activities, but the DBHCP will reduce negative effects to a degree that will facilitate efforts to recover listed aquatic species in the Deschutes Basin and help prevent the listing of other species.

The DBHCP will serve as one part of a larger regional effort to restore and enhance aquatic habitats for the covered species in the Deschutes Basin. Range-wide threats to the conservation and recovery of the three listed species (bull trout, steelhead and Oregon spotted frog) were identified at the time of their listings. Of the myriad identified threats, altered hydrology due to the storage and diversion of water for irrigation is pertinent to all three species. This is the threat addressed by the DBHCP. Other threats that may affect one or more of the three species in the Deschutes Basin include loss of habitat to human development, changes in hydrology and blockages to migration from hydropower development and flood control, predation by non-native fish and amphibians, loss of habitat due to invasive plant species, alteration of habitat due to livestock grazing, alteration of habitat due to logging, blockage of migration, degradation of habitat due to road construction, degradation of habitat and water quality due to mining, diseases, fragmentation of populations, and overutilization for commercial, recreational, scientific or educational purposes. These threats are not discussed in the DBHCP because the DBHCP does not address factors that are unrelated to the covered activities, but it does facilitate addressing those other factors by improving the surface water hydrology that is the basis for all aquatic habitats. By providing favorable hydrology in the Deschutes River and its tributaries, the DBHCP will be the first and possibly most important step toward recovery of the listed species.

Climate change has also been identified as a threat to the covered species, and the DBHCP has been designed to continue providing benefits to the covered species and supporting recovery efforts in the face of climate change. The conservation measures of the DBHCP are mostly commitments to maintain target instream flows in the covered rivers and creeks. The flows will be met by reducing the storage, release and diversion of irrigation water, as needed. If climate change results in decreased availability of water, the instream flow targets of the DBHCP will have priority and irrigation uses of water will occur only if the flow targets are met.

The changes to surface hydrology under the DBHCP will be phased over time, for two reasons. First, many of the stream channels and floodplains in the basin have been altered from their natural conditions by several decades of irrigation storage and release. Channels have become over-widened in many places, and existing habitats for the covered species are often dependent on the artificially high flows that occur when stored water is released from the reservoirs in the summer. Increases in winter flows to improve overwintering habitat conditions will result in corresponding decreases in summer flows. If winter increases are too great, summer flows will drop too low to support existing habitats. It is anticipated that efforts by parties other than the Permittees, including many activities that will be supported by the DBHCP through the Upper Deschutes Basin Habitat Conservation Fund, will restore channels and floodplains and eventually enable lower summer flows to provide habitats comparable to those that exist today. In recognition of this, the increases in winter flows and corresponding decreases in summer flows under the DBHCP will be phased to accommodate channel restoration activities. In addition, human development within the historical floodplain of the Deschutes River creates the potential for flooding of homes and other private property if winter flows are allowed to approach natural levels. The phasing of winter releases will allow local land use planners to make provisions for the higher winter flows.

The second reason for phasing the implementation of the DBHCP is economic. The modifications to irrigation reservoir operations that will occur under the DBHCP will leave some of the farmers served by the Permittees with dramatically reduced access to water. The Permittees will make system improvements to reduce overall demand for irrigation water, and some will make conserved water available to others with greater anticipated shortage under the DBHCP. The conservation and movement of water in this way will require several years and several hundred million dollars to complete. Phasing of the conservation measures under the DBHCP will allow time for the Permittees to accomplish the conservation projects and water movements, so that no Permittee is faced with the risk of having insufficient water to support agriculture.

1.2 Scope of the DBHCP

The DBHCP supports the issuance of 30-year incidental take permits to Arnold Irrigation District (AID), Central Oregon Irrigation District (COID), Lone Pine Irrigation District (LPID), North Unit Irrigation District (NUID), Ochoco Irrigation District (OID), Swalley Irrigation District (SID), Three Sisters Irrigation District (TSID), Tumalo Irrigation District (TID) and the City of Prineville, Oregon. Each of the nine Permittees conducts activities that are distinct from the activities of the other eight, and the activities of each Permittee result in impacts to the covered species that are similarly distinct from the impacts of the other Permittees. Under the DBHCP, each Permittee will be responsible for the implementation of conservation measures to minimize and mitigate the impacts of its activities. The conservation requirements of the nine Permittees are combined into this single DBHCP to provide a comprehensive overview of the effects of the Permittees' activities, but the conservation measures are not interdependent. The effectiveness of conservation measure being implemented by one Permittee will not influence the effectiveness of measures being implemented by the other Permittees in any way. For purposes of implementation, the Permittees are nine independent entities responsible for nine independent sets of conservation measures. The only exception to this involves the coordination of winter diversions of water by three Districts on the Deschutes River (Conservation Measure DR-1). The respective roles and responsibilities of the nine Permittees, including the joint implementation of Conservation Measure DR-1, are covered by inter-district agreements that are included with this DBHCP (Appendix B).

The DBHCP covers the activities of the Permittees that influence surface hydrology and water quality in the Deschutes Basin. These include the storage and release of water at irrigation reservoirs, the diversion of water from natural streams, and the return of water to natural streams. Groundwater pumping and seasonal discharge of treated effluent by the City are also covered activities. Each of the covered activities is associated with an identified structure or feature, such as a dam, reservoir, diversion or return. The DBHCP covers four dams and reservoirs, 47 large and small surface diversions, 14 wells (12 current and 2 future) and 37 returns.

The waters upon which the covered activities occur are identified as covered lands and waters in the DBHCP (Figure 1-1). This includes all waters downstream of the covered activities where covered species could be impacted by altered hydrology or water quality. The upstream limits of the covered lands and waters are those locations where the covered activities first influence surface hydrology. On the Deschutes River and Ochoco Creek, the covered lands begin at the full-pool elevations of Crane Prairie and Ochoco reservoirs, respectively. On Crescent Creek, Whychus Creek, Crooked River, McKay Creek and Lytle Creek, the first points of influence are dams or diversion structures operated by the Permittees. On Tumalo Creek the first point of influence is the outfall from TID's Crater Creek diversion, and on Trout Creek the first point of influence is a return flow from NUID. The downstream limit of all covered lands and waters is the mouth of the Deschutes River. Within the covered stream reaches, the covered lands and waters extend only to stream channels and floodplains potentially subjected to surface inundation. The DBHCP does not cover upland areas outside the influence of the covered activities.

1.3 Current Conditions of the Covered Lands and Waters

The covered lands and waters lie entirely along the Deschutes River and its upper tributaries in Central Oregon. They extend over 150 miles from headwater streams at elevations over 4,000 feet to the mouth of the Deschutes River at elevation 164 feet. Climate conditions are variable across the covered lands, but cold winters and hot, dry summers prevail throughout. Higher elevations receive 40 inches or more precipitation annually, most of which comes as snow. Lower elevations are generally arid with less than 10 inches of precipitation per year, making crop production impossible without irrigation.

Surface hydrology is variable across the covered lands and waters due to differences in geology and soils. Flows in the covered streams all originate in mountain headwaters, mostly from snowfall, but the patterns of runoff are highly variable from stream to stream. In the Upper Deschutes River, porous volcanic soils and subsoils rapidly transmit rain and snowmelt to a complex system of aquifers, with the result that stream flows originate primarily from groundwater discharge (springs) rather than direct surface runoff. This groundwater influence causes flows in the mainstem Deschutes River to show considerably less fluctuation on a daily, annual and year-to-year basis than a typical Cascade Mountain stream. The Crooked River subbasin, in contrast, shows a strong seasonal hydrology that is almost entirely dependent on spring snowmelt in the headwaters. Flows in the Crooked River subbasin are naturally quite low at all times of year except for one to two months during spring snowmelt and brief periods after large rain events. Intermediate between these two extremes are the Little Deschutes River (including Crescent Creek), Tumalo Creek and Whychus Creek, which are more typical of Cascade Mountain streams. All three experience rapid increases in flow during spring snowmelt, very low flows in late summer, and brief high flows after rain events that can occur in any month.

The covered lands are divided into separate geographic units for purposes of the DBHCP. These are Upper/Middle Deschutes River, Crescent Creek/Little Deschutes River, Whychus Creek, Lower Deschutes River, Trout Creek, and Crooked River subbasin (Crooked River/Ochoco Creek/McKay Creek/Lytle Creek). Key reference points on the covered lands are Lake Billy Chinook (RM 110 to 120) at the confluence of Deschutes, Crooked and Metolius rivers, the City of Bend (RM 164 to 175), the City of Prineville at the confluence of Crooked River and Ochoco Creek, and Sunriver at the confluence of Deschutes and Little Deschutes Rivers (Figure 1-1).

The current hydrology and water quality of the covered stream reaches are heavily influenced by human activities. Flows and water temperatures have been modified from natural conditions by the storage, release, diversion and return of irrigation water for over a century. Habitat conditions in the basin have been altered by agriculture and residential development (both rural and urban) in the lowlands, and to a lesser extent by forest practices in the higher elevations. Past and ongoing land use activities have modified riparian and wetland vegetation, with associated loss of shade. Human activities have also increased the levels of certain contaminants in surface waters, and most of the covered reaches are listed under Section 303(d) of the Clean Water Act as water quality limited for flow modification, temperature and/or one or more other water quality metrics.

Aquatic habitat conditions for the covered species are heavily influenced by flow and water temperature in the covered streams. The storage of water in irrigation reservoirs during the winter decreases stream flows relative to natural (unregulated) conditions downstream of the reservoirs. The release of stored water in the summer increases flows compared to unregulated conditions between the reservoirs and the points of diversion that are as far as 60 miles downstream. The diversion of water (both storage and natural flow) for irrigation reduces stream flows from unregulated conditions downstream of the diversions. Low flows generally reduce the quantity and quality of habitat for the covered species. Low flows can also affect water temperatures to the detriment of covered species by increasing water temperature during the summer and decreasing it during the winter. In both extremes, water temperatures can exceed the preferred or tolerance limits of the covered species.

Ongoing activities also have positive effects on habitat for the covered species in selected areas. On the Crooked River, the release of cold water from Prineville Reservoir during the summer has created high-quality habitat for salmonids in the 14-mile reach between the reservoir and the Crooked River Diversion. In Crescent Creek and the Little Deschutes River, the release of water from Crescent Lake Reservoir during the summer has a similar effect of supporting wetland habitat for the Oregon spotted frog that would not otherwise occur.

1.4 Current Conditions of the Covered Species

1.4.1 Bull Trout

The bull trout is a native char known for its reliance on cold, clean waters and its voracious feeding behavior. Populations of bull trout can be resident (remaining in the same stream for their entire life cycle), migratory (moving between water bodies seasonally) or a combination of the two. Bull trout in the Deschutes Basin employ both strategies, but most are migratory. Resident bull trout upstream of Pelton Round Butte Project spend their entire life cycle within the Metolius River subbasin, all of which is outside the waters covered by the DBHCP. Migratory bull trout upstream of the Project spawn and rear in the Metolius River and its tributaries, but forage on landlocked sockeye salmon (kokanee) and other fish in Lake Billy Chinook during cooler months (mainly November to May). Small numbers of these migratory fish may also forage seasonally short distances upstream of Lake Billy Chinook in the Deschutes River, Whychus Creek and Crooked River, but high water temperatures in the streams and the availability of a large prey base in Lake Billy Chinook generally discourage bull trout from moving out of the reservoir.

Smaller numbers of bull trout reside in the lower mainstem Deschutes River above Sherars Falls, as well as in Shitike Creek and the Warm Springs River. Migratory life-history forms from this subpopulation are known to forage in the mainstem Deschutes River between the confluence with the White River and the Pelton Regulating Dam, and possibly the Lower Deschutes River to the confluence with the Columbia River. Bull trout are absent from the Deschutes River upstream of Big Falls at RM 132.

USFWS listed Columbia River populations of bull trout, including those in the Deschutes Basin, as threated on June 10, 1998. Critical habitat for the bull trout was designated by revised final rule on September 30, 2010. About 100 miles of river and creek covered by the DBHCP (roughly 22 percent of the total covered lands) are designated as *Bull Trout Critical Habitat Unit 6 – Lower Deschutes River Basin*. The vast majority of this critical habitat (88 miles) consists of Lake Billy Chinook and the Lower Deschutes River downstream of the Warm Springs Reservation.

The Deschutes Basin is considered a population stronghold for bull trout due to stable habitat conditions and large population size. The Bull Trout Recovery Plan prepared by USFWS in 2015 discusses species status and recovery needs for core areas in the Deschutes Basin. Core areas have both suitable habitat and existing bull trout populations, while core habitat has suitable habitat for the species but no existing populations. Bull trout habitat on the covered lands downstream of Big Falls lies within the Lower Deschutes River Core Area for purposes of recovery planning. The Upper Deschutes Core Habitat Area includes the Deschutes River and its tributaries upstream of Big Falls.

The Lower Deschutes River Core Area Implementation Plan for Bull Trout identifies no primary threats to the species in the Deschutes Basin, but recommends continued monitoring of bull trout populations, angling impacts in the spring fishery of Lake Billy Chinook, and spawner and juvenile densities in the Warm Springs River. USFWS also recommends continued assessment and monitoring of the distribution of bull trout and nonnative brook trout. The implementation plan makes several recommendations for recovery, including continuation of ongoing work on upstream and downstream passage at the Pelton Round Butte Project, installation and maintenance of fish screens at water diversions and irrigation ditches, and implementation of land management plans and BMPs. In addition to these continued efforts, the plan recommends “adaptively managing” bull trout and kokanee harvest in Lake Billy Chinook.

1.4.2 Steelhead Trout

The steelhead is an anadromous variant of the rainbow trout that rears in freshwater rivers and creeks, migrates to saltwater as a juvenile, and returns to its natal stream to spawn. It shares freshwater habitat with the resident variant (redband trout in the Deschutes Basin) and the two variants are capable of interbreeding.

The covered lands contain summer steelhead within the Middle Columbia River (MCR) Steelhead Distinct Population Segment (DPS). Downstream of the Pelton Round Butte Project, MCR steelhead are listed as threatened. Upstream of the Project, where a reintroduction program is underway, MCR steelhead are classified as nonessential experimental under Section 10(j) of the ESA until 2025. A final critical habitat rule published in 2005 included the Lower Deschutes River and lower Trout Creek as the only designated critical habitat for MCR steelhead within the covered lands.

Deschutes River steelhead are a summer-run variety. Returning adults enter freshwater 9 to 10 months prior to spawning and migrate up the Deschutes River from June through October. They spawn from about the middle of March to the end of May and eggs hatch within 35 to 50 days, depending on water temperature. The newly hatched steelhead remain in the gravel for 2 to 3 weeks and fry (young salmonids that have absorbed the yolk sac) usually emerge from redds in the middle to late summer. Juvenile steelhead (parr) rear in freshwater for 1 to 4 years prior to emigration, depending on water temperature and growth rates. Downstream migration and smoltification typically occurs from April to mid-June. The majority of Deschutes River steelhead typically emigrate at age 2 and spend 1 to 2 years in saltwater before returning to spawn. Although there are a variety of life history patterns, most returning Deschutes River steelhead spawners are expected to be 4-year old fish.

The Deschutes Basin summer steelhead population is part of the Cascade Eastern Slope Tributaries (CEST) Major Population Group (MPG). The CEST is the most robust MPG within the MCR Steelhead distinct population segment. Steelhead currently have access to all 102 miles of the Deschutes River downstream of the Pelton Reregulating Dam. Historically the species also had access to 158 miles (44 percent) of the covered rivers and creeks upstream of the Reregulating Dam, including the 20 miles of mainstem Deschutes River currently occupied by the dams and reservoirs of the Pelton Round Butte Project. The historical range also extended several miles upstream of the covered lands in the upper Crooked River and Ochoco Creek subbasins. The portions of the covered lands upstream of the Reregulating Dam and downstream of Bowman Dam, Ochoco Dam and Big Falls (about 143 miles total) are the focus of an ongoing steelhead reintroduction program.

Fish passage has recently been restored at Pelton Round Butte Project to allow migratory fish to access the Upper Deschutes River and its tributaries. Steelhead reintroduction is being supplemented with hatchery stock from the Round Butte Hatchery. As many as 800,000 fry and 56,000 smolts have been released into Whychus Creek and the Crooked River subbasin each year since 2008. These fish began moving downstream through the Pelton Round Butte Project as juveniles in 2010. Since 2011, as many as 128 adult steelhead have been transported upstream of the Pelton Round Butte Project each year since to further support the reintroduction.

The Conservation and Recovery Plan for Oregon populations of MCR steelhead identified limiting factors and threats to recovery. Major limiting factors for populations in the Deschutes Basin are degraded floodplain and channel structure, degraded riparian communities, water quality (temperature, chemical contaminants and nutrients), altered hydrology, altered sediment routing, blocked and impaired fish passage, and limited spawning habitat. Key threats are hatchery practices, hydropower operations, land use practices and irrigation systems. Land use has been identified as having the most key concerns of any threat category. Specific threats related to land use include agriculture, grazing, forestry and road maintenance activities that result in impaired upstream and downstream movement of juvenile and adult steelhead, impaired physical habitat quality, impaired water quality due to elevated water temperatures and agricultural chemicals, and reduced water quantity and/or modified hydrologic processes. For the Crooked River, operation of irrigation systems is included as a land use activity that negatively impacts summer steelhead by altering seasonal hydrographs and increasing summer water temperatures.

1.4.3 Sockeye Salmon

Sockeye salmon is the anadromous variant of *Oncorhynchus nerka*; kokanee is the freshwater variant. Both forms spawn in freshwater streams and move downstream to lakes as young fry. Kokanee typically mature in freshwater lakes while anadromous sockeye continue on to the ocean after 1 to 2 years. Adult sockeye return to spawn after 1 to 3 years in the ocean. Both forms die after spawning in the fall.

Sockeye salmon and kokanee are both present on the covered lands, with kokanee making up most of the current population. Anadromous sockeye historically spawned in the Metolius River subbasin (outside the covered lands) and migrated through the Deschutes River, but anadromy ended with the construction of Round Butte Dam and all *O. nerka* upstream of the dam in recent decades have been land-locked kokanee. The recent construction of fish passage facilities at the Pelton Round Butte Project has once again made it feasible for anadromous sockeye to reach the Metolius River subbasin to spawn, and a reintroduction program is under way.

Sockeye/kokanee salmon within the Mid-Columbia ESU are not listed as threatened or endangered at the state or federal level and no critical habitat has been designated. If sockeye salmon in the Deschutes Basin becomes ESA listed during the term of the DBHCP the Permittees will receive incidental take coverage for it.

Large numbers of kokanee migrate from Lake Billy Chinook into the Metolius River subbasin for spawning. Smaller numbers spawn in the lower 2 miles of Whychus Creek, in the Crooked River below Opal Springs, and possibly in the Deschutes River downstream of Big Falls. A similar migration of Wickiup Reservoir kokanee occurs annually in the short segment of the Deschutes River below Crane Prairie Dam, but these are not covered by the DBHCP. The DBHCP only covers sockeye/kokanee downstream of Big Falls because all areas upstream of Big Falls are inaccessible to anadromous fish.

Following the commencement of sockeye reintroduction efforts in 2009, ODFW developed the HabRate model to assess the habitat quality of streams that were historically occupied above the Pelton Round Butte Project. The HabRate model estimates habitat suitability and reintroduction success for each life stage. HabRate predicted that current habitat conditions would limit sockeye distribution to the Metolius River subbasin, with probable spawning areas in Lake Creek and rearing in Suttle Lake.

The purpose of the Sockeye Salmon Reintroduction Plan is to return an anadromous run of *O. nerka* to the Upper Deschutes River to restore self-sustaining and harvestable populations to historical sites within the Deschutes Basin. The large numbers of resident kokanee from Lake Billy Chinook have been utilized to begin developing an anadromous sockeye run. Juvenile kokanee that exhibit migratory behavior and enter downstream collection facilities are marked and released downstream of Pelton Dam into the Deschutes River. Marked adults originating from the Upper Deschutes River subbasin that return to the Pelton Fish Trap are passed upstream to spawn naturally or moved to Round Butte Hatchery.

Since 2011, nearly 500,000 yearling kokanee and sockeye have been collected at the downstream fish collection facility to be released below Round Butte Dam. However, numbers of returning adult fish captured at the Pelton Fish Trap have seen only modest gains due to reintroduction efforts, and adult sockeye returns originating from rearing sites in the upper basin did not exceed 100 fish annually until 2016 when over 500 fish were passed upstream of the Pelton Round Butte Project. Genetic analysis determined that over 90 percent of the fish passed had originated from Lake Billy Chinook.

As of 2016, specific target numbers for sockeye escapement had not been set, as there were too many variables and unknown factors. Decisions by fish managers on the future direction of the reintroduction effort will be dependent on (1) criteria outlined in the Draft Sockeye Reintroduction Plan, and (2) an assessment of progress thus far.

1.4.4 Oregon Spotted Frog

The Oregon spotted frog is federally listed as a threatened species. The State of Oregon lists the frog as sensitive and places it on the sensitive-critical list. There are 34 known occurrences of Oregon spotted frog on the covered lands, including Crane Prairie and Wickiup reservoirs on the Upper Deschutes River, wetlands along Crescent Creek and the Little Deschutes River, and wetlands along the Deschutes River downstream to Bend. Additional sites could be present on unsurveyed portions of the covered lands. USFWS has designated critical habitat for the species, of which 22,690 acres lie on the covered lands.

The Oregon spotted frog is a medium-sized, highly aquatic ranid frog. Adults often breed communally, and the same sites tend to be used year after year. Preferred breeding sites (shallow, exposed wetlands) provide warm waters that accelerate egg development during the day, but these same conditions put egg masses at risk of freezing at night. Shallow waters also make eggs vulnerable to desiccation if water levels fluctuate. Larval development (hatching to metamorphosis) is variable depending on water temperature, but generally occurs in about 3 to 5 months. During the summer, adults and post-metamorphic juveniles are usually found among herbaceous wetland vegetation in pools, ponds and small floodplain wetlands associated with permanent bodies of water. Juveniles and adults overwinter in springs, beaver dams, and slow-moving stream channels associated with breeding habitat, and frogs have been observed to be active beneath surface ice. Although overwintering sites are typically located close to breeding sites, radio-telemetry studies have shown that adults may travel more than 1 mile between the two.

Oregon spotted frogs breed in the spring (March and April) and individual females can lay as many as 600 eggs each year. Hatching occurs typically 18 to 30 days after egg-laying, depending on water temperatures. The duration of the larval life stage (hatchling to juvenile frog) in is 3 and 5 months. Mortality rates are believed to be highest immediately post-hatching, with increasing survival in subsequent life stages. Predation by a variety of native and non-native invertebrates, fish, amphibians, reptiles and birds has the greatest impact on larval and post-metamorphic abundance.

The historical range of the Oregon spotted frog extended from southwestern British Columbia to the Pit River drainage in northeastern California. Currently, Oregon spotted frogs occur from British Columbia through Washington to the Klamath Basin of southern Oregon. The species is believed to be extirpated in California and substantially reduced in distribution elsewhere in its historical range.

The Deschutes Basin remains a primary population center for the species. Within the basin Oregon spotted frogs are present in wetlands from headwaters lakes and streams to Bend. In addition to the 34 known occupied sites on the covered lands, another 25 sites have been documented in adjacent waters off the covered lands. Small numbers are also known to occur in tributaries to the Deschutes River downstream of Madras, but historical sites directly along the river downstream of Bend were surveyed in 1997 and 2013 and found not to be occupied.

Oregon spotted frog habitats on the covered lands are a combination of seasonal and perennial wetlands associated with lakes (Crane Prairie and Wickiup reservoirs) and flowing waters (Deschutes River, Little Deschutes River and Crescent Creek). Habitats within Crane Prairie and Wickiup reservoirs are predominantly shoreline wetlands that are directly connected to the reservoirs and have experienced annual water level fluctuations of 3 feet or more due to seasonal storage and release of irrigation water. A few wetlands adjacent to the reservoirs lack direct surface connections, but are connected through sub-surface flow and also experience fluctuations as the reservoirs rise and fall.

Along the Deschutes River, Oregon spotted frog habitats can be found in riverine and oxbow wetlands between Wickiup Dam and Bend. These wetlands have varying degrees of surface connection to the river. Most are directly connected during summer high-flow conditions and partially or completely isolated, if not completely dewatered, during the winter. Others are permanently isolated from the river and supported by flows from adjacent uplands that keep them inundated year round. Most of the major identified wetland complexes along this reach of the Deschutes River are known to be occupied by Oregon spotted frogs.

Oregon spotted frog habitats along Crescent Creek and the Little Deschutes River also consist of oxbow and riverine wetlands with varying levels of connection to the flowing water. Overall, the density of wetlands (acres of wetland per mile of stream) is higher along Crescent Creek and the Little Deschutes River than along the Deschutes River.

At the time of listing, USFWS evaluated potential threats to Oregon spotted frogs by breeding location and occupied watersheds, and summarized threats by subbasin. USFWS determined that survival of the species is threatened by one or more of the following factors:

- Threat Factor A: The present or threatened destruction, modification, or curtailment of its habitat or range
- Threat Factor C: Disease or predation
- Threat Factor D: Inadequate existing regulatory mechanisms
- Threat Factor E: Other natural and human-caused factors affecting the species' existence

USFWS found no evidence that Oregon spotted frogs are being over-utilized for commercial, recreational, scientific, or educational purposes (Threat Factor B).

Within the major threat categories, USFWS identified several specific threats to Oregon spotted frogs within the Upper Deschutes and Little Deschutes river subbasins. The analysis noted that all subbasins contain multiple threats to the species, providing a cumulative risk to the populations. Many of the threats are intermingled and may act synergistically. In addition, USFWS concludes that current regulatory mechanisms are not sufficient to protect Oregon spotted frog and its habitat. In fact, programs designed to benefit fish species have resulted in the unintentional reduction of habitat quality for Oregon spotted frogs in some locations.

USFWS formally designated 65,038 acres of critical habitat for the Oregon spotted frog on May 11, 2016. Of this total, 35,065 acres (54%) lie within the Upper Deschutes River and Little Deschutes River subbasins, where 22,690 acres coincide with the covered lands. The primary constituent elements (PCE) of critical habitat are those specific elements of the physical or biological features supporting the life history processes of the Oregon spotted frog that are essential to the conservation of the species. Three primary constituent elements were identified by USFWS:

- PCE 1 – Nonbreeding (N), Breeding (B), Rearing (R), and Overwintering (O) habitat
- PCE 2 – Aquatic movement corridors
- PCE 3 – Refugia habitat

Certain areas occupied by Oregon spotted frogs may require special management considerations to protect the physical or biological features identified as essential for the conservation of this species. Threats to these essential features include, but are not limited to the following:

- Habitat modifications brought on by non-native plant invasions or native vegetation encroachment (trees and shrubs)
- Loss of habitat from conversion to other uses
- Hydrologic manipulation
- Removal of beavers and features created by beavers
- Livestock grazing

- Predation by invasive fish and bullfrogs

Management activities that could ameliorate the threats described above include, but are not limited to the following:

- Treatment or removal of exotic and encroaching vegetation (for example mowing, burning, grazing, herbicide treatment, shrub/tree removal)
- Modifications to fish stocking and beaver removal practices in specific water bodies
- Non-native predator control
- Stabilization of extreme water level fluctuations
- Restoration of habitat features
- Implementation of appropriate livestock grazing practices

1.5 Habitat Conservation

The Permittees and the Services developed biological goals and objectives for management of the covered lands to minimize and mitigate the impacts of the covered activities on the covered species. Twenty-one conservation measures were then developed to achieve those goals and objectives (Table 1-1). Each of the 21 conservation measures addresses the effects of a specific covered activity or set of activities, such as operation of storage reservoirs or diversions of water. Most of the measures modify an activity to reduce or eliminate its adverse effects on covered species, while a small number of the measures provide offsetting mitigation for adverse effects that cannot be avoided. For covered activities that are currently providing benefits to covered species, the conservation measures include provisions to continue those benefits.

The goal of most of the conservation measures is to modify the hydrology of the covered waters from historical conditions (i.e., past operation of irrigation reservoirs and diversions) to improve conditions for the covered species. The effects of the conservation measures on the covered waters and covered species are as follows:

- The operation of Crane Prairie Reservoir will be directed by Conservation Measure CP-1 to reduce annual fluctuations in water surface elevation and provide improved breeding, summer rearing and overwintering conditions for Oregon spotted frogs that currently reside there. Historical fluctuations of 9 feet or more between spring and fall of each year due to reservoir management will be reduced to a routine maximum of 2.25 feet. This will cause corresponding reductions in the annual release of water for irrigation use. Adaptive management provisions in the DBHCP will require effectiveness monitoring of the new operating regime, and further reductions in active storage will be made if needed to provide optimal conditions for Oregon spotted frogs. Periodic increases in seasonal reservoir fluctuation may also occur if needed to benefit Oregon spotted frogs.
- Conservation Measure WR-1 will alter the operation of Wickiup Reservoir to improve conditions for the Oregon spotted frog in the Deschutes River between the reservoir and Bend. NUID will forego storage in Wickiup Reservoir, as needed, to maintain specified minimum flows downstream of Wickiup Dam during the winter. The minimum flow will be 100 cfs in Years 1 through 7, 300 cfs in Years 8 through 12, and 400 cfs (with provisions for up to 500 cfs) in Years 13 through 30. Flows will exceed these minimums

whenever inflow to the reservoir in a given year is predicted to be more than enough to fill the reservoir. NUID will also increase flows below the dam to at least 600 cfs by April 1 and maintain flows within specified limits for the entire month of April to support Oregon spotted frog breeding. The rate at which flows can be increased or decreased (ramping rates) will be limited by a number of provisions in Measure WR-1 to protect downstream fish and wildlife from sudden changes in water depth.

- Habitat restoration/enhancement and other activities in the Upper Deschutes Basin to benefit the Oregon spotted frog will be supported by annual funding of $150,000 under Conservation Measure UD-1.
- Winter flows in the Deschutes River below Bend will be maintained at or above 250 cfs for covered fish species by Conservation Measure DR-1, which requires the Permittees to coordinate their winter diversions of water for livestock.
- Crescent Lake Reservoir will be operated according to Conservation Measures CC-1, CC-2 and CC-3 to maintain and enhance habitats for Oregon spotted frogs in lower Crescent Creek and lower Little Deschutes River. The minimum flow below Crescent Lake Dam from October through June will be increased from the historical 6 cfs to 10-12 cfs to enhance overwintering and breeding habitat. Additional winter flow can be provided, as needed, through adaptive management. The minimum flow from July 1 through September 30 will be 50 cfs to maintain summer rearing habitat. Ramping rates will also be limited at all times of year to avoid sudden changes in water depth in wetlands occupied by Oregon spotted frogs. A portion of the storage capacity in Crescent Lake Reservoir will be designated for use specifically to manage flows in lower Crescent Creek and lower Little Deschutes River, as needed, to improve habitat conditions for Oregon spotted frogs.
- Flows in Whychus Creek will be managed according to Conservation Measure WC-1, which goes beyond the instream water right transfers of over 31 cfs that TSID proactively made during DBHCP development and prevents the extremely low flows that occurred in the past. Conservation Measures WC-2 and WC-4 will promote further increases in instream flow by supporting on-farm conservation and temporary instream leasing. Fish screens at the TSID diversion will be maintained according to Conservation Measure WC-3 to avoid entrainment of covered species, and ramping rates in Conservation Measure WC-5 will protect covered fish downstream of the diversion from sudden changes in water depth. Conservation Measure WC-6 will provide funding for habitat restoration work in Whychus Creek and WC-7 will support the removal of a small dam that has blocked fish movements in the creek.
- The storage, release and diversion of water in the Crooked River, Ochoco Creek and McKay Creek will be conducted in accordance with Conservation Measures CR-1, CR-2, CR-3 and CR-6 to protect habitat for covered fish species. In addition, the Permittees will provide annual funding for fisheries habitat restoration and enhancement projects in the subbasin according to Conservation Measure CR-4, and the screening of small patron diversions (which are not covered by the DBHCP) will be supported by Conservation Measure CR-5 to reduce the potential for entrainment of covered fish. Spring pulse flows for steelhead smolt migration will be protected from diversion by the Permittees according to Conservation Measure CR-7.

Table 1-1. Habitat Conservation measures to be implemented under the Deschutes Basin Habitat Conservation Plan.

Conservation Measure(s)	Covered Activity	Covered Species	Description	Responsible Permittee
CP-1	Crane Prairie Reservoir	Oregon spotted frog	Modifies operation of reservoir to improve habitat for all life stages of Oregon spotted frog within the reservoir.	COID
WR-1	Wickiup Reservoir	Oregon spotted frog	Modifies operation of reservoir to benefit Oregon spotted frogs downstream of Wickiup Dam in the Deschutes River.	NUID
UD-1	Crane Prairie, Wickiup, and Crescent Lake reservoirs	Oregon spotted frog	Provides $150,000 per year for term of DBHCP to support habitat restoration and other activities in Upper Deschutes Basin to benefit Oregon spotted frogs.	AID, COID, LPID, NUID, SID, TID
DR-1	Winter Diversions of Stock Water	Bull trout, steelhead and sockeye salmon	Requires coordination between three Districts to maintain flows of at least 250 cfs in Deschutes River below Bend during the winter.	AID, COID, SID
CC-1, CC-2, CC-3	Crescent Lake Reservoir	Oregon spotted frog	Modify operation of reservoir to benefit Oregon spotted frogs downstream of Crescent Lake Dam in Crescent Creek and Little Deschutes River.	TID
WC-1, WC-5	Whychus Creek Diversion	Bull trout and steelhead	Modify operation of TSID Diversion to increase instream flow and improve habitat for covered fish species.	TSID
WC-2	Whychus Creek Diversion	Bull trout and steelhead	Funds temporary instream transfer of water to increase instream flow and improve habitat for covered fish species.	TSID
WC-3	Whychus Creek Diversion	Bull trout and steelhead	Requires maintenance of fish passage and fish screens at TSID Diversion.	TSID
WC-4	Whychus Creek Diversion	Bull trout and steelhead	Encourages water conservation and instream transfer of water rights by TSID patrons.	TSID
WC-6	Whychus Creek Diversion	Bull trout and steelhead	Provides $10,000 per year for term of DBHCP to support habitat restoration activities in Whychus Creek.	TSID
WC-7	Whychus Creek Diversion	Bull trout and steelhead	Supports removal of a small irrigation diversion that block fish migration in Whychus Creek.	TSID
CR-1	Crooked River Diversion	Bull trout, steelhead and sockeye salmon	Allows Reclamation to reduce OID storage in Prineville Reservoir when needed to maintain specified winter flows in Crooked River.	OID
CR-2	Ochoco Reservoir and Ochoco Creek Diversions	Bull trout, steelhead and sockeye salmon	Modifies operation of Ochoco Reservoir and Ochoco Creek diversions to maintain specified minimum flows in Ochoco Creek.	OID
CR-3	McKay Creek Diversions	Bull trout, steelhead and sockeye salmon	Modifies operation of McKay Creek diversions to maintain specified minimum flows in McKay Creek.	OID

Conservation Measure(s)	Covered Activity	Covered Species	Description	Responsible Permittee
CR-4	Mitigation for multiple activities	Bull trout, steelhead and sockeye salmon	Provides annual funding for aquatic and wetland habitat restoration and enhancement in Crooked River subbasin.	OID, NUID, City
CR-5	Mitigation for multiple activities	Bull trout, steelhead and sockeye salmon	Provides funding for the screening of small diversions (pumps) operated by OID patrons on Crooked River and Ochoco Creek.	OID
CR-6	Crooked River Pumps	Bull trout, steelhead and sockeye salmon	Modifies operation of diversion at pumps to maintain specified minimum flows in Crooked River.	NUID
CR-7	OID and NUID Crooked River Diversions	Bull trout, steelhead and sockeye salmon	Protects spring smolt migration pules flows from diversion by Permittees.	OID, NUID

1.6 Monitoring, Reporting and Adaptive Management

Three types of monitoring will occur under the DBHCP; compliance, implementation and effectiveness. Compliance monitoring will be conducted by the Permittees to verify the conservation measures and other provisions of the DBHCP are being implemented as required. The majority of compliance monitoring will involve the collection of data on stream flows and reservoir volumes. Compliance monitoring will also involve verification that fish screens and other structures covered by the DBHCP are being properly maintained, and that contributions to habitat conservation funds are being made. The results of compliance monitoring will be reported to the Services annually.

Implementation monitoring will be done to support conservation measures that have provisions for real-time adjustment based on weather and site-specific conditions of the covered lands. Conservation Measure CC-1 specifies that a portion of Crescent Lake Reservoir storage (OSF Storage) will be available each year to increase flows in lower Crescent Creek and lower Little Deschutes River for Oregon spotted frogs, but the measure does not specify exactly how and when the water will be used. Rather, the use of the OSF Storage will be determined by USFWS based on the results of annual monitoring of Oregon spotted frog breeding and periodic monitoring/assessment of wetland habitat conditions along the affected waters.

Effectiveness monitoring will be conducted to support adaptive management for a subset of the DBHCP conservation measures. Adaptive management is included in an HCP when there is uncertainty about the biological effectiveness of a conservation measure. In the case of the DBHCP, adaptive management will be applied to Conservation Measure CP-1 for Crane Prairie Reservoir. Specifically, the effects of the modified reservoir operating regime on wetland vegetation within Crane Prairie Reservoir will be monitored, and the operation will be adjusted within specified limits if the monitoring reveals a reduction in emergent wetland for the Oregon spotted frog. The effects of reservoir operation on Oregon spotted frog breeding and larval development will also be monitored, and the regime will be altered if monitoring indicates a decline in breeding or impact to developing frogs.

On the Deschutes River, effectiveness monitoring will be conducted to determine whether the restrictions on changing the outflow from Wickiup Reservoir during April (Conservation Measure WR-1) can be relaxed without impacting breeding Oregon spotted frogs. If monitoring indicates Oregon spotted frogs eggs in the Dead Slough wetland can tolerate decreases in water depth of more than 1 inch without being adversely affected, Item C of Conservation Measure WR-1 may be modified after review and approval by USFWS.

1.7 Effects of the Proposed Incidental Take on the Covered Species

The effects of the covered activities and the associated conservation measures will vary by covered species and by location within the covered lands and waters. Each of the four covered species is evaluated individually.

1.7.1 Bull Trout

The covered activities and the DBHCP will have minor effects on the bull trout, for a number of reasons. The Deschutes Basin is considered a stronghold for bull trout, but the majority of the bull trout in the basin spawn and rear in the Metolius River subbasin. No bull trout spawning or juvenile rearing is known to occur on the covered lands, and none is anticipated to occur there in the future. Adult and juvenile bull trout forage in Lake Billy Chinook on a seasonal basis, but the covered activities have relatively little effect on habitat conditions for bull trout within the reservoir and conditions are not expected to change under the DBHCP. Within the tributaries most heavily influenced by the covered activities (Deschutes River upstream of Lake Billy Chinook, Whychus Creek and Crooked River) bull trout are generally restricted to the lower reaches where large influxes of cold groundwater provide favorable conditions for the species. Upstream of the reaches affected by spring discharges, bull trout use is limited by naturally high water temperatures and blockages to upstream migration. Bull trout require cold waters, particularly for spawning and rearing. The DBHCP will not be able to appreciably alter water temperatures within the reaches accessible to bull trout and consequently habitat conditions for the species are not expected to change. Bull trout use of the covered waters will continue to be quite limited. The recent removal of a fish barrier near Opal Springs in the Crooked River (unrelated to the DBHCP) now creates the potential for seasonal bull trout use of the Crooked River upstream as far Bowman Dam, but much of this reach of the river will continue to be too warm for bull trout during the summer. The DBHCP will not reduce the potential benefits to bull trout from removal of the barrier.

In the Deschutes River from Big Falls to the Columbia River the DBHCP will result in increased winter flows, but the benefits of these increases to bull trout will be small because winter flows are not currently limiting the bull trout population within this reach. During the summer, small increases in flow in the Deschutes River will produce corresponding increases in water temperatures that could be detrimental to bull trout, but the species already has limited presence in the river (outside of Lake Billy Chinook) during the summer and any negative impacts will be negligible.

Bull trout do not spawn or rear in Whychus Creek, but adults and subadults from the Metolius River subbasin populations may forage in Whychus Creek during cooler months. This will not change under the DBHCP.

1.7.2 Steelhead Trout

The DBHCP will have positive effects on steelhead in the Deschutes Basin, and the overall potential for successful reintroduction upstream of Pelton Round Butte Project will remain constant or improve slightly. Conditions for adult migration and spawning will show little overall change, and current conditions that allow adult access to most potential spawning habitat will continue. Incubation and summer rearing may improve slightly, while winter rearing could show measurable improvement, particularly during dry water years. Smolt migration will be aided by the DBHCP in the upper Deschutes Basin by preventing spring pulse flows in the Crooked River from being diverted before they reach Lake Billy Chinook, and in the lower Deschutes River where higher releases from Wickiup Reservoir are expected to increase flows in April. The majority of juvenile steelhead in the Deschutes Basin are produced downstream of the Pelton Round Butte Project, and a large portion of these fish will benefit from the flow increase during the emigration season.

The lower Crooked River is of particular importance to the steelhead reintroduction, and the DBHCP, in coordination with Reclamation’s use of uncontracted water in Prineville Reservoir, will provide flows to support winter rearing habitat for steelhead in the river. Winter flow conditions are recognized as a potential limit to successful steelhead reintroduction. The DBHCP will help sustain suitable winter rearing habitat, most importantly during dry water years.

1.7.3 Sockeye Salmon

The DBHCP will have minor positive effects on sockeye salmon in the Deschutes Basin. As a result, the potential for successful reintroduction upstream of Pelton Round Butte Project will remain unchanged or improve slightly. Anadromous sockeye and their land-locked counterpart kokanee have historically made very little use of lands covered by the DBHCP upstream of Lake Billy Chinook, and this is not anticipated to change as a result of reintroduction. The vast majority of sockeye spawning upstream of Lake Billy Chinook is expected to occur in the Metolius River subbasin, where it will not be influenced by the covered activities and the DBHCP. The lower reaches of Whychus Creek, Middle Deschutes River and Crooked River, where sockeye could spawn in small numbers, will continue to have high flows and cool waters provided by natural groundwater discharge, and this will not change under the DBHCP.

Conditions for adult sockeye migration through the Lower Deschutes River and Lake Billy Chinook will be unaffected by the DBHCP because flows entering the reservoir, which are influenced by the covered activities, will not change during the period when sockeye would be migrating upstream. During sockeye outmigration, increased releases from Wickiup Reservoir under the DBHCP from mid-October through mid-April could improve conditions for the movement of sockeye smolts through Lake Billy Chinook; this could facilitate the reestablishment of an ocean-going population.

1.7.4 Oregon Spotted Frog

Oregon Spotted Frog Overwintering

The effects of the DBHCP on Oregon spotted frogs will vary by location and by season within the covered lands, but some general trends will occur. Overwintering habitat for Oregon spotted frogs will improve or remain the same in most areas affected by the covered activities, with a few notable exceptions. Conditions for overwintering will improve in Crane Prairie Reservoir, portions of the Deschutes River between Wickiup Dam and Bend, Crescent Creek and the Little Deschutes River, all due to increased inundation of wetlands during the winter. Improvements in overwintering habitat will be more pronounced in Crane Prairie Reservoir because emergent wetlands that were historically dry in the winter will now remain inundated year round. Improvements along Crescent Creek and the Little Deschutes River will be less noticeable because suitable overwintering habitat is already present adjacent to both water bodies, and changes to winter inundation levels will be relatively subtle. Improvements along the Deschutes River will be modest because new inundation levels will not be sufficient to reach emergent (sedge) wetlands, and overwintering habitats will still be restricted to unvegetated backwater areas and side channels of the river.

Conditions will deteriorate in Wickiup Reservoir because it will be consistently lower (with less storage volume) during the winter than it was historically. Lower storage volumes will confine overwintering frogs to a smaller area with less substrate vegetation, making them increasingly vulnerable to predation. Conditions in the Deschutes River reach between Wickiup Reservoir and Crane Prairie Dam will decline because flows will be lower throughout the winter due to the need to begin storing water in Crane Prairie Reservoir almost immediately after the end of the irrigation season each October.

The net effect of the DBHCP on overwintering Oregon spotted frogs in the upper Deschutes Basin will be positive because the areas that will improve the most (Crane Prairie Reservoir, Crescent Creek and Little Deschutes River) are areas with the highest concentrations of habitat and highest numbers of known Oregon spotted frogs. Based on recent survey data and associated estimates of the numbers of breeding females, these three areas support roughly 78 percent of the known Oregon spotted frogs on the covered lands.

Oregon Spotted Frog Breeding

Breeding conditions for Oregon spotted frogs will improve on all covered lands except Wickiup Reservoir and the reach of the Deschutes River between Crane Prairie Dam and Wickiup Reservoir. Improvements will be due to the following: a) increased flows and associated wetland inundation levels at the beginning of the Oregon spotted frog breeding season, and b) reduced fluctuation in flows during the breeding season. Oregon spotted frogs on the covered lands will have greater access to preferred breeding habitats (shallowly inundated emergent wetlands) and they will be less exposed to fluctuations in water level that can lead to stranding, desiccation or flushing. The improvements will be most pronounced at Crane Prairie Reservoir where habitat conditions will be consistently favorable for breeding in all years. Improvements on Crescent Creek and Little Deschutes River will be more subtle because conditions are already conducive to breeding along both waters. Improvements along the Deschutes River will vary by reach, but will be greatest in the reaches with the largest known numbers of Oregon spotted frogs.

Breeding conditions in Wickiup Reservoir will deteriorate under the DBHCP because water levels (storage volumes) will be consistently lower at the onset of breeding and the levels will drop faster during egg and larval development than they did historically. Frogs attempting to breed in Wickiup Reservoir will have to utilize marginal habitats, and their eggs and larvae will be consistently exposed to elevated risk of desiccation, freezing and predation. Breeding conditions along the Deschutes River between Crane Prairie Dam and Wickiup Reservoir will be hampered by flows that are lower and more variable from day to day than they were in the past. Flows in this reach will be dictated by the need to hold water levels in Crane Prairie Reservoir relatively constant as inflows to the reservoir fluctuate. Natural fluctuations in reservoir inflow during spring storms and snowmelt, which were historically held in Crane Prairie Reservoir for irrigation storage, will now be passed downstream to Wickiup Reservoir. The result will be that the reach of Deschutes River between the reservoirs will see considerably more fluctuation in flow and depth during the breeding season.

Oregon Spotted Frog Summer Rearing and Foraging

Summer rearing and foraging habitat for Oregon spotted frogs will improve on some of the covered lands and deteriorate on others. Improvements will be most apparent in Crane Prairie Reservoir, Crescent Creek, Little Deschutes River and Deschutes River, where water levels will be managed to maintain suitable conditions through the completion of larval development in late summer.

Deteriorating conditions will occur in Wickiup Reservoir because the storage volume in the reservoir will be consistently low by mid-summer. Summer rearing along the Deschutes River downstream of Wickiup Dam could be temporarily impacted by flows lower than those needed to keep wetlands inundated throughout the summer, but restoration and enhancement actions supported by the Upper Deschutes Basin Habitat Conservation Fund will counteract the negative effects of lower summer flows. Over the long term, Oregon spotted frog summer rearing and foraging habitat is expected to improve along this reach of the Deschutes River.

Due to the large areas of emergent wetlands and large number of breeding Oregon spotted frogs in Crane Prairie Reservoir, Crescent Creek and Little Deschutes River, the favorable conditions for summer rearing and foraging that will be maintained in these areas will offset any short-term reductions in habitat quality and quantity along the Deschutes River while habitat restoration and enhancement activities are completed.

1.8 Changed and Unforeseen Circumstances

Changed circumstances are changes in circumstances affecting a species or geographic area covered by a habitat conservation plan that can reasonably be anticipated by applicants and the Services and planned for in advance. The DBHCP identifies nine categories of changed circumstances pertinent to the covered lands and covered species, along with the steps the Services may require the Permittees to take if any of these six changed circumstances occurs. The conservation measures and the changed circumstances provisions of the DBHCP constitute the total requirements of the Permittees in the event of a changed circumstance. The Services will not place additional restrictions on the covered activities or require additional commitments of land, water or financial resources beyond those specified in the DBHCP without the consent of the Permittees. The nine categories of changed circumstances are:

1. Changes in habitat on the covered lands due to flooding
2. Non-emergency maintenance, repair and modification of covered facilities
3. Failure or impairment of a dam or diversion structure
4. Change in the biological status of a covered species
5. Change in the federal status of a species;
6. Climate change
7. Permittee(s) seeking amendment to or exit from the DBHCP
8. Inability of NUID to secure alternate sources of irrigation water
9. Change in the status of Whychus Creek

Unforeseen circumstances are changes in circumstances affecting a species or geographic area covered by an HCP that could not reasonably have been anticipated by an applicant or the Services at the time of HCP development, and that result in a substantial and adverse change in the status of a covered species. By definition, unforeseen circumstances cannot be predicted and response measures cannot be developed in advance. In the event of an unforeseen circumstance the Services will not require the commitment of additional land, water or financial compensation or place additional restrictions on the use of land, water (including quantity and timing of delivery), or other natural resources beyond the levels already provided in the DBHCP. However, the Permittees and the Services will make good-faith efforts and use the best available scientific and commercial data to address unforeseen circumstances that occur, and develop voluntary actions that could be taken to avoid or minimize the impacts consistent with continued performance of the covered activities and implementation of the DBHCP.

1.9 Costs and Funding of the Habitat Conservation Measures

The costs of DBHCP implementation include initial capital costs for system improvements, annual contributions to conservation funds, annual costs for increased labor to operate the covered facilities according to the DBHCP, and annual costs to monitor and report on implementation. Costs vary by Permittee, with initial capital costs for a single Permittee of up to $46,500 and annual costs of up to $119,228. Large capital costs will be funded with loans that will be repaid by increasing irrigation district patron fees. Smaller capital costs and annual costs will also be paid by increasing patron fees. Most increases will be moderate, but some annual patron fees could increase as much as 22 percent to fully fund implementation.

Most of the irrigation district Permittees will be able to accommodate the loss of water under the DBHCP due to ongoing and planned piping of canals to reduce seepage losses. This piping will not be required to fulfill the Permittees obligations under the DBHCP, and consequently piping is not part of the DBHCP. Nevertheless, the costs of piping, which will be substantial, influence the financial ability of the Permittees to provide additional mitigation. The costs of piping vary by District, and it is anticipated that significant portions of the costs will be covered by federal grants. The piping costs that will remain for individual Permittees to cover range from approximately $2,000,000 to as much as $115,000,000.

1.10 Alternatives to the Proposed Incidental Take

During the development of the DBHCP the Permittees and the Services identified alternatives to the proposed incidental take, including avoidance of take. The alternatives involving incidental take were mostly increased levels of mitigation that were found to be impracticable or infeasible. Like the conservation measures, the alternatives were identified for the individual geographic subsets of the covered lands.

- **Crane Prairie Reservoir:** No alternatives were identified for the management of Crane Prairie Reservoir. Conservation Measure CP-1 and the associated adaptive management provisions of Chapter 7 will optimize the management of the reservoir for the Oregon spotted frog.
- **Wickiup Reservoir and Upper Deschutes River:** Three alternatives were identified for the management of Wickiup Reservoir; all involving changes in the timing and magnitude of winter minimum flows in the Deschutes River below Wickiup Dam. Wickiup Alternative 1 would accelerate the scheduled flow increases and require a minimum of 200 cfs at Year 1, 300 cfs at Year 6, and a variable minimum of 400 to 500 cfs starting in Year 11. Wickiup Alternative 2 would accelerate the increases even further and require a variable minimum of 400 to 600 cfs starting in Year 6. Alternative 2 would also shorten the term of the DBHCP to 20 years. Both alternatives were dismissed because NUID is unable to identify a practicable means of ensuring the required minimum winter flows without jeopardizing the viability of irrigated agriculture within its district. Wickiup Alternative 3 was the proposal put forward in the 2019 Draft DBHCP. It is similar to Conservation Measure WR-1 in the Final DBHCP, with the primary difference being that Alternative 3 has longer periods of time between scheduled

increases in minimum winter flows. Wickiup Alternative 3 was not selected because USFWS did not consider the timing for the proposed increases in winter minimum flow to be quick enough to support conservation and recovery goals for the Oregon spotted frog in the Upper Deschutes River.

- **Middle Deschutes River:** Early in the development of the DBHCP the Permittees and the Services explored options for increasing summer flows in the Middle Deschutes River by transferring irrigation rights to instream uses. This approach was dismissed because it conflicted with efforts to provide additional flow in the Deschutes River during the winter for Oregon spotted frogs.
- **Crescent Creek and Little Deschutes River:** Two alternatives were identified for the operation of Crescent Lake Reservoir. One alternative was to maintain a flow of 30 cfs below Crescent Lake Dam from March 15 to November 30 and 20 cfs from December 1 to March 14. The other alternative, which was proposed in the 2019 Draft DBHCP, included a minimum flow of 20 cfs the entire winter. Both alternatives contrast with Conservation Measure CC-1, which requires a minimum of 10 to12 cfs from October 1 through May 31 and includes provision for the use of a portion of Crescent Lake Reservoir storage for Oregon spotted frog habitat management. Neither alternative was selected because neither included OSF storage In Crescent Lake Reservoir, which is considered a better allocation of the limited amount of water available for supporting Oregon spotted frogs.
- **Whychus Creek:** No alternatives were considered for the management of Whychus Creek. Conservation Measure WC-1 represents the instream transfer of all water available from TSID's piping of its entire canal system. Any additional water right transfers would prevent TSID from fulfilling its obligations to deliver water to its patrons.
- **Crooked River, Ochoco Creek and McKay Creek:** Two alternatives for the Crooked River subbasin were considered during DBHCP development. The first was a modification to Conservation Measure CR-1 to have a target minimum flow of 80 cfs in the Crooked River year round. This alternative was dismissed because a flow of 80 cfs in the Crooked River during the summer would have limited benefit to covered fish species, but it would reduce the amount of water available to maintain habitat conditions during the winter, particularly in the high-quality reach of the Crooked River between Bowman Dam and the Crooked River Diversion. The second alternative would be a modification to Conservation Measure CR-1 or a new conservation measure requiring NUID to use a portion of the 10,000 acre-feet of Prineville Reservoir storage it can purchase each year to increase flows in the Crooked River rather than for irrigation. This alternative was dismissed because NUID will be heavily reliant on the 10,000 acre-feet to meet its irrigation demands under the DBHCP. Any reduction in NUID's access to the 10,000 acre-feet, or modification in the timing of the release of the water from Prineville Reservoir, could have severe consequences to the District's patrons.

Take avoidance was considered but dismissed for a number of reasons. For most Permittees the avoidance of take is not feasible. Presumably, NUID would need to eliminate the use of Wickiup Reservoir to avoid incidental take, but this would immediately render the District incapable of delivering water to its patrons and end irrigated agriculture on several thousand acres. Similar, but less severe situations could exist for LPID and TID, both of which rely heavily on reservoirs that affect habitat for Oregon spotted frogs. For SID, TSID and OID, avoidance of incidental take would require elimination of the diversions that provide all of their water. These Districts could not remain viable without the diversions. For COID, take avoidance is feasible but more costly than implementation of the DBHCP. This could change, however, if additional requirements were placed on COID. The District's need for incidental take coverage of the Oregon spotted frog is limited to its operation of Crane Prairie Reservoir. COID could eliminate the need for the reservoir by retaining all of the water it conserves through canal piping rather than make a portion of this available to NUID. Instead, the two Districts have chosen to pursue a cooperative agreement that will keep them both viable.

The practicability of providing additional mitigation for the proposed incidental take was evaluated for each individual Permittee using three criteria:

1. The cost of DBHCP implementation versus the cost of take avoidance;
2. The cost of DBHCP implementation compared to the economic benefit of the covered activities; and
3. The legal, technological and physical feasibility of the conservation action.

As with take avoidance, the limits of practicability vary by Permittee and depend on how heavily each relies on the covered activities.

FINAL

DESCHUTES BASIN
HABITAT CONSERVATION PLAN

Chapter 2 – Introduction and Background

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2 – INTRODUCTION AND BACKGROUND

2.1 Introduction

Eight Central Oregon irrigation districts and the City of Prineville, Oregon (City) have prepared this Deschutes Basin Habitat Conservation Plan (DBHCP) to support the issuance of incidental take permits under the Endangered Species Act of 1973, as amended (ESA). The eight irrigation districts utilize waters of the Deschutes River and its tributaries (Table 2-1, Figure 2-1). All eight districts are quasi-municipal corporations formed and operated according to Oregon law to distribute water to irrigators (patrons) within designated geographic boundaries in accordance with the individual water rights appurtenant to the lands of those patrons. Prineville is an incorporated city and the county seat for Crook County, Oregon. It operates City-owned infrastructure and provides essential services, including public safety, municipal water supply, and sewage treatment to more than 9,000 residents.

Table 2-1. Deschutes Basin Habitat Conservation Plan Permittees.

Name	Address
Arnold Irrigation District (AID)	19604 Buck Canyon Road, Bend, OR 97702
Central Oregon Irrigation District (COID)	1055 SW Lake Court, Redmond, OR 97756
Lone Pine Irrigation District (LPID)	PO Box 87, Terrebonne, OR 97760
North Unit Irrigation District (NUID)	2024 NW Beech Street, Madras, OR 97741
Ochoco Irrigation District (OID)	1001 Deer Street, Prineville, OR 97754
Swalley Irrigation District (SID)	64672 Cook Avenue, Suite 1, Bend, OR 97703
Three Sisters Irrigation District (TSID)	68000 Highway 20, Sisters, OR 97759
Tumalo Irrigation District (TID)	64697 Cook Avenue, Bend, OR 97703
City of Prineville, Oregon (City)	387 NE 3rd Street, Prineville, OR 97754

Certain activities conducted by the Permittees have the potential to indirectly take fish and wildlife species listed under the ESA as threatened. In accordance with Section 10 of the ESA, the Permittees have applied to the US Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) (collectively called the Services) for incidental take permits that will allow specified levels of take to listed species without the threat of federal prosecution under Section 9 of the ESA. The Permittees will implement this DBHCP to minimize and mitigate the impacts of that authorized incidental take. The nature and magnitude of the covered incidental take are summarized in Section 2.2 of this chapter, and described in detail in Chapter 8, *Effects of the Proposed Incidental Take on the Covered Species*.

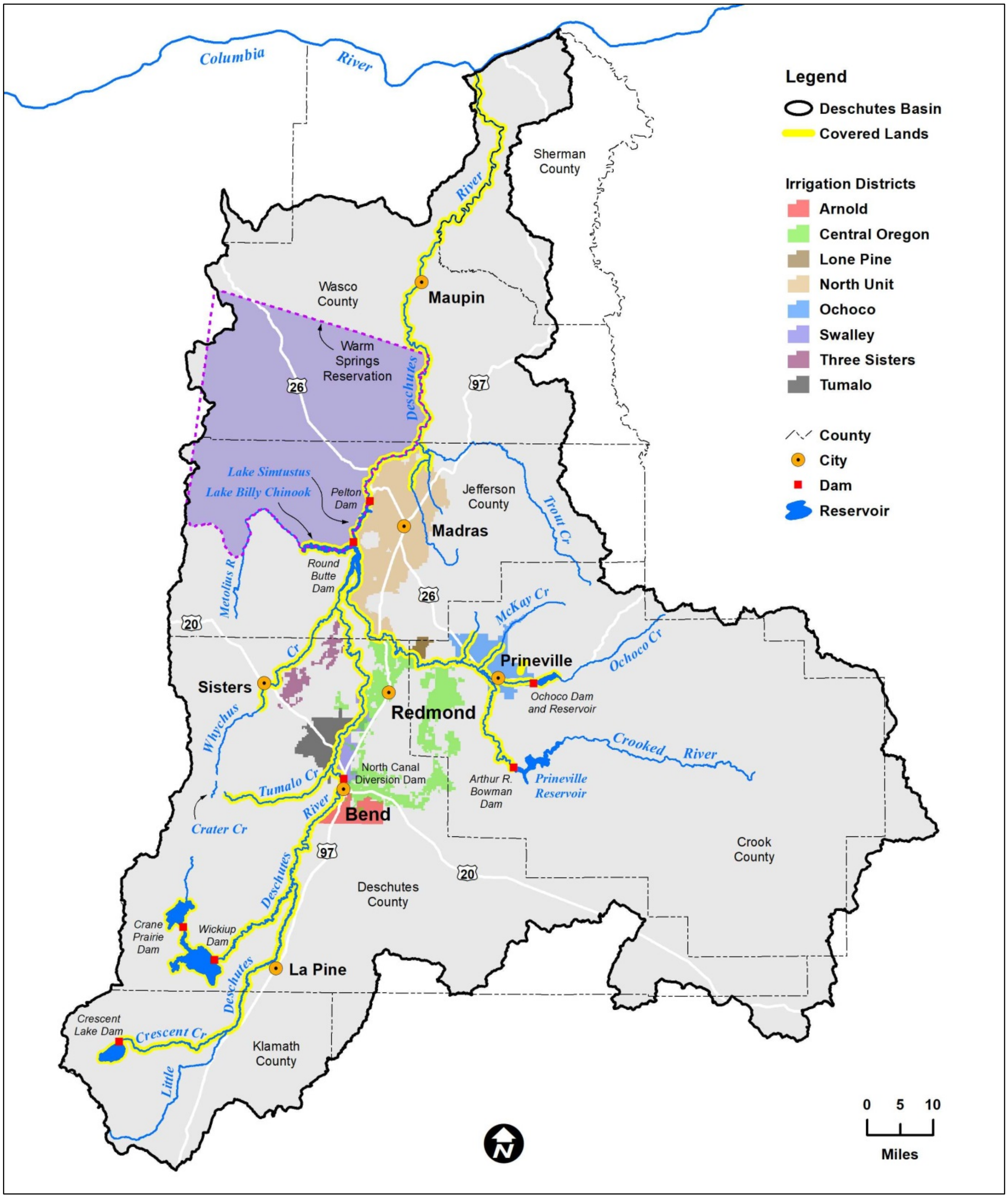

Figure 2-1. Map of the Deschutes Basin showing the DBHCP Permittees.

2.2 Need for Incidental Take Coverage

Section 9 of the ESA and its implementing regulations prohibit the "taking" of species that are formally listed as endangered, where taking means, "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" [16 USC 1532]. The ESA implementing regulations extend, under certain circumstances, the prohibition of take to threatened species (50 CFR 17.31). While the definition of take originally focused on activities that directly impact individuals of the species, it was subsequently expanded to include "habitat modification or degradation that significantly impairs essential behavioral patterns of fish or wildlife" [CFR 64 (215): 60727-60731].

In the course of storing, releasing, diverting and returning irrigation water, the Permittees alter the hydrology (flow) of the Deschutes River and a number of its tributaries. In a similar fashion, the pumping of groundwater for municipal water supply by the City affects the hydrology in one of those tributaries, the Crooked River. These changes in hydrology alter habitat conditions for three species protected under the ESA, thereby creating the potential for incidental take of the species. The Middle Columbia River steelhead trout (*Oncorhynchus mykiss*) is listed as threatened in the Deschutes River downstream of Pelton Reregulating Dam at River Mile (RM) 100 and is listed as non-essential experimental in the Deschutes River and tributaries upstream of Pelton Reregulating Dam. Protection of the steelhead trout falls under the jurisdiction of NMFS. The bull trout (*Salvelinus confluentus*) is listed as threatened throughout its current range, which includes portions of the Deschutes River and its tributaries. The Oregon spotted frog, which is found within portions of the upper Deschutes Basin, is also listed as threatened throughout its current range in Washington and Oregon. The bull trout and Oregon spotted frog fall under the jurisdiction of USFWS.

The Permittees cannot conduct their otherwise lawful activities of managing water for irrigation and municipal water supply without altering habitat for these three listed species. In addition, some of the irrigation diversions covered by the DBHCP have the potential to entrain covered fish species. To the extent that habitat alteration results in "habitat modification or degradation that significantly impairs essential behavioral patterns" of one or more of these three species, it amounts to take under Section 9 of the ESA [CFR 64 (215): 60727-60731]. If entrainment results in injury or significant impairment of essential behavioral patterns of a listed species, it is considered take as well. The Permittees have already implemented a number of measures to reduce the effects of their activities on the listed species and they will implement additional measures under the DBHCP. However, the Permittees are unable to avoid incidental take altogether without severely limiting or ceasing the activities they are required by law to conduct.

Oregon law requires the irrigation districts to provide water to their patrons, consistent with the water rights pursuant to which the districts provide such water, in the amounts and at the times specified in the water rights [ORS 545.025, 545.221]. As the Oregon Supreme Court has held, irrigation districts exist to enable owners of irrigable land to organize and facilitate the development and distribution of water for irrigation purposes [*Fort Vannoy Irrigation District v. Water Resources Comm'n*, 345 Or 56, 67-69, 188 P3d 277 (2008)]. To accomplish that purpose, an irrigation district is authorized to acquire and manage property, including water and water rights [ORS 545.239(1), 545.253]. With respect to such property that is held or managed by an irrigation district, the district acts as trustee on behalf of its members, who are viewed as beneficiaries. And as trustee, an irrigation district has the duty to manage "the water that it provides" on behalf of all its members [*Fort Vannoy,* 345 Or at 84, 86]. That water must be managed in furtherance of the purposes for which the irrigation district was formed, which the Oregon Supreme Court has described as "the improvement, by irrigation, of the lands within the district" [*Smith v. Enterprise Irrigation District*, 160 Or 372, 378-79, 85 P2d 1021 (1939); *see also* ORS 545.025, 545.253].

Similarly, the City must provide safe, reliable domestic water to its citizens. Oregon law provides Oregon cities with the authority to "build, own, operate and maintain waterworks … within and without its boundaries for the benefit and use of its inhabitants" [ORS 225.020]. The City owns and operates such a municipal system, and in so doing, is required to comply with the Oregon Drinking Water Quality Act of 1981, which was enacted to "ensure that all Oregonians have safe drinking water" [ORS 448.123]. And in addition to meeting present-day water needs of its citizens, the City is further required by Oregon law to plan to serve its Urban Growth Boundary as well [ORS 197.712].

Beyond the strict legal requirements to provide water, the Permittees form the basis for a large portion of the economy of Central Oregon. In 2012, Deschutes, Crook and Jefferson counties produced crops with a combined market value of $71,938,000 that resulted in gross farm-related income of $8,037,000 (NASS 2014). In the same year, agriculture in these three counties accounted for 2,448 jobs and produced $20,544,000 in direct payroll. Prineville is both the economic and population center of Crook County. The recently constructed data centers by Facebook and Apple also contribute substantial amounts to local and state economies. Without access to clean, reliable water the future of Prineville would be in jeopardy.

Inclusion of habitat modification in the definition of take provided necessary protection for threatened and endangered species, but it also broadened the range of otherwise lawful activities that could result in federal prosecution. Acknowledging that it may sometimes be impracticable, if not impossible, to avoid all take of a listed species, the ESA also includes provisions for allowing take that is incidental to otherwise lawful activities. Non-federal entities such as the DBHCP Permittees may seek incidental take permits under Section 10(a)(1)(B) of the ESA that allow them to continue the activities without the threat of federal prosecution, provided the Services determine, under Section 10(a)(2)(B) of the ESA, that:

(i) the taking will be incidental to otherwise lawful activities;

(ii) the applicant will, to the maximum extent practicable, minimize and mitigate the impacts of the incidental taking;

(iii) the applicant will ensure that adequate funding for the conservation actions necessary to minimize and mitigate the impacts of the incidental taking will be provided;

(iv) the incidental taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild; and

(v) any other measures considered necessary or appropriate by USFWS and/or NMFS will also be implemented.

To obtain an incidental take permit, an applicant must prepare and submit a plan, commonly referred to as a habitat conservation plan or HCP, in accordance with Section 10(a)(2)(A) of the ESA that specifies:

(i) the impact which will likely result from such taking;

(ii) what steps the applicant will take to minimize and mitigate such impacts, and the funding that will be available to implement such steps;

(iii) what alternative actions to such taking the applicant considered and the reasons why such alternatives are not being utilized; and

(iv) such other measures that the Services may require as being necessary or appropriate for purposes of the plan.

This DBHCP has been prepared to comply with Section 10(a)(2)(A) of the ESA and support the Permittees' applications to the Services for incidental take permits covering the effects of their ongoing activities on steelhead trout, bull trout and Oregon spotted frog. The ESA's implementing regulations also include provisions for addressing unlisted species in an HCP and obtaining certainty that if those species become federally listed during the term of the HCP they too will be covered under the incidental take permits [CFR 63 (35): 8859-8873]. The benefits of unlisted species coverage are twofold: a) it provides regulatory certainty for non-federal entities involved in long-term activities, and b) it facilitates proactive planning and habitat conservation that will reduce the need to list additional species as threatened or endangered in the future. In order to be included in an HCP and be covered by the incidental take permits in the event of future listing, an unlisted species must be treated in the HCP as though it were listed and it must be evaluated to the same degree as the listed species.

The DBHCP Permittees, in collaboration with the Services, conducted an exhaustive review of fish and wildlife species within Central Oregon to identify whether any unlisted species warranted inclusion in the DBHCP. The selection of unlisted species was guided by the following criteria:

- The species must be present or potentially present with the areas affected by the covered activities.
- The species must have a reasonable likelihood of becoming listed under the ESA as threatened or endangered during the term of the DBHCP (for this criterion a planning window of 50 years was used).
- There must be a reasonable potential for the species or its habitat to be adversely affected by the covered activities.
- Incidental take coverage for the species would be consistent with the Section 10(a)(1)(B) issuance criteria and would not appreciably reduce the likelihood of the survival and recovery of the species in the wild.
- The biology and ecology of the species are understood well enough to support a meaningful analysis of effects in the DBHCP.

The initial phase of review identified 91 species that met one or more of the criteria (Biota Pacific et al. 2012). Detailed analyses of the 91 species and subsequent consideration by the Permittees reduced the final list to one unlisted species to be included in the DBHCP: the sockeye salmon (*Oncorhynchus nerka*). It is present in portions of the Deschutes River where it may be affected by changes in flow brought about by the activities of the Permittees, and it is listed as threatened in other portions of its range. Due to a number of recent and ongoing studies in the region as a whole and the Deschutes Basin in particular, the status and habitat requirements of the species are well understood. While federal listing of the species in the Deschutes Basin is not anticipated at the present time, there exists a potential for its listing over the next several decades. The Permittees anticipate that the conservation actions in the DBHCP directed at the steelhead trout and bull trout will benefit sockeye salmon as well, and that issuance of an incidental take permit will not reduce the potential for its long-term survival in the wild.

The draft DBHCP circulated for public review and comment in late 2019 also included Chinook salmon (*Oncorhynchus tshawytscha*) as a covered species. After further review, however, the Permittees elected not to seek incidental take coverage for Chinook salmon at this time. While it is listed as a threatened species in other parts of its range, Chinook salmon is not listed in the Deschutes Basin and is not expected to become listed in the basin in the foreseeable future. The Permittees originally considered seeking incidental take coverage for the species because, like steelhead, it is the subject of an ongoing reintroduction upstream of Pelton Round Butte Hydroelectric Project. If the reintroduction is successful, the species will breed and rear in waters affected by the activities covered by this DBHCP. However, detailed review of the ongoing reintroduction and the effects of the covered activities on Chinook salmon indicated that more information is needed to determine how the Permittees can best support that reintroduction. Because of the certainty required under an HCP, inclusion of Chinook salmon in the DBHCP at this time could bind the Permittees and the Services to a course of action they would later need to modify. For listed species, the need for incidental take coverage in the short-term typically overrides the need for flexibility in the long-term, and the HCP amendment process is triggered if substantial modification to the conservation measures is required during implementation. The amendment process is lengthy and costly, however, and should not be relied upon unless no other option exists. In the case of an unlisted species like Chinook salmon, the more judicious option is to delay initial coverage, allow the Services and Permittees to gather additional information on the relationship between the species and the covered activities, and if necessary (i.e., if listing becomes imminent), seek incidental coverage later.

2.3 DBHCP Development Process and Participants

The DBHCP is the result of several years of collaboration between the Permittees, the Services and multiple stakeholders with the region. In addition to providing habitat for fish and wildlife, the Deschutes River and its tributaries form the basis for most economic and recreational activities in Central Oregon. In recognition of the fact that few persons within the basin are unaffected by the river, the Permittees and the Services took a number of steps to incorporate public input into the development of the DBHCP. Governmental agencies and organized non-governmental groups with established interests in the Deschutes River were invited to participate in the DBHCP Working Group beginning in 2008 (Table 2-2). The Working Group has met up to four times a year throughout DBHCP preparation to help guide each step of the process, from the initiation of baseline studies, to selection of covered species, to the development and review of conservation measures (Table 2-3). When specific technical issues were identified, Technical Working Groups were assembled from the members of the larger Working Group with specialized expertise to provide the Permittees and the Services with detailed input. In addition, a broader Stakeholder Group was created to keep the greater Central Oregon community apprised of DBHCP development and solicit their input. The Stakeholder Group, which has met 11 times since 2008, is open to anyone within the Deschutes Basin with an interest in the effects of the DBHCP on biological, economic or social resources of the basin.

Table 2-2. Deschutes Basin Habitat Conservation Plan Working Group.

DBHCP Working Group Participants	
USDI Bureau of Reclamation	Deschutes River Conservancy
USDI Bureau of Land Management	Trout Unlimited
USDA Forest Service	WaterWatch of Oregon
Confederated Tribes of Warm Springs	American Rivers
Oregon Water Resources Department	Upper Deschutes Watershed Council
Oregon Department of Environmental Quality	Crooked River Watershed Council
Crook County Oregon	Portland General Electric

Table 2-3. DBHCP Working Group, Stakeholder Group and Technical Group meetings.

Meeting Date	Working Group	Stakeholder Group	Technical Group
October 15, 2008	X		
November 5, 2008		X	
February 4, 2009	X		
April 16, 2009	X		
April 27, 2009		X	
July 31, 2009	X		
December 14, 2009	X		
April 29, 2010	X		
July 27, 2010	X		
November 5, 2010	X		
March 15, 2011	X		
March 16, 2011		X	
August 30, 2011	X		
December 12, 2011	X		
May 10, 2012	X		
September 21, 2012	X		
December 10, 2012	X	X	
March 6, 2013	X		
May 10, 2013			X
May 23, 2013			X

Meeting Date	Working Group	Stakeholder Group	Technical Group
September 24, 2013			X
December 18, 2013	X	X	
February 10, 2014			X
August 29, 2014	X		
September 16, 2014	X		
October 22, 2014	X		
November 5, 2014			X
December 9, 2014			X
December 19, 2014	X	X	
January 14, 2015			X
February 11, 2015			X
March 11, 2015			X
May 6, 2015			X
September 16, 2015	X	X	
February 8, 2016	X		
May 3, 2016			X
May 18, 2016			X
June 14, 2016			X
July 6, 2016			X
July 26, 2016			X
August 24-25, 2016			X
November 9, 2016	X	X	
December 14, 2017	X	X	
December 13, 2018	X	X	
September 11, 2019	X	X	

The DBHCP reflects the input of participants in the collaborative process, while remaining true to its specific and focused objective of minimizing and mitigating the effects of the Permittees' activities on three listed and one unlisted species. The public's interests in the Deschutes River and its tributaries are diverse, wide-ranging and sometimes conflicting. The DBHCP cannot resolve all issues concerning the use and fate of the river, but it can and has considered the implications of the covered activities on all other interests in the basin while meeting the requirements of the ESA. The DBHCP is not considered to be a guiding document for the use and management of the Deschutes River; it is rather a memorialization of the steps the Permittees will take over the next several decades to minimize and mitigate the effects of their activities. It has been designed to be consistent with larger and more diverse regional plans and programs, and it is intended to serve as one building block in that larger effort.

2.4 Deschutes Basin Approach to Habitat Conservation

The activities covered by the DBHCP cause changes in surface water hydrology that alter the quantity and/or quality of aquatic habitats for listed species in positive and negative ways. The approach of the DBHCP is to modify the covered activities to reduce the negative effects on aquatic habitats while preserving the positive effects. The negative effects of the covered activities cannot be eliminated altogether without complete cessation of the covered activities, but the DBHCP will reduce negative effects to a degree that will facilitate efforts to recover listed aquatic species in the Deschutes Basin and prevent other species from becoming listed.

The covered activities modify the timing and magnitude of flow in the Deschutes River and a number of its tributaries through the storage, release, diversion and return of irrigation water. On tributaries where irrigation storage occurs (Upper Deschutes River, Crescent Creek/Little Deschutes River, Crooked River and Ochoco Creek) the storage of water in the fall and winter reduces flows downstream of the reservoirs from natural levels. When stored water is released from the reservoirs during the irrigation season (spring and summer), flows are increased above natural levels between the reservoirs and to the points of diversion. Downstream of the diversions, flows are reduced from natural levels year round. On three tributaries to the Deschutes River with no irrigation storage (Whychus Creek, Tumalo Creek and McKay Creek), instream flows are affected by irrigation activities only during the spring, summer and early fall when water is being diverted.

In most cases, the hydrologic changes resulting from irrigation activities have negative impacts on aquatic habitats for the covered species. When flows are reduced, the total area of usable habitat for aquatic species generally decreases and water temperatures typically increase to the extent that habitat quality is negatively impacted. The conservation measures of the DBHCP will modify irrigation activities that reduce instream flow (storage and diversion of water) to reverse the negative effects. As a result, flows in the affected reaches will be higher than they were historically and water temperatures (particularly peak summer temperatures) will be lower.

In a number of locations on the covered lands, irrigation activities have historically improved habitats for one or more of the covered species; the DBHCP will seek to maintain these habitats. On Crescent Creek and the Little Deschutes River, the release of stored water from Crescent Lake Reservoir in the late summer has provided summer rearing and foraging habitats (wetlands) for Oregon spotted frogs that would not otherwise occur. At Crane Prairie Reservoir, the seasonal storage of water has created several hundred acres of year-round wetland habitat for the Oregon spotted frog that would not otherwise occur. On the Crooked River, the release of large amounts of cool water from Prineville Reservoir during the summer supports several miles of high-quality habitat for salmonid fishes that would not otherwise occur. All of these habitats will be maintained, and in some cases enhanced, under the DBHCP.

The DBHCP biological objectives, conservation measures, and resulting effects on surface water hydrology of the upper Deschutes Basin are described in detail in Chapter 6, *Habitat Conservation*. The effects of these hydrologic changes on the covered species are described in Chapter 8, *Effects of the Proposed Incidental Take on the Covered Species*.

The DBHCP will serve as one part of a larger regional effort to restore and enhance aquatic habitats for the covered species in the Deschutes Basin. Range-wide threats to the conservation and recovery of three covered species (bull trout, steelhead and Oregon spotted frog) were identified at the time of their listings (USFWS 1999, NOAA 2006 and USFWS 2014, respectively). Myriad threats were identified; one threat that is pertinent to all three species is altered hydrology due to the storage and diversion of water for irrigation. Other threats that affect one or more species include loss of habitat to human development, changes in hydrology and blockages to migration from hydropower development and flood control, predation by non-native fish and amphibians, loss of habitat due to invasive plant species, alteration of habitat due to livestock grazing, alteration of habitat due to logging, blockage to migration and degradation of habitat due to road construction, degradation of habitat and water quality due to mining, diseases, fragmentation of populations, climate change, and overutilization for commercial, recreational, scientific or educational purposes. Many of these factors affect Oregon spotted frogs, bull trout and steelhead within portions of the upper Deschutes Basin.

The DBHCP does not directly address factors that are unrelated to the covered activities, but it does address them indirectly. By dealing with the surface water that is the basis for all aquatic habitats, the DBHCP provides favorable hydrology in the Deschutes River and its tributaries. This will be a key step toward recovery of the listed species. In addition, the DBHCP establishes a number of habitat conservation funds that will be available for the 30-year term to support efforts by the Services and other entities in the basin to directly address threats that are unrelated to the covered activities. These funds are described in detail in Chapter 6.

The changes to surface hydrology under the DBHCP will be phased over time, for two reasons. First, the morphologies of many surface waters in the basin have been altered from their natural conditions by several decades of irrigation storage and release. Stream channels have become over-widened in many places, and existing habitats for the covered species are often dependent on the artificially high flows that occur when stored water is released from the reservoirs in the summer. Increases in winter flows to improve overwintering habitat conditions will result in corresponding decreases in summer flows. If winter increases are too great, summer flows will drop too low to support existing habitats. It is anticipated that efforts by other parties, with monetary support from the DBHCP conservation funds, will restore the channel of Upper Deschutes River over time and enable lower summer flows to provide habitats comparable to those that exist today. The increased winter flows, and corresponding decreased summer flows, under the DBHCP will be phased to accommodate channel restoration activities. In addition, human development within the historical floodplain of the Deschutes River creates the potential for flooding of homes and other private property if winter flows are allowed to approach natural levels. The phasing of winter releases will allow local land use planners to make provisions for the higher winter flows.

The second reason for phasing the implementation of the DBHCP is economic. The modifications to irrigation reservoir operations that will occur under the DBHCP will leave some of the districts with dramatically reduced access to water. The districts will make system improvements to reduce overall demand for irrigation water and some districts will make conserved water available to other districts with greater anticipated shortage under the DBHCP. The conservation and movement of water in this way will require several years and several hundred million dollars to complete. Phasing of the conservation measures under the DBHCP will allow time for the districts to accomplish the conservation projects and water movements, so that no district is faced with the risk of having insufficient water to support agriculture. The anticipated shortages and costs of replacement of irrigation water under the DBHCP are described in greater detail in Chapter 11, *Alternatives to the Proposed Incidental Take*.

2.5 References Cited

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DESCHUTES BASIN HABITAT CONSERVATION PLAN

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3 – SCOPE OF THE DBHCP

3.1 Permittees

The DBHCP supports the issuance of federal ESA section 10(a)(1)(B) incidental take permits by USFWS and NMFS to eight Deschutes Basin irrigation districts and the City of Prineville, Oregon (Permittees). The irrigation districts, all of which are members of the Deschutes Basin Board of Control, are Arnold Irrigation District (AID), Central Oregon Irrigation District (COID), Lone Pine Irrigation District (LPID), North Unit Irrigation District (NUID), Ochoco Irrigation District (OID), Swalley Irrigation District (SID), Three Sisters Irrigation District (TSID), and Tumalo Irrigation District (TID). All eight districts are quasi-municipal corporations formed and operated under Oregon law to distribute water to irrigators (patrons) within designated district boundaries. The districts lie along and utilize the waters of the Deschutes River, Crooked River, Ochoco Creek, Tumalo Creek, Whychus Creek, Crescent Creek and a number of smaller tributaries within the greater Deschutes Basin (Figure 3-1). They range in size from about 2,400 to 59,000 acres and serve from 20 to over 6,300 patrons each. All eight districts have been in existence since the early 20th Century.

The City of Prineville is a municipality of about 9,900 residents that was incorporated in 1880. It lies at the confluence of the Crooked River and Ochoco Creek, and has an economy based on agriculture and light industry. The total area within the city limits and urban growth boundary is about 9,500 acres.

3.2 Covered Lands and Waters

The incidental take permits apply to all aquatic, wetland, riparian and floodplain habitats affected by the covered activities (collectively referred to hereinafter as the "covered lands and waters"). Within the covered lands and waters, incidental take coverage extends only to the parties identified in Section 3.1, *Permittees*; only for the species identified in Section 3.4, *Covered Species*; and only for the activities and facilities described in Section 3.5, *Covered Activities and Facilities*. The covered lands and waters are shown in Figure 3-1 and summarized below.

- The waters and associated wetlands, riparian areas and floodplains of the Deschutes River from the maximum pool elevation of Crane Prairie Reservoir at elevation 4,445 feet, downstream to the confluence of the Deschutes River and the Columbia River, including Wickiup Reservoir to maximum pool elevation at 4,337.66 feet, North Canal Diversion Dam impoundment, and the impoundments of the Pelton Round Butte Project (Lake Billy Chinook, Lake Simtustus and the Reregulating Reservoir).
- The waters and associated wetlands, riparian areas and floodplains of Crescent Creek from the maximum pool elevation of Crescent Lake at elevation 4,847 feet, downstream to the confluence of Crescent Creek and the Little Deschutes River.
- The waters and associated wetlands, riparian areas and floodplains of the Little Deschutes River from the confluence of Crescent Creek and the Little Deschutes River downstream to the confluence of the Little Deschutes River and the Deschutes River.

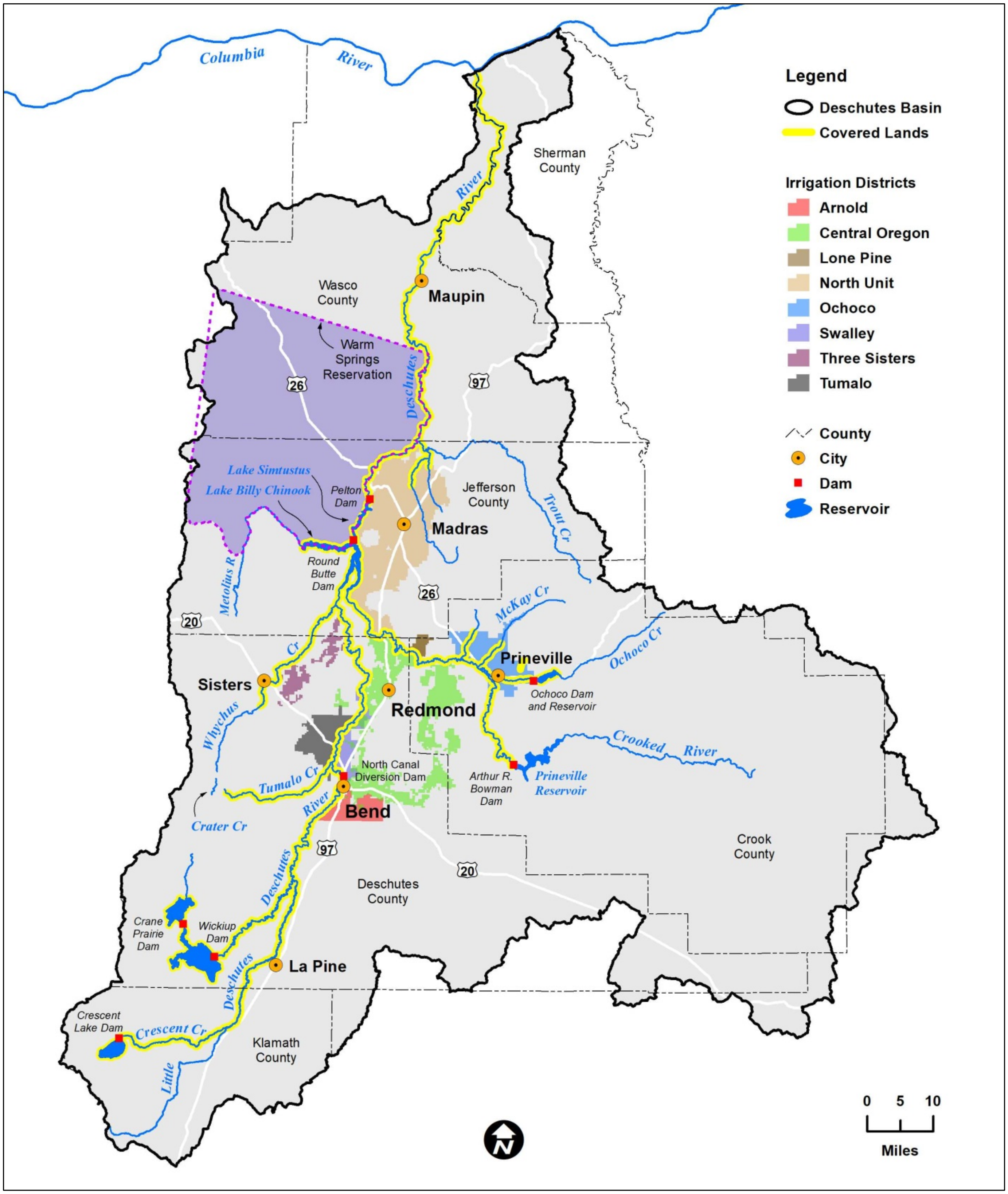

Figure 3-1. Map of the Deschutes Basin showing lands and waters covered by the Deschutes Basin Habitat Conservation Plan.

- The waters and associated wetlands, riparian areas and floodplains of the Crooked River from Bowman Dam (RM 70.5), downstream to the confluence of the Crooked River and the Deschutes River at Lake Billy Chinook.
- The waters and associated wetlands, riparian areas and floodplains of Ochoco Creek from the maximum pool elevation of Ochoco Reservoir at elevation 3,131 feet, downstream to the confluence of Ochoco Creek and the Crooked River.
- The waters and associated wetlands, riparian areas, and floodplains of McKay Creek from Jones Dam (RM 5.8), downstream to the confluence of McKay Creek and the Crooked River.
- The waters and associated wetlands, riparian areas and floodplains of Lytle Creek from the Grimes Flat West Canal crossing (RM 5.7), downstream to the confluence of Lytle Creek and the Crooked River.
- The waters and associated wetlands, riparian areas and floodplains of Johnson Creek from the Johnson Creek Canal crossing, downstream to the Ochoco Main Canal.
- The waters and associated wetlands, riparian areas and floodplains of Dry Creek from the Ochoco Main Canal crossing, downstream to McKay Creek.
- The waters and associated wetlands, riparian areas and floodplains of Crater Creek, Little Crater Creek, and Soda Creek from the TID points of diversion downstream to the confluence of Crater Creek and Tumalo Creek.
- The waters and associated wetlands, riparian areas and floodplains of Tumalo Creek from the confluence of Crater Creek and Tumalo Creek downstream to the confluence of Tumalo Creek and the Deschutes River.
- The waters and associated wetlands, riparian areas and floodplains of Whychus Creek from the Plainview Ditch diversion downstream to the confluence of Whychus Creek and the Deschutes River.
- The waters and associated wetlands, riparian areas and floodplains of Sagebrush Creek from the NUID 58-11 return downstream to the confluence of Sagebrush Creek and Mud Springs Creek.
- The waters and associated wetlands, riparian areas and floodplains of Mud Springs Creek from the NUID 61-11 return downstream to the confluence of Mud Springs Creek and Trout Creek.
- The waters and associated wetlands, riparian areas and floodplains of Trout Creek from the confluence of Mud Springs Creek and Trout Creek downstream to the confluence of Trout Creek and the Deschutes River.
- All lands outside the waters, riparian areas, wetlands and floodplains listed above upon which the covered activities described in Section 3.5, *Covered Activities and Facilities*, are conducted and/or upon which covered facilities are located.

3.3 Term of the DBHCP

The DBHCP and associated incidental take permits will have concurrent terms of 30 years, beginning on the date of authorization by the Services. The 30-year term was selected, after thorough consideration by the Permittees and technical assistance from the Services, to balance the risks associated with shorter and longer terms. A term of less than 30 years would reduce the regulatory certainty sought by the Permittees, and limit their abilities to finance and complete system improvements that will be necessary to compensate for the reduced availability of irrigation water under the DBHCP conservation strategy. The conservation measures and adaptive management provisions in this DBHCP constitute the sum total of the Permittees' requirements with regard to the covered species for the term of the incidental take permits. This level of certainty enables the Permittees and their patrons to make long-term plans and investments with the assurances they will be able to continue irrigating without the threat of federal prosecution for incidental take of the covered species. Conversely, a term of more than 30 years would reduce the long-term certainty associated with the conservation and recovery of the covered species. During the term of the DBHCP the Services will have limited opportunities to modify the conservation measures for the covered lands and waters. A term of 30 years is generally considered a safe amount of time to commit to a specific conservation strategy, particularly since natural systems can take a decade or more to respond to a change in management. Beyond 30 years, however, the potential need for adjustments to the conservation strategy increases.

3.4 Covered Species

The incidental take permits being issued to the Permittees apply to three species listed as threatened under the ESA and one species that currently has no formal ESA status (Table 3-1). These four species are collectively referred to hereinafter as the "covered species." The selection process for the covered species is described in Chapter 2.

Table 3.1. Species covered by the Deschutes Basin Habitat Conservation Plan.

Scientific Name	Common Name	Listing Status	
		Federal	State
Salvelinus confluentus	Bull trout	Threatened	Sensitive
Oncorhynchus mykiss	Steelhead, Middle Columbia River distinct population segment	Threatened[1]	Sensitive
Oncorhynchus nerka	Sockeye salmon/Kokanee[2]	None	None
Rana pretiosa	Oregon spotted frog	Threatened	Sensitive

Notes:
[1] The steelhead trout is listed as threatened only downstream of the Pelton Round Butte Project.
[2] Kokanee upstream of Big Falls in the Deschutes River are not covered by the DBHCP.

3.5 Covered Activities and Facilities

3.5.1 Overview

The incidental take permits cover the storage, release, diversion and return of surface water by the eight irrigation districts; the diversion of surface water directly by one TSID patron; the withdrawal of surface and groundwater by the City for domestic, commercial and industrial use; and the discharge of treated wastewater by the City. The conveyance of water by the irrigation districts from the points of diversion to the points of delivery and the use of irrigation water by patrons beyond the points of delivery are not covered activities because no covered species are present in the conveyance systems and the conveyance of water through the systems does not have the potential to result in the incidental take of covered species. Similarly, the use of water by the City and its water customers is not a covered activity because it does not result in the incidental take of covered species. The covered activities are summarized in the remainder of Section 3.5.1 and described in detail in Sections 3.5.2 through 3.5.10.

3.5.1.1 Operation and Maintenance of Storage Dams and Reservoirs

The irrigation dams and reservoirs covered by the DBHCP include two non-federal facilities owned and operated by Permittees and two federal facilities under the jurisdiction of the USDI Bureau of Reclamation (Reclamation) (Table 3-2). The DBHCP covers all irrigation activities at one of the non-federal facilities (Crescent Lake Dam), as well as operation and maintenance activities at the other non-federal facility (Ochoco Dam) and the two federal facilities (Crane Prairie and Wickiup dams). The federal facilities are operated by the Permittees as transferred works, which means daily responsibilities for operation and maintenance have been transferred to and are financed by the irrigation district while Reclamation retains responsibility for periodic inspection and safety compliance. Ochoco Dam is owned and operated by OID, but Reclamation retains authority for periodic inspection and safety compliance at Ochoco Dam under Section 12 of the Dam Safety Act. The DBHCP does not cover inspection and safety compliance at the transferred works or at Ochoco Dam; these federal activities will receive incidental take coverage through ESA section 7 consultation between Reclamation and the Services concurrent with the issuance of incidental take permits to the Permittees.

Incidental take coverage associated with the federal facilities provided under the DBHCP extends only to the Permittees and only to the extent that the Permittees have duties or authorities at the federal facilities. ESA section 10(a)(2)(B) incidental take coverage does not extend to Reclamation or other federal agencies involved in the operation or oversight of the federal facilities. Such federal operation and/or oversight is subject to the take avoidance requirements of ESA section 9 and the consultation requirements of ESA section 7.

The DBHCP does not cover Bowman Dam/Prineville Reservoir on the Crooked River because this is a reserved federal facility, which means Reclamation retains responsibility for operation and maintenance. OID operates Bowman Dam under contract with Reclamation, but Reclamation retains administrative and financial responsibility for the facility. The operation and maintenance of Bowman Dam will receive incidental take coverage through ESA section 7 consultation between Reclamation and the Services concurrent with the issuance of incidental take permits to the Permittees.

Table 3-2. Irrigation reservoirs in the Deschutes Basin that are covered by the Deschutes Basin Habitat Conservation Plan and associated incidental take permits.

Facility	Surface Water	Ownership	Responsibility for Operation and Maintenance	Description
Crane Prairie Dam and Reservoir	Deschutes River	Reclamation	COID (transferred)	In-channel facility to store water for COID, AID, LPID and NUID
Wickiup Dam, East Dike, South Dike and Reservoir	Deschutes River	Reclamation	NUID (transferred)	In-channel facility to store water for NUID
Crescent Lake Dam and Reservoir	Crescent Creek	TID	TID	In-channel facility to store water for TID
Ochoco Dam and Reservoir	Ochoco Creek	OID	OID	In-channel facility to store water for OID and provide flood control

The Pelton Round Butte Hydroelectric Project (Lake Billy Chinook, Lake Simtustus and Pelton Reregulating Reservoir) lies within the covered lands and waters downstream of the irrigation dams covered by the DBHCP, but operation of the hydroelectric project is not covered by the DBHCP because it is owned, operated and maintained by Portland General Electric and the Confederated Tribes of the Warm Springs Reservation under license from the Federal Energy Regulatory Commission. The DBHCP covers the effects of upstream irrigation activities on habitats for covered species within the hydroelectric project, but it does not cover the operation of the hydroelectric project itself.

The covered dams and reservoirs have three main operating seasons:

- Fall and Winter Operations (October/November to early March). Reservoirs are refilled during the fall and winter. Portions of the natural flow are bypassed at the dams during the storage season to maintain downstream flows, but there is generally no release of stored water.
- Spring Operations (March to June). Reservoir releases for irrigation can begin as early as March, although natural flow (live flow) is often sufficient to meet irrigation demand until mid-summer. When inflow exceeds irrigation demand in the spring the reservoirs generally continue to store the extra water.
- Summer Operations (approximately June to October). Summer operations begin when live flow is insufficient to meet irrigation demand. Storage water, if available, is released from reservoirs as necessary to meet anticipated demands.

3.5.1.2 Operation and Maintenance of Diversions, Pumps and Intakes

The incidental take permits cover the presence, operation and maintenance of facilities for the diversion of irrigation water by the Permittees (Table 3-3). With the exception of Ochoco Creek, all covered diversions of water by the Permittees occur at instream diversion structures (primarily small dams) or pumps. On Ochoco Creek, OID releases a portion of its water directly from Ochoco Reservoir into the Ochoco Main Canal at Ochoco Dam.

All diversion structures covered by the DBHCP are operated by the Permittees. Diversion structures typically create small impoundments to raise water levels and facilitate gravity flow out of stream channels. Such impoundments are not managed for active water storage.

Diversion structures direct water to intakes with gates that allow operators to control the volume and timing of flow into conveyance systems. Pumps require no separate intake structure. All intake structures that could be encountered by covered fish species (i.e., all intakes within current or potential anadromous waters) are fitted with fish screens to prevent fish from being entrained into the conveyance systems. Screens receive regular maintenance, including cleaning of debris from the screen surface to ensure effective operation. Similarly, all diversions within current or potential anadromous waters have provisions for volitional upstream and downstream fish passage.

Water that is diverted or pumped at these covered facilities is conveyed by the irrigation districts through several miles of canals, flumes, pipelines and ditches (collectively the water conveyance systems) until it is delivered to patrons at specified points of delivery. Beyond the points of delivery, the responsibility for water conveyance and use lies with the patrons who must comply with State water law as well as policies and procedures of their respective districts. The conveyance of water by the districts and their patrons is not a covered activity. No covered species inhabit the water conveyance systems.

Table 3-3. Water diversions covered by the Deschutes Basin Habitat Conservation Plan.

Facility	Surface Water	Ownership	Operation and Maintenance	Description
Arnold Diversion and Headworks	Deschutes River	AID	AID	Diverts live flow and stored water released from Crane Prairie Reservoir
Central Oregon Canal Headworks	Deschutes River	COID	COID	Diverts live flow and stored water released from Crane Prairie Reservoir
North Canal Diversion Dam	Deschutes River	Private	COID, NUID and SID	Impounds water for diversion (listed below) by COID (for delivery to COID patrons and to LPID), NUID and SID
Pilot Butte Canal Headworks	Deschutes River	COID	COID	Located at North Canal Diversion Dam; diverts live flow and stored water released from Crane Prairie Reservoir
North Unit Headworks	Deschutes River	Reclamation	NUID (transferred)[1]	Located at North Canal Diversion Dam; diverts live flow and stored water released from Wickiup Reservoir
Crooked River Pumping Plant	Crooked River	NUID	NUID	Pumps Crooked River water into North Unit Main Canal
Crooked River Diversion and Headworks	Crooked River	Reclamation	OID (transferred)[1]	Diverts live flow and water stored and released from Prineville Reservoir
Red Granary, Breese, North and South Infiltration Galleries and Ryegrass Diversions	Ochoco Creek	OID	OID	Divert live flow and stored water released from Ochoco Reservoir downstream of Ochoco Dam and, in the case of Ryegrass Diversion, Crooked River live flow and storage spilled at the Crooked River Diversion Canal crossing of Ochoco Creek
Johnson Creek Diversions	Johnson Creek	OID	OID	Gravity diversions at the Johnson Creek Canal and Ochoco Main Canal crossings, and six diversions of flow from Johnson Creek along with live flow and stored water from Ochoco Creek that are conveyed in Johnson Creek
Dry Creek Diversions	Dry Creek	OID	OID	Two gravity diversions and two pumps that divert Dry Creek flow plus live and stored flows from Ochoco Creek and the Crooked River that are spilled into Dry Creek at the Ochoco Main Canal crossing

Facility	Surface Water	Ownership	Operation and Maintenance	Description
Jones Dam/Siphon, Cook Inverted Weir and Smith Inverted Weir	McKay Creek	OID	OID	Divert live flow from McKay Creek plus live and stored flows from Ochoco Creek and the Crooked River that are conveyed in McKay Creek
Pine Products Siphon	McKay Creek	OID	OID	Conveys live and stored flows from Ochoco Creek and the Crooked River beneath McKay Creek on the Ryegrass Canal; could be utilized to divert flow into the canal in the future
Reynolds Siphon	McKay Creek	Reclamation	OID	Conveys live and stored flows from Ochoco Creek and the Crooked River beneath McKay Creek on the Crooked River Distribution Canal; could be used to divert flow into the canal in the future
Lytle Creek Diversions	Lytle Creek	OID	OID	Eight gravity diversions and three pumps that divert Lytle Creek flow plus live and stored flows from Ochoco Creek and the Crooked River that are conveyed in Lytle Creek
Swalley Headworks	Deschutes River	SID	SID	Located at North Canal Diversion Dam; diverts live flow
Whychus Creek Diversion and Headworks	Whychus Creek	TSID	TSID	Diverts live flow
Other Whychus Creek Diversion	Whychus Creek	TSID patron	TSID patron	One small diversion of live flow for direct delivery to TSID patron
Bend Diversion and Headworks	Deschutes River/ Crescent Creek	TID	TID	Diverts Deschutes River live flow and stored Crescent Creek water released from Crescent Lake
Tumalo Creek Diversion and Headworks	Tumalo Creek	TID	TID	Diverts live flow
Crater Creek, Little Crater Creek and Soda Creek Diversions	Crater Creek, Little Crater Creek and Soda Creek	TID	TID	Divert live flows from Crater Creek, Little Crater Creek and Soda Creek into Tumalo Creek

[1] Transferred works are facilities for which daily responsibilities for operation and maintenance activities have been transferred to and are financed by the irrigation district.

3.5.1.3 Diversion of Water

Diversion of water by the Permittees is a covered activity. Irrigation water can originate from in-channel reservoir storage, out-of-channel storage and live flow. Most of the covered irrigation districts utilize a combination of in-channel reservoir storage and live flow. TSID relies entirely on out-of-channel storage and live flow, and SID relies entirely on live flow.

The amount of water diverted by an irrigation district at any time is determined by the amount available (storage and live flow combined), the surface water rights pursuant to which the district delivers water, the operational constraints of the conveyance system, and, in some cases, by local demand. Some irrigators must request water from their respective irrigation district as they need it, while others receive water without having to make specific requests.

The irrigation season typically begins in April and runs through October. Maximum diversion rates occur between May 15 and September 15 (summer irrigation diversions), with minimum diversion rates in April and October. During the maintenance season (November to March), some districts divert live flows (when available) into canals about every 5 to 6 weeks to provide water for livestock. This schedule is highly dependent on weather conditions and water availability, both of which can vary considerably.

3.5.1.4 Return Flow

Diverted irrigation water that is allowed to flow back into a natural river or creek is known as return flow. Two types of return flow may occur on the covered lands and waters: tailwater and spills. Tailwater is water that has been applied to irrigated lands and subsequently returned to a river or creek through surface flow. Tailwater may enter a river or creek directly from irrigated land or through a drain or canal operated by an irrigation district. Tailwater is relatively uncommon on the covered lands. The DBHCP and associated incidental take permits only cover tailwater returns that occur through drains or canals operated by the eight districts. Tailwater that comes directly from irrigated lands or through drains and canals outside the jurisdiction of the districts is not a covered activity.

Spills represent diverted irrigation water that returns as surface water to a river or creek without ever being applied to irrigated lands. Spills are used to manage flows within district canals, flush canals, or drain canals during emergencies or at the end of the irrigation season. The amount of spill varies by irrigation district and is largely a function of system design. Some districts are able to operate without spilling, while others require spills to maintain reliable water delivery.

This DBHCP provides detailed descriptions of the covered return flows (see Section 3.5.3.6, *COID – Return Flow*; Section 3.5.4.4, *LPID – Return Flow*; Section 3.5.5.6, *NUID – Return Flow*; and Section 3.5.6.8, *OID – Return Flow*). This DBHCP also identifies the ongoing effects of the returns on streamflow and water temperature on the covered lands (see Sections 4.8.3, *Crooked River Subbasin – Water Temperature* and Section 4.7.3, *Trout Creek – Water Temperature*). The effects of the return flows on habitat for the covered fish species are incorporated into the analyses of effects in Chapter 8 of this DBHCP. Meanwhile, multiple sources contribute to water quality impairments in the Deschutes Basin, including agricultural practices and other nonpoint and point sources. Thus, this DBHCP and associated incidental take permits only cover return flows to the extent they contribute to temperature and streamflow-related impacts on the covered species. The extent to which return flows may contribute to other water quality impairments will be addressed as part of Oregon Department of Environmental Quality's (ODEQ) efforts to develop basin-wide water quality regulations for all impaired streams in the Deschutes Basin.

3.5.1.5 Habitat Conservation, Monitoring and Adaptive Management

All conservation measures described in Chapter 6, *Habitat Conservation* are covered activities under this DBHCP. Similarly, all requirements for monitoring, reporting and adaptive management specified in Chapter 7, *Monitoring, Reporting and Adaptive Management* are covered activities.

3.5.1.6 Irrigation District Legal Authorities and Responsibilities

The DBBC districts are quasi-municipal corporations formed and operated under Oregon State law (ORS Chapter 545) to deliver water to patrons (individual landowners) within designated geographic district boundaries. The districts hold state rights to store, divert and convey water. In most cases the application of the water to a beneficial purpose (usually irrigation) is performed by the individual landowners. In limited situations districts may be responsible for applying the water to a beneficial purpose; this is typically a temporary condition that results when a landowner within the district wishes to stop irrigating his or her own land and the district temporarily leases the water right to instream use until the right can be permanently transferred to other lands.

The districts' water rights usually specify the source of the water (e.g., Deschutes River), the lands to which the water can be applied (geographic location and total acres), the season (dates) during which the water can be diverted and applied, the total amount of water that can be applied to land each year (duty; measured in acre-feet) and the maximum rate at which water can be diverted and/or delivered [measured in gallons per minute (gpm) or cubic feet per second (cfs)]. State water law also requires that landowners maintain adequate infrastructure to utilize the water, and that they utilize the water for a beneficial use without waste. Landowners must use the full water right appurtenant to their land at least 1 out of every 5 years, or make some use of the water right on all of their authorized lands and be ready, willing and able to make full use at least one out of every 5 years. Failure to meet the requirements of State water law can lead to the forfeiture of water rights.

The districts are required by State water law and/or individual district bylaws to:

- Maintain infrastructure (works) for diversion and delivery (and for some districts storage) of irrigation water, and deliver to each patron the full amount of water allowed under the right to the extent water is available.
- Take the necessary steps to ensure individual patrons use no more water than they are allowed by the water rights.
- Develop Water Management and Conservation Plans that evaluate water supply alternatives and identify the role that water conservation can have in meeting irrigation demand; and update plans at intervals of 5 to 10 years.

In addition, most districts monitor individual patrons to ensure they are utilizing the water for a beneficial use. The districts cannot legally:

- Deny or limit delivery of available water to an individual patron who is in compliance with State water law and the specific water right.
- Compel an individual patron to modify his or her irrigation infrastructure for increased efficiency if the infrastructure is in compliance with State water law and the specific water right.
- Voluntarily transfer rights to store or divert water to another entity without the consent of individual patrons if the transfer would reduce the ability of the district to deliver to those patrons the full amount of water allowed under the specific water rights.
- Voluntarily reduce the storage and/or diversion of water if that reduction would reduce the ability of the district to meet patron demand up to the full amounts of water allowed under the specific water rights.

Conservation options that are legally available to the districts are:

- Reducing water deliveries to all patrons uniformly (to the extent possible given the limitations of existing infrastructure) when supply (live flow plus storage) is less than demand.
- Lining and piping of diversion canals and laterals to reduce seepage losses (and thereby reducing diversion rates) without reducing deliveries to patrons.
- Creating incentives for landowners to voluntarily reduce demand for water. These incentives can include
    - educating patrons on wise and efficient water use;
    - facilitating temporary instream water right transfers under State water law that allow individual landowners to forgo irrigation up to 5 years, with the option of renewal, without risk of forfeiture of the right; and
    - providing funding and/or technical expertise for landowner system improvements such as piping of ditches and conversion to high-efficiency delivery systems.

3.5.2 Arnold Irrigation District Activities

3.5.2.1 Overview

Arnold Irrigation District provides water to about 650 patrons on about 4,384 acres east of the Deschutes River and south of US Highway 20 in Deschutes County (Figure 3-2). The majority of the water is used for irrigation, with less than 10 percent allocated for municipal use, pond maintenance, industrial use, domestic use, and livestock watering. Covered facilities owned and operated by AID are the Arnold Diversion, headworks, and fish screens.

3.5.2.2 Water Rights

AID holds 1905 water rights for a maximum diversion of 150 cfs of live flow from the Deschutes River and a 1913 supplemental right for 13,500 acre-feet of storage in Crane Prairie Reservoir. By a supplemental decree dated 1933, diversions under the live flow water rights are limited during portions of the irrigation season (Table 3-4). The 13,500 acre-feet of Crane Prairie storage consists of 10,500 acre-feet of reliable water and 3,000 acre-feet of surplus storage that only becomes available after Wickiup Reservoir is filled. Storage allocations in Crane Prairie Reservoir were historically made in accordance with the January 4, 1938 inter-district agreement between AID, COID, LPID and NUID, which is described in detail in Section 3.5.3.3, *Crane Prairie Dam and Reservoir*.

Table 3-4. Arnold Irrigation District live flow diversion rights.

Period	Maximum Diversion Rate
April 1 – April 30	86.5 cfs
May 1 – May 15	113 cfs
May 16 – September 15	150 cfs
September 16 – September 30	113 cfs
October 1 – October 31	86.5 cfs

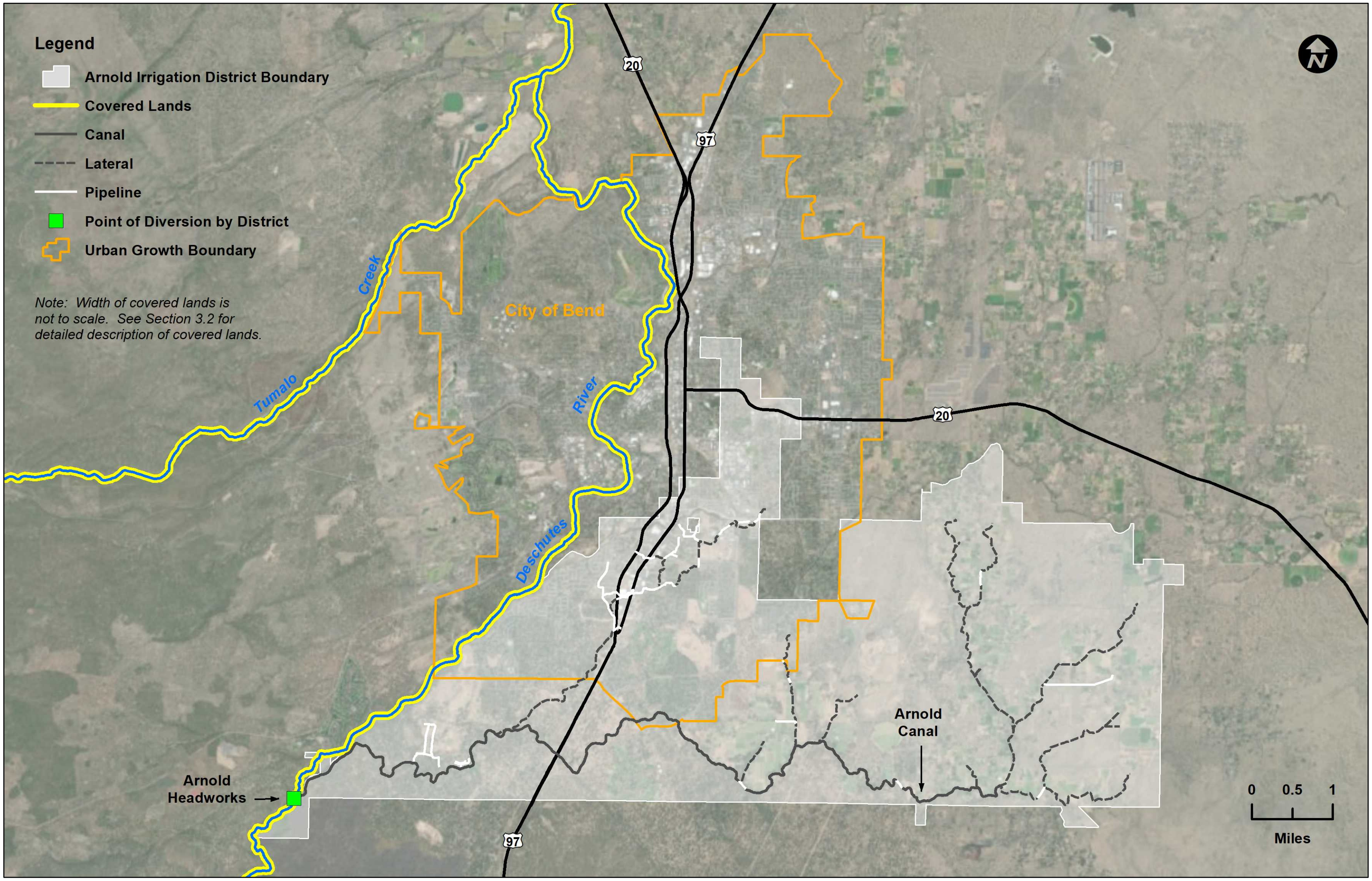

Figure 3-2. Map of Arnold Irrigation District.

3.5.2.3 Arnold Diversion and Headworks

The Arnold Diversion is located at RM 175 on the Deschutes River, about 5 miles south of Bend (Figure 3-2). It consists of a 15-inch-high concrete structure that spans the river 178 feet from an island to the right (east) bank and directs flow into the headworks. Under extremely low flow conditions, AID can also erect temporary splash boards between the island and the left (west) bank of the river to direct additional flow east of the island and into the headworks. Holes drilled in the bedrock streambed allow for occasional use of the 2-foot-high splashboards without the need for any permanent instream structures west of the island. When in use, the splashboards do not span the entire river or block upstream or downstream fish movement.

The intake structure has a capacity of 150 cfs. It is equipped with a trash rack and fish screens that return fish to the river about 234 feet downstream of the diversion.

From 2010 through 2017 AID diverted an average of 32,266 acre-feet per year at the diversion. The majority of AID's diversion is live flow, with Crane Prairie storage being utilized only about 2 years out of 10.

3.5.2.4 Return Flow

Water is supplied to AID patrons on a continuous basis during the irrigation season and regulated at the points of delivery (turnouts). Patrons are not allowed to flood back (refuse water delivery without prior notice). As a result, AID is able to operate the system with no direct returns (spills) to the Deschutes River.

3.5.3 Central Oregon Irrigation District

3.5.3.1 Overview

Central Oregon Irrigation District provides water to about 3,590 agricultural and industrial patrons on about 45,000 acres in the Terrebonne, Redmond, Bend, Alfalfa and Powell Butte areas (Figure 3-3). COID also provides water to the City of Redmond and several associated subdivisions, as well as many parks and schools in the City of Bend. In addition to maintaining and operating two primary diversion structures and over 450 miles of canals, COID is responsible for daily operation and maintenance of Crane Prairie Dam, which is a federally owned (Reclamation) transferred work. COID also diverts irrigation water at its Pilot Butte Canal Headworks for delivery to LPID at the Lone Pine Weir. Covered COID facilities are Crane Prairie Dam and Reservoir, Central Oregon Canal Headworks, North Canal Diversion Dam and Pilot Butte Canal Headworks. Central Oregon Canal Headworks and Pilot Butte Canal Headworks are owned by COID. North Canal Diversion Dam is privately owned. Crane Prairie Dam is federally owned.

3.5.3.2 Water Rights

COID holds 1900 and 1907 water rights for live flow from the Deschutes River originally issued for maximum diversions of about 978 cfs and 392 cfs, respectively. These water rights have been reduced due to permanent instream water right transfers and numerous Allocation of Conserved Water projects (see ORS 537.540 to 537.500, and OAR 690-018), and now have maximum diversions of 918.433 cfs and 367.853 cfs, respectively. In addition, COID holds 1913 water rights to store 50,000 acre-feet at Crane Prairie Reservoir for supplemental irrigation on behalf of itself, AID and LPID. Annual allocations of the storage have historically been made in accordance with the January 4, 1938 inter-district agreement between COID, AID, LPID and NUID (see Section 3.5.3.3, *Crane Prairie Dam and Reservoir*). As part of the 1938 agreement, the total amount of storage water available in Crane Prairie Reservoir each year has been determined by the extent to which Wickiup Reservoir fills.

3.5.3.3 Crane Prairie Dam and Reservoir

Crane Prairie Dam was constructed by Reclamation in 1939-40 at RM 238.5 on the mainstem Deschutes River, about 37 miles southwest of Bend (see Figure 3-1). It is a 36-foot-high earthen structure with a crest elevation of 4,455 feet and length of 285 feet. The dam has a controlled outlet capacity of 1,800 cfs and an uncontrolled spillway with a capacity of 2,500 cfs. The controlled outlet is screened to exclude fish. The reservoir has a storage capacity of 55,300 acre-feet and a surface area of about 4,900 acres at full pool.

The federal government retains title to Crane Prairie Dam and Reservoir, but operation and maintenance have been transferred to COID as provided for in the 1939 repayment contract between Reclamation and COID, which was fulfilled in 1959 when COID completed repayment to Reclamation for 100 percent of original construction costs. By Congressional authorization, Crane Prairie Dam and Reservoir are operated solely for storage of irrigation water. The dam may be operated informally for flood storage in anticipation of abnormally high inflow according to operating rules developed by Reclamation, but only to the extent that flood control does not compromise the storage of irrigation water. Such operation for flood control is a rare event.

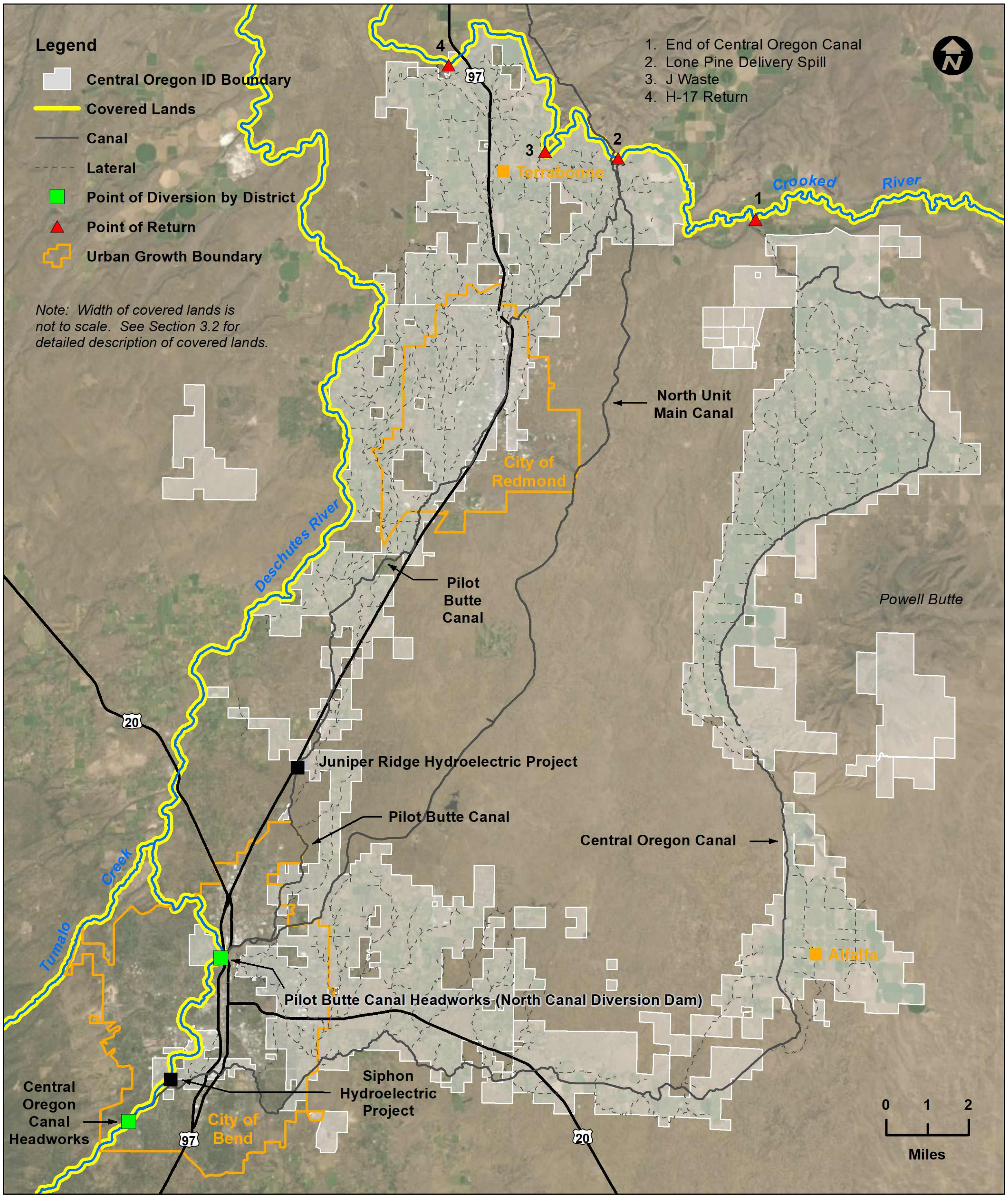

Figure 3-3. **Map of Central Oregon Irrigation District.**

Crane Prairie Dam has historically been operated in coordination with Wickiup Dam and Reservoir (2 miles downstream) according to the 1938 inter-district agreement (Figure 3-4). Storage and release of water are coordinated by the Oregon Watermaster according to the inter-district agreement and other pertinent water rights, and implemented by COID personnel operating the dam. During the refill period, which typically begins in October, Crane Prairie Reservoir has been filled to about 30,000 acre-feet to provide reliable storage for AID, COID and LPID before storage began at Wickiup Reservoir. Inflow water has then been bypassed at Crane Prairie until Wickiup Reservoir reached 180,000 acre-feet. If additional inflows were available prior to the irrigation season, another 15,000 acre-feet have been stored in Crane Prairie Reservoir. After that, flows have again been bypassed to fill Wickiup Reservoir (to a maximum capacity of 200,000 acre-feet) before filling Crane Prairie to a maximum capacity of 55,300 acre-feet. Full pool in Crane Prairie Reservoir has been achieved about one year in three. There has been no requirement to maintain a minimum pool, but the reservoir has rarely held less than 10,000 acre-feet at the end of the irrigation season. The record low pool of 9,470 acre-feet was reported in 1980. The average carryover volume at the end of the irrigation season from 1961 to 2001 was 24,000 acre-feet.

While Crane Prairie Reservoir has a storage capacity of 55,300 acre-feet, the three districts' water rights and 1938 inter-district agreement only account for the first 50,000 acre-feet. Water stored in excess of 50,000 acre-feet has been released during the subsequent irrigation season for instream flow and managed by the Oregon Watermaster.

Reservoir refill has been managed to maximize storage while maintaining relatively uniform flow in the Deschutes River between Crane Prairie Dam and Wickiup Reservoir. This has been accomplished by monitoring snow pack and streamflow to predict water availability, and storing only at the rate needed to achieve refill. There has been no requirement to release for instream flow below Crane Prairie Dam, but the irrigation districts and Oregon Watermaster have an informal, nonbinding agreement to maintain a minimum of 30 cfs below Crane Prairie Dam for fish and wildlife purposes.

Irrigation releases from Crane Prairie Reservoir have typically begun in April, but the reservoir has not been drafted appreciably until late May or early June when irrigation demand began to exceed the districts' live flow water rights, particularly those held by LPID. In most years, irrigation releases have peaked between 200 and 500 cfs in June and July. Releases have been higher in years of abundant water and lower in years of limited storage to ensure availability through the end of the irrigation season. Irrigation releases have typically ended by early October.

Inspection and maintenance of Crane Prairie Dam occur on a regular schedule. Inspection and maintenance conducted by COID are covered activities. These include annual tests of the regulating gates and 6-year tests of the emergency gates. Since construction of a splitter wall in 2008, these inspections are accomplished without interrupting flows through the dam.

Reclamation also conducts annual inspections, periodic facility reviews, and comprehensive facility reviews in accordance with the Facility Review and Dam Safety Program. These activities are not covered by the DBHCP.

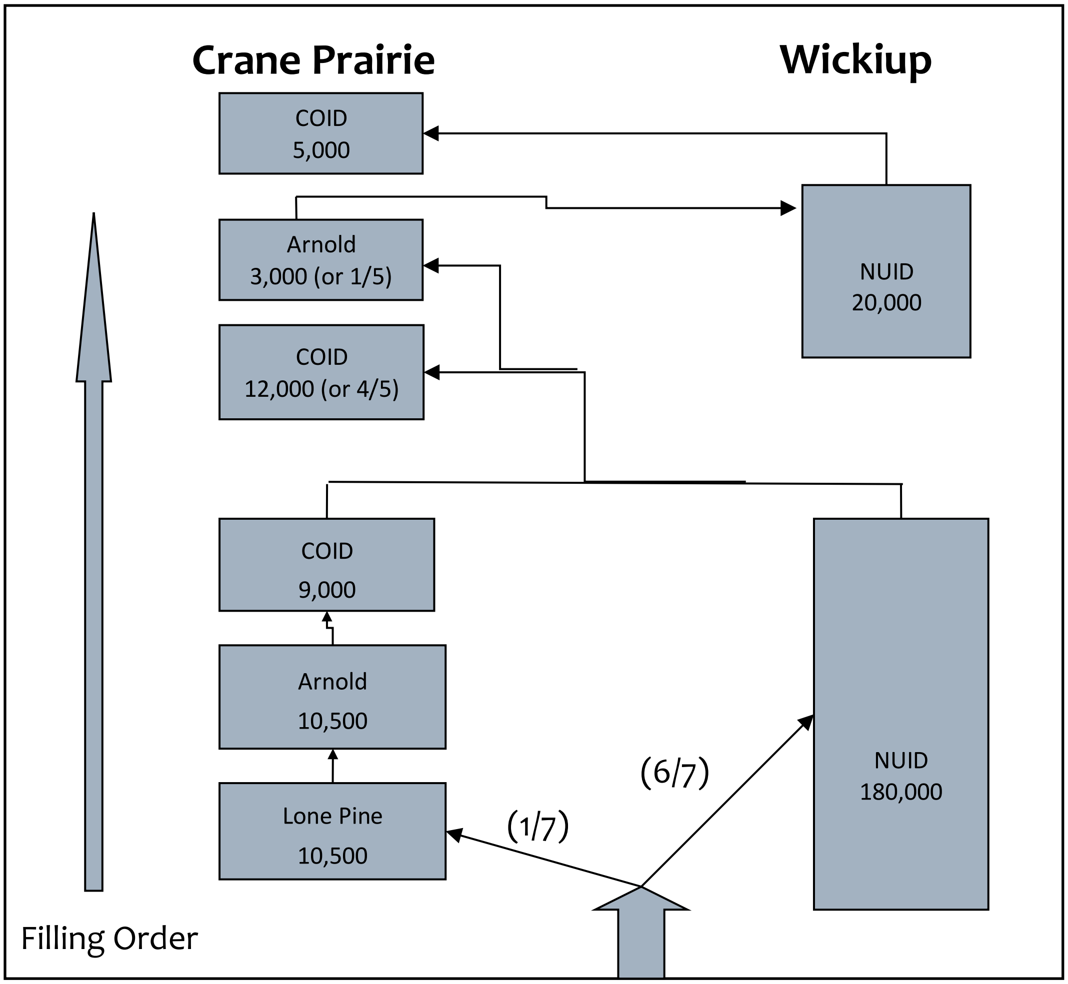

Figure 3-4. Reservoir filling order at Crane Prairie and Wickiup reservoirs specified in the 1938 inter-district agreement.

3.5.3.4 Central Oregon Canal Headworks

The COID irrigation system consists of two main canals: the Central Oregon Canal that runs east through Bend, Alfalfa and Powell Butte; and the Pilot Butte Canal that runs north through Bend, Redmond and Terrebonne. Water from the Deschutes River enters the Central Oregon Canal at the Central Oregon Diversion Headworks (RM 170.5), where natural stream morphology has been modified to capture and direct flows without a dam or other obstruction of the river. The headworks consist of an intake structure with trash rack and control gate. The intake is screened to exclude fish.

The Central Oregon Canal carries both live flow and stored water. Early and late in the irrigation season (April to mid-May, and October) diverted water is primarily from live flow, with some use of stored water released from Crane Prairie Reservoir. From mid-May through September, however, COID's live flow water right is higher and is usually sufficient to meet all needs of the patrons served by the Central Oregon Canal. Up to 200 cfs of livestock water are also diverted into the system for 5 days every 5 to 6 weeks during the winter maintenance season. From 2010 through 2017 COID diverted an average of 160,218 acre-feet per year at the Central Oregon Canal Headworks.

3.5.3.5 North Canal Diversion Dam and Pilot Butte Canal Headworks

The Pilot Butte Canal is one of three irrigation canals that originate at the North Canal Diversion Dam at RM 164.8 on the Deschutes River in Bend (the others are operated by NUID and SID). The dam is privately owned, but maintained by the three irrigation districts. It is a 40-foot-high concrete-arch structure originally built in 1912. It is the lowest point on the middle Deschutes River where irrigation water is diverted by gravity flow alone (i.e., without pumping).

North Canal Diversion Dam was a blockage to upstream fish movement until COID, NUID, SID and Oregon Department of Fish and Wildlife jointly funded the design and construction of a fish ladder in 2017. Resident fish now have the ability to move upstream and downstream at the dam. To prevent fish entrainment, all intakes, including the Pilot Butte Canal Headworks, are screened.

In addition to providing water for COID patrons, the Pilot Butte Canal conveys all of LPID's water (see Section 3.5.4) and a small portion of NUID's water. Diversions at the Pilot Butte Canal Headworks are combinations of live flow and stored water, similar to diversions at the Central Oregon Canal Headworks. Early and late in the irrigation season (April to mid-May, and October) diverted water is primarily from live flow along with small amounts of Crane Prairie storage used by COID and LPID. From mid-May through September, COID's live flow water right is higher and is sufficient to meet all irrigation needs, but LPID's need for storage continues throughout the summer. From 2010 through 2017 COID diverted an average of 159,602 acre-feet per year at the Pilot Butte Canal Headworks. In addition to meeting COID needs, these diversions supported average annual deliveries of 12,016 acre-feet to LPID and 4,918 acre-feet to NUID.

3.5.3.6 Return Flow

Water diverted by COID from the Deschutes River is operationally spilled into the Crooked River at four locations (Figure 3-3): one from the Central Oregon Canal and three associated with the Pilot Butte Canal. Water that reaches the end of the Central Oregon Canal is spilled near the top of Dry Canyon, where it continues as surface and shallow subsurface return flow to the Crooked River at about RM 34.1, about 13 miles downstream of Prineville. Water is spilled directly from the Pilot Butte Canal throughout the irrigation season to manage the rate of delivery to the LPID Canal. This water travels a short distance before reaching the Crooked River at about RM 27.7. Water is also spilled less than once per year from two Pilot Butte Canal Laterals (J-22 and H-17) to facilitate lowering of the canal for operational or emergency purposes. These flows reach the Crooked River at RM 25.0 and RM 18.0, respectively.

3.5.4 Lone Pine Irrigation District

3.5.4.1 Overview

Lone Pine Irrigation District (previously known as Crook County Improvement District No. 1) serves 19 patrons who irrigate 2,369 acres for commercial agriculture north of the Crooked River and east of Terrebonne in Crook and Jefferson counties (Figure 3-5). LPID utilizes a combination of live flow from the Deschutes River and storage in Crane Prairie Reservoir. All of LPID's water is diverted from the Deschutes River at the North Canal Diversion Dam in Bend and conveyed via the Pilot Butte Canal (owned and operated by COID) to the Lone Pine Weir just south of the Crooked River. From there, the water crosses the Crooked River in a pipeline and is distributed to patrons through LPID-owned ditches. LPID maintains a single return flow to the Crooked River at the downstream end of LPID.

3.5.4.2 Water Rights

LPID holds a live flow water right for up to 29.1 cfs (measured at the Lone Pine Weir) with a priority date of 1900 (Table 3-5). To account for seepage losses during conveyance in the Pilot Butte Canal, LPID's live flow right at North Canal Diversion Dam is up to 38.8 cfs. This diversion right is adjusted seasonally to account for variations in Deschutes River live flow.

LPID also holds a storage right for up to 10,500 acre-feet in Crane Prairie Reservoir with a priority date of 1913. The storage of water in Crane Prairie Reservoir has historically occurred in compliance with the January 4, 1938 inter-district agreement between AID, COID, LPID and NUID (see Section 3.5.3.3, *Crane Prairie Dam and Reservoir*). As noted in the 1938 agreement, LPID holds the senior right for use of storage in Crane Prairie Reservoir.

Table 3-5. Lone Pine Irrigation District live flow diversion right.

Period	Maximum Live Flow Diversion	
	At Lone Pine Weir	At North Canal Diversion Dam
April 1 – April 30	18.5 cfs	24.8 cfs
May 1 – May 15	23.0 cfs	30.7 cfs
May 16 – September 15	29.1 cfs	38.8 cfs
September 16 – September 30	23.0 cfs	30.7 cfs
October 1 – October 31	18.5 cfs	24.8 cfs

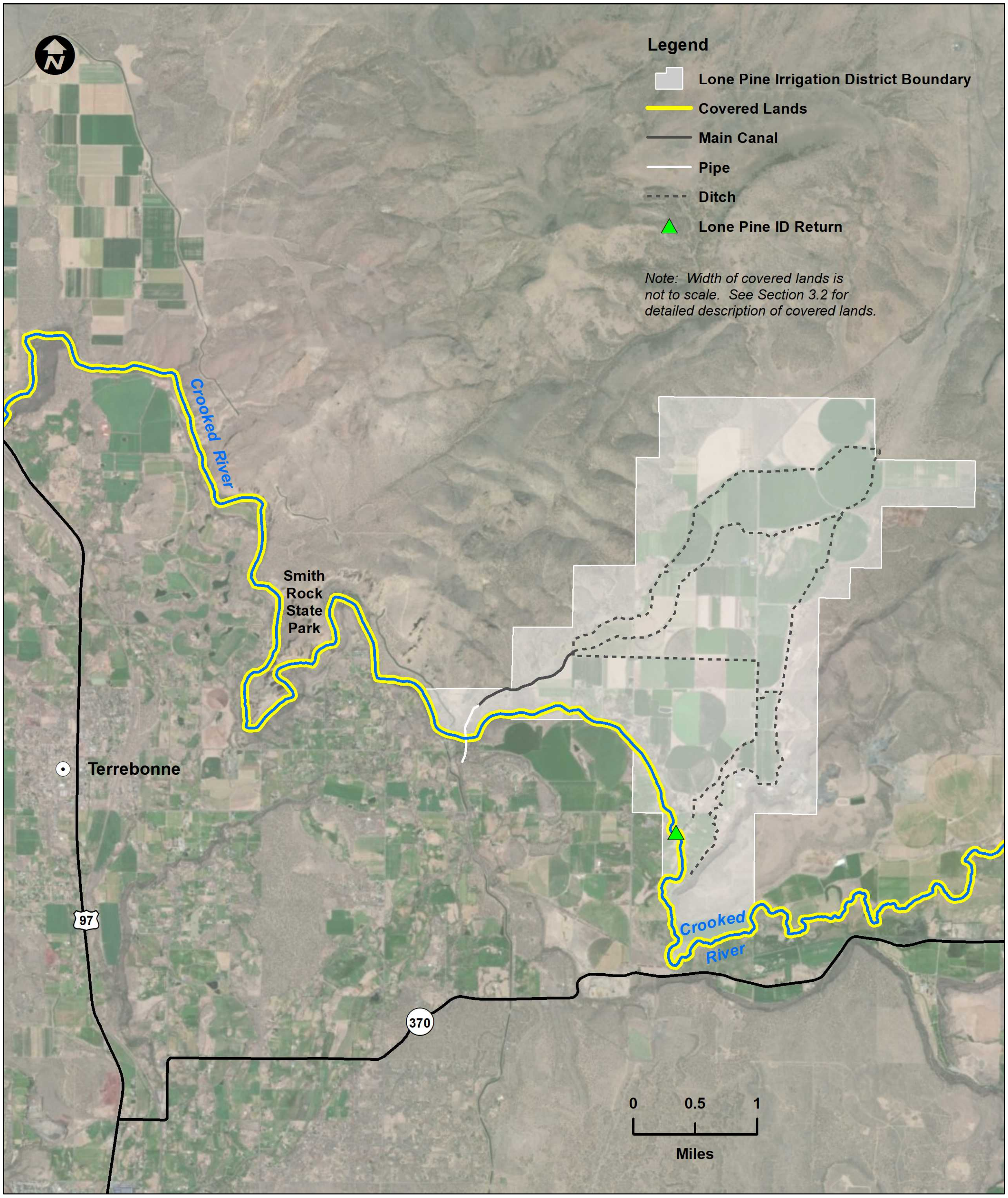

Figure 3-5. Map of Lone Pine Irrigation District.

3.5.4.3 Diversion

LPID does not operate its own diversion structure. All irrigation water delivered to LPID patrons is diverted from the Deschutes River by COID at the North Canal Diversion Dam, conveyed through the Pilot Butte Canal, and delivered to the Lone Pine Main Canal at the Lone Pine Weir on the south side of the Crooked River. From 2010 through 2017, average annual deliveries to LPID were 12,016 acre-feet.

3.5.4.4 Return Flow

Excess water in the LPID system is returned to the Crooked River downstream of LPID's Lower Ditch. In 2005, the Deschutes River Conservancy estimated the average flow at the end of the Lower Ditch to be 3.81 cfs (DRC 2005). Between the end of the Lower Ditch and the Crooked River, the excess water passes through a series of man-made wetlands. Evaporative losses and irrigation diversions from those wetlands likely reduce the average rate of Crooked River return flow to 1 cfs or less.

3.5.5 North Unit Irrigation District

3.5.5.1 Overview

North Unit Irrigation District provides water to 980 patrons on about 59,000 acres in the area east of the Crooked and Deschutes rivers that surrounds Culver, Metolius and Madras in Jefferson County (Figure 3-6). This is the largest service area of the DBBC member irrigation districts. NUID stores water in Wickiup Reservoir and diverts water from the Deschutes River at North Canal Diversion Dam and from the Crooked River at the Crooked River Pumping Plant. NUID facilities covered by the DBHCP are Wickiup Dam and associated dikes (East Dike and South Dike), Wickiup Reservoir, North Canal Diversion Dam, North Unit Headworks and the Crooked River Pumping Plant. All of these except the Crooked River Pumping Plant are federal facilities for which operation and maintenance was transferred to NUID in 1955.

3.5.5.2 Water Rights

NUID holds a 1913 water right for a maximum diversion of 1,100 cfs of live flow from the Deschutes River, a 1913 water right to store 200,000 acre-feet of water in Wickiup Reservoir, and a 1955 water right to store 5,650 acre-feet in Haystack Reservoir (a small reregulating reservoir associated with the North Unit Main Canal). NUID also holds primary and supplemental water rights dated 1968 and 1955, respectively, that originally provided for a total of 200 cfs of live flow from the Crooked River.

Of the five DBBC member irrigation districts that divert water from the Deschutes River, NUID's water rights are the most junior. The amount of live flow available to NUID from the Deschutes River depends on the time of season and the amount of water the other districts are diverting. During the height of the irrigation season (typically June through August) when the other Deschutes River districts are fully exercising their live flow rights, NUID only receives live flow when the live flow in the river exceeds 1,250 cfs. In April, May, September and October, when the live flow rights of the other districts are reduced, relative availability for NUID increases. Whenever NUID's need for Deschutes River water exceeds availability, NUID relies on Wickiup Reservoir storage. In recent years Wickiup Reservoir storage has been used to meet between 40 and 80 percent of NUID's total annual demand.

NUID also diverts water from the Crooked River. In addition to its live flow rights for the Crooked River, NUID can purchase up to 10,000 acre-feet of Prineville Reservoir storage from Reclamation each year, when available. Crooked River water is used to: a) irrigate lands within NUID upon which only Crooked River water can be used, b) supplement other lands within NUID when Deschutes River water is in limited availability, and c) respond to short-term changes in demand during the season. The third use of Crooked River water is important because of the distance between Wickiup Dam and NUID's irrigated lands. Water released from Wickiup Reservoir can take several days to reach NUID delivery points. Sudden, short-term increases in NUID demand often cannot be met by releasing Wickiup Reservoir storage, and NUID must divert from the Crooked River.

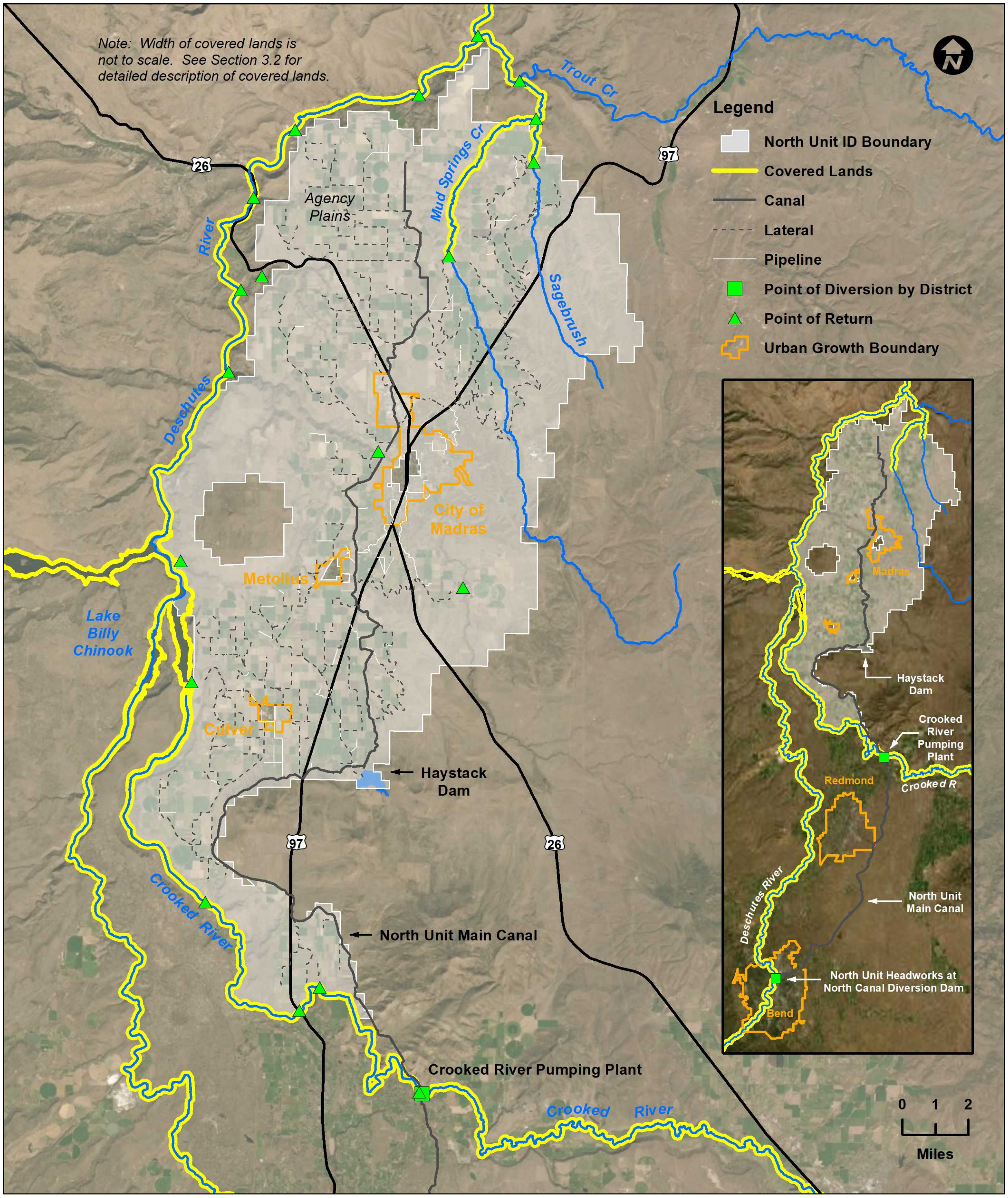

Figure 3-6. **Map of North Unit Irrigation District.**

3.5.5.3 Wickiup Dam, East Dike, South Dike and Reservoir

Wickiup Dam was constructed by Reclamation between 1939 and 1949 at RM 226.8 on the mainstem Deschutes River, about 32 miles southwest of Bend (see Figure 3-1). It is a 100-foot-high rock-faced earthen structure with a crest elevation of 4,347 feet and length of 13,860 feet. An associated earthen dike (East Dike) with a height of 28 feet and length of 3,420 feet contains the east side of the reservoir. A second dike (South Dike) measuring 2,000 feet long and 5 feet high contains the southern rim of the reservoir.

The dam has a controlled outlet capacity of 4,000 cfs and the East Dike has an emergency spillway with a capacity of 5,000 cfs. The controlled outlet consists of two pipes with 8-foot-wide gates and 90-inch-diameter regulating valves. The emergency spillway is an open, unlined chute located at the left end of the East Dike. It has a 400-foot-wide concrete inlet structure that consists of twelve 25-foot bays with earthen plugs and eight 12.5-foot bays with buried stop-logs. The emergency spillway is designed to be used only if the controlled outlet works are inoperative, or in the case of an unprecedented flood when the reservoir cannot be held below elevation 4,339 feet by the outlet works alone.

Wickiup Reservoir has a storage capacity of 200,000 acre-feet and a surface area of about 11,200 acres at full pool. It has historically been operated in coordination with Crane Prairie Dam and Reservoir (2 miles upstream) according to the 1938 inter-district agreement (see Figure 3-4). Storage and release are coordinated by the Oregon Watermaster according to the inter-district agreement and pertinent water rights, and implemented by NUID personnel operating the dam. During the refill period, which typically begins in October, Crane Prairie Reservoir has been filled to 30,000 acre-feet before storage began at Wickiup Reservoir. Inflow water has then been bypassed at Crane Prairie until Wickiup Reservoir reached 180,000 acre-feet. If additional inflows were available prior to the irrigation season, another 15,000 acre-feet have been stored in Crane Prairie Reservoir. After that, flows have again been bypassed to fill Wickiup Reservoir (to a maximum capacity of 200,000 acre-feet) before filling Crane Prairie (to a maximum capacity of 55,300 acre-feet). Reservoir refill has been managed to maximize storage while maintaining relatively uniform flow downstream in the Deschutes River. This has been accomplished by monitoring snow pack and streamflow to predict water availability, and storing only at the rate needed to achieve refill. Full pool in Wickiup Reservoir has been achieved during the storage season in about 7 years out of 10.

Irrigation releases from Wickiup Reservoir have typically begun by mid-April, but they have been delayed until May or June in wet years. Releases have usually peaked at 1,400 to 1,600 cfs in July, although they have gone higher. Irrigation releases have typically decreased in September and ended by mid-October. Prior to 2016, the minimum winter flow in the Deschutes River below Wickiup Dam was 20 cfs, as established by the Oregon State Engineer in 1955. Since October 2016, the minimum flow below Wickiup Dam has been 100 cfs. NUID does not release water outside the irrigation season for stock runs. There has been no requirement to maintain a minimum pool in Wickiup Reservoir. The average carryover volume at the end of the irrigation season has been 61,000 acre-feet, and the recent recorded minimum carryover volume was less than 3,000 acre-feet in the fall of 2018.

By Congressional authorization, Wickiup Reservoir is operated solely for storage of irrigation water. The dam may be operated informally for flood storage in anticipation of abnormally high inflow according to operating rules developed by Reclamation, but only to the extent that flood control does not compromise the storage of irrigation water. Operation for flood control is a rare event.

Inspection and maintenance of Wickiup Dam occur on a regular schedule. Inspection and maintenance conducted by NUID are covered activities. These include annual tests of the regulating gates and 6-year tests of the emergency gates.

Reclamation also conducts annual inspections, periodic facility reviews and comprehensive facility reviews in accordance with the Facility Review and Dam Safety Program. These activities are not covered by the DBHCP.

Repairs at Wickiup Dam are accomplished as needed, and are typically scheduled to minimize interference with storage and release. All maintenance and repair activities are the responsibility of NUID, with oversight by Reclamation.

3.5.5.4 North Unit Headworks

The North Unit Main Canal is one of three irrigation canals that originate at the North Canal Diversion Dam at RM 164.8 on the Deschutes River (see Section 3.5.3.5 for a description of the dam). The North Unit Headworks are located on the right abutment of the dam, where diversions are controlled by a 16.0-foot by 15.5-foot automated radial gate. The intake is fitted with a trash rack and two rotating-drum fish screens that were installed in 1945. The drums are 24 feet long and 15 feet in diameter, and are covered with 0.25-inch wire mesh.

The North Unit Headworks has a maximum capacity of 1,100 cfs, but generally diverts only 300 to 800 cfs during the irrigation season. Diverted water is a combination of live flow and stored water. Early in the irrigation season the diversion is primarily live flow. By late May, however, live flow diminishes and water released from Wickiup Reservoir makes up a larger portion of the diversion. By late summer, the diversion is almost entirely stored water. From 2010 through 2017 the average annual diversion at the North Unit Headworks was 182,963 acre-feet.

3.5.5.5 Crooked River Pumping Plant

NUID owns and operates a pumping plant where the North Unit Main Canal crosses the Crooked River at about RM 27.6. The plant was constructed in 1968 to provide supplemental irrigation water for the 50,000 acres of NUID lands receiving primary irrigation water from the Deschutes River and primary irrigation for 8,853 acres of NUID lands not otherwise served from the Deschutes River. The plant was designed to accommodate NUID's original Crooked River water right of 200 cfs, but it generally pumps 144 cfs as required to meet NUID's needs. Historically the State of Oregon required NUID to bypass a minimum of 10 cfs in the Crooked River when the pumps were in operation. Recent conservation projects now require NUID to bypass between 43 and 181 cfs, depending on the month and water year type (Dry Year versus Non-Dry Year) when the pumps are in operation. From 2012 through 2017 the pumping plant diverted an average of 13,796 acre-feet per year. Maintenance activities at the pumps are conducted without interfering with flows in the Crooked River. If it becomes necessary to dewater the pumps they are simply turned off and the entire flow in the river is allowed to pass.

The pumping plant was originally fitted with rotary drum fish screens. In 2008 the pumps were refitted with Hydrolox™ Series 1800 polymer vertical traveling screens with Intralox Series-1800 mesh. Each of nine screen panels measures 4.5 feet wide by about 15 feet high. Reclamation

(2004) assessed the Intralox screen surface mesh on a traveling screen under laboratory conditions, and concluded the screen material generated uniform approach and sweep velocity conditions and that rainbow trout avoided the screen surface. Similarly, correspondence from NOAA in 2003 indicated the Intralox Series-1800 fish screen mesh met all aspects of the NMFS criteria for slotted screen face materials for the protection of fry-size and larger salmonid fishes (Nordlund 2003; Wantuck 2003).

The Crooked River Pumping Plant is monitored to ensure that it conveys enough water to serve the needs of the 8,853 acres of lands not served by the Deschutes Project. The Crooked River water can also be applied as a supplemental source to lands served by the Deschutes Project, but NUID attempts to avoid this because of the expense of pumping Crooked River water.

The Crooked River Pumping Plant has also been used on an intermittent basis to pump stored water released from Prineville Reservoir during drought years. Since 1968, NUID has secured temporary water service contracts with Reclamation for Prineville Reservoir water five times. Under the provisions of the Crooked River Collaborative Water Security and Jobs Act of 2014 (Crooked River Act), up to 10,000 acre-feet of storage in Prineville Reservoir are available to NUID through temporary water service contracts. Temporary contracts, which require Reclamation approval on a case-by-case basis, are not covered by the DBHCP.

3.5.5.6 Return Flow

Irrigation water return flows occur at four points along the North Unit Main Canal and 11 drains on laterals (Table 3-6). Most of the return flows are spills to maintain proper water levels in the canal and laterals throughout the irrigation season. Others are spills that serve the dual function of flushing organic debris (plant materials) from the canal and laterals at the start of the irrigation season and drainage during emergencies.

Table 3-6. Return flows from the North Unit Main Canal and laterals.

Location	Receiving Water	Maximum Rate of Return (cfs)
Spills to flush the North Unit Main Canal for less than one day at the start of the irrigation season, and to drain the canal during emergencies		
Main Canal at Mile Post 37	Crooked River	100
Main Canal at Crooked River Crossing[1]	Crooked River	200
Main Canal at Willow Creek	Willow Creek, to Lake Simtustus	100
Spills from the North Unit Main Canal throughout the irrigation season		
Main Canal terminus at Frog Springs	Frog Springs to Deschutes River	10 (average)
Spills from NUID lateral canals throughout the irrigation season		
Lateral 31 Drain	Crooked River	1.0
Lateral 34 Drain	Crooked River	1.0
Lateral 37 Drain	Lake Billy Chinook	1.0
Lateral 41 Drain	Lake Billy Chinook	1.1
Lateral 43 Drain	Lake Billy Chinook	1.2
Lateral 51 Drain	Willow Creek, to Lake Simtustus	1.2
Lateral 57/59 Drain	Campbell Creek, to Pelton Reregulating Reservoir	1.3
Lateral 58-11 Drain	Sagebrush Creek, to Mud Springs Creek, to Trout Creek, to Deschutes River	50
Lateral 61-11	Mud Springs Creek, to Trout Creek, to Deschutes River	25
Lateral 63 Drain	Deschutes River	1.0
Lateral 64 Drain	Deschutes River	1.0

[1] This spill is not used every year.

3.5.6 Ochoco Irrigation District

3.5.6.1 Overview

Ochoco Irrigation District provides water to about 898 patrons on 20,062 acres mostly north and east of the Crooked River in Crook County (Figure 3-7). The DBHCP covers the diversion and return of irrigation water by OID. OID also owns and operates Ochoco Dam and Reservoir and it operates Bowman Dam and Prineville Reservoir under contract with Reclamation. However, Bowman Dam and Prineville Reservoir are not covered by the DBHCP because they are reserved works.

The OID water conveyance system is composed of four main canals (Crooked River Diversion Canal, Crooked River Distribution Canal, Ochoco Main Canal and Ryegrass Canal) and roughly 99 miles of smaller canals and associated laterals. While the operation and maintenance of the canals are not covered activities, the locations of the canals are shown in Figure 3-8 to provide a basis for understanding the diversion structures that are covered by the DBHCP. Water is diverted from the Crooked River at the Crooked River Diversion. Water is diverted from Ochoco Creek at Ochoco Dam, three small diversions operated by OID downstream of Ochoco Dam and two infiltration galleries operated by OID. OID also diverts water from multiple locations on Johnson Creek, Dry Creek, McKay Creek and Lytle Creek. Some of the diversions are federally owned, with operation and maintenance transferred to OID. The remaining structures are owned and operated by OID.

3.5.6.2 Water Rights

The primary water right appurtenant to most OID lands is for a maximum diversion of 209.7 cfs of live flow from Ochoco Creek and all tributaries. This right has priority dates of 1916 and 1917. OID holds a 1914 water right for 190 cfs of live flow from the Crooked River for primary irrigation of 3,087.3 acres and supplemental irrigation of 12,011.9 acres. OID also holds a right for 59.93 cfs from the Crooked River, Ochoco Creek and McKay Creek for supplemental irrigation of 4,601.87 acres. OID has a right to 47,000 acre-feet of storage in Ochoco Reservoir, and a contract with Reclamation for 60,639 acre-feet of storage in Prineville Reservoir, including 2,740 acre-feet of storage allocated for lands in the vicinity of McKay Creek under the Crooked River Act. Lastly, a water right for 2.75 cfs allows OID to divert Ochoco Creek water year round for industrial use.

3.5.6.3 Ochoco Dam and Ochoco Reservoir

Ochoco Dam is an earthfill structure owned and operated by OID. It is located at RM 11.2 on Ochoco Creek, about 6 miles east of Prineville. It was originally completed in 1920 and repaired by Reclamation in 1949-50. Recent modifications to the embankment, spillway and right abutment were completed under the federal Safety of Dams Program between 1994 and 1998. The dam has a crest height of 125 feet, a crest elevation of 3,131 feet, and a length of 1,350 feet. The outlet has a controlled capacity of 430 cfs and the spillway has an uncontrolled capacity of 30,000 cfs at reservoir elevation 3,143.0 feet. The outlet is not screened, and the dam does not have provisions for upstream fish passage.

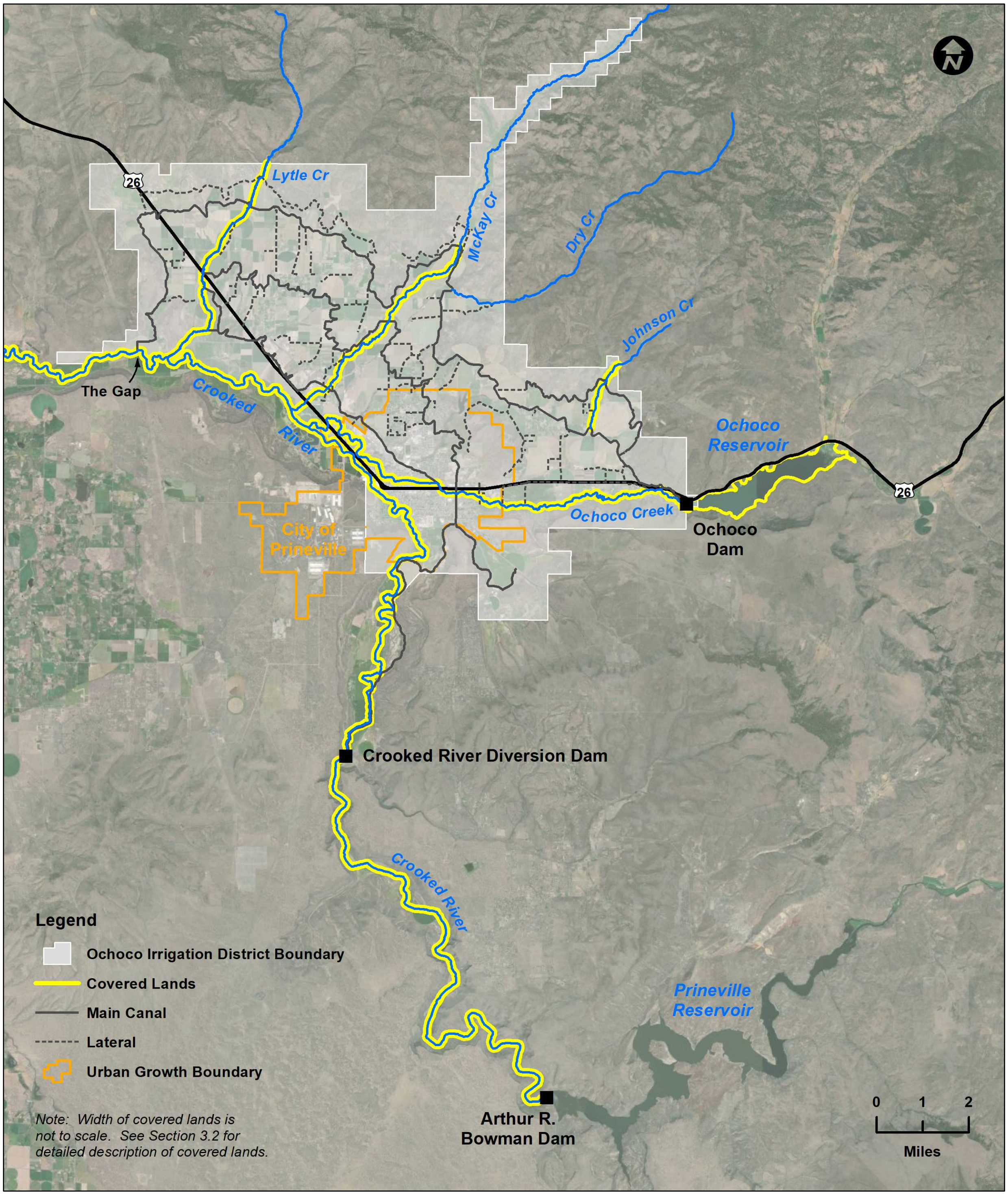

Figure 3-7. Overview map of Ochoco Irrigation District.

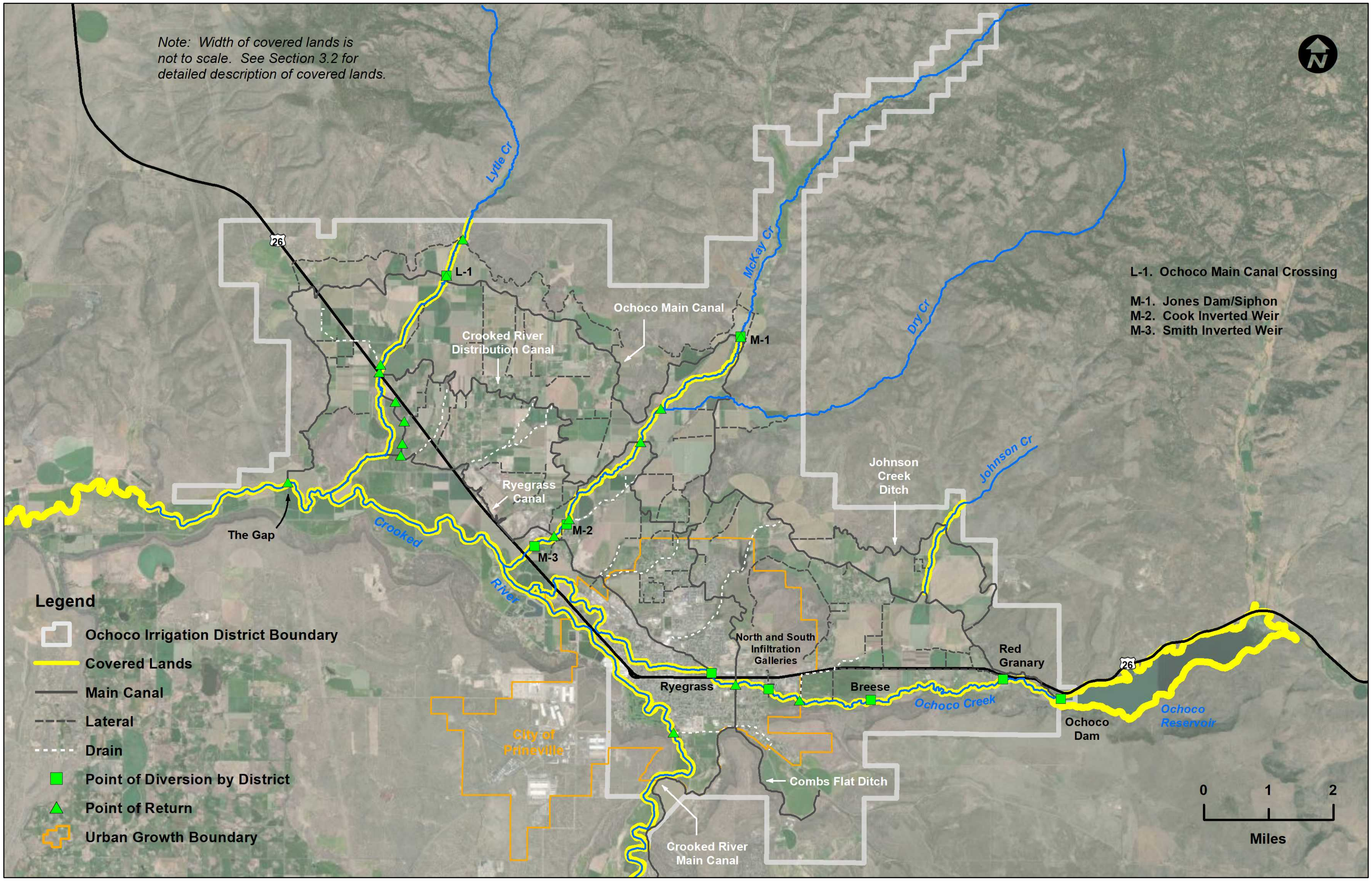

Figure 3-8. Detail map of Ochoco Irrigation District.

Ochoco Reservoir has a total volume of 44,330 acre-feet, but 5,330 acre-feet of the active storage are only accessible by pumping. At full pool, the reservoir has a surface area of about 1,060 acres. On average, it has reached full pool in only about 4 years out of 10 because Ochoco Creek flow consists almost entirely of snow melt and surface runoff that are quite variable from year to year. Water released from Ochoco Reservoir flows directly into the Ochoco Main Canal. Water can be spilled back into Ochoco Creek a short distance below the dam for downstream diversion by OID and others (see Section 3.5.6.6, *Other OID Ochoco Creek Diversions*) or retained in the canal for subsequent delivery to patrons. From 2010 through 2017 OID released an average of 24,692 acre-feet per year into the Ochoco Main Canal. This water was conveyed to patrons through the canal or released back into Ochoco Creek for diversion at one of the downstream facilities covered by the DBHCP (see Section 3.5.6.6).

OID conducts balanced regulated gate testing at Ochoco Dam every year and unbalanced regulated gate testing every 6 years. These activities, which do not require interruption of reservoir outflow, are covered by the DBHCP. Additional inspections and tests required by Reclamation for dam safety are not covered by the DBHCP; these will be covered by section 7 consultation between Reclamation and the Services.

Ochoco Reservoir is also authorized and operated for flood control, which can limit the rate at which OID can fill the reservoir during the irrigation storage season (November through March) and occasionally requires OID to release water and create room in the reservoir for anticipated flood flows. Flood control operations at Ochoco Dam are directed by Reclamation and are not covered by the DBHCP.

3.5.6.4 Coordinated Reservoir Operation

Ochoco Reservoir and Prineville Reservoir are operated in a coordinated fashion by OID, as described below. The operation of Bowman Dam/Prineville Reservoir is included here for context only. As noted in Section 3.5.1.1, the operation and maintenance of Bowman Dam and Prineville Reservoir are not covered by the DBHCP.

Water for irrigation use is generally released from Ochoco and Prineville reservoirs from April 1 through October 31 and the reservoirs are refilled between November and June. Peak irrigation releases occur between June and September, with variation from year to year depending on the types of crops being grown. Filling is based on Reclamation runoff forecasts and guided by US Army Corps of Engineers’ rule curves to balance demands for irrigation and flood control. At least 16,500 acre-feet of evacuated space (flood storage capacity) are retained in Ochoco Reservoir from November 15 through January 31, and at least 60,000 acre-feet of flood storage capacity are retained in Prineville Reservoir from November 15 through February 15. After these dates, additional storage occurs according to established rule curves to limit flood flows to 3,000 cfs below Prineville Reservoir and 1,100 cfs below Ochoco Reservoir. Both reservoirs typically reach annual highs during April or May.

OID releases water from both reservoirs to meet the needs of its patrons. Some OID patrons can only be served by one of the two reservoirs because those patrons’ use of water under the water rights are specific to that reservoir, but the majority of the acres in OID can be served by either reservoir. Prineville Reservoir has better refill capability, so it is typically used to support the majority of the patrons who can be served by either reservoir. Ochoco Reservoir is smaller and fills less frequently, and therefore is managed to ensure patrons who are limited to use of water from that reservoir are treated equitably. The source of water delivered to an individual patron can vary from year to year depending on the relative volumes of water in the two reservoirs. There is no requirement to maintain a minimum pool elevation or minimum release rate at Ochoco Reservoir, although seepage through the dam contributes about 2 cfs to lower Ochoco Creek at all times.

3.5.6.5 Other OID Ochoco Creek Diversions

The authorized point of diversion for OID water in Ochoco Creek is Ochoco Dam. However, a portion of the water is released back into the creek below the dam for conveyance to five non-federal diversion structures between the dam and the confluence with the Crooked River. These include three small surface diversions and two infiltration galleries. The numbers and locations of these structures could change over the term of the DBHCP as needed to facilitate OID's utilization of its water rights for diversion at Ochoco Dam.

The five structures are described below. They were all reconstructed between 1999 and 2009 to reduce potential effects on fish; all are now designed to allow volitional upstream and downstream fish movement and screened to prevent entrainment.

Red Granary Diversion consists of an inflatable Obermeier dam supported by a concrete apron and walls at about RM 10.2. It can be raised to a height of 4 feet to divert up to 30 cfs into the Breese Canal or lowered to allow unrestricted flow of the creek. It is fitted with screens to exclude fish from the canal and a fish ladder to allow upstream and downstream fish movement when the dam is raised. The screens have 3/32-inch openings, and can be operated to maintain approach velocity at or below 0.4 feet/second. They return fish to the creek immediately below the Obermeier dam.

Breese Diversion is an inverted weir at about RM 7.5. It consists of a perforated 36-inch-diameter steel pipe laid horizontal across the creek and bedded in concrete. The pipe serves as both a weir and an intake, as water passing over it is drawn by gravity through flat plate fish screens in the top. Water in the pipe continues by gravity flow to both streambanks, where it is pumped into OID canals. Each of the two pumps has a capacity of 5 cfs. The weir has a v-notch to concentrate low flows and allow upstream and downstream fish movement. The low point of the v-notch is below the level of the intake holes, thus ensuring the weir cannot cause the creek to run dry.

The North and South Infiltration Galleries are located along the north and south sides of Ochoco Creek at about RM 5.7. They were constructed in 2000 to replace instream diversion structures at the Slaughterhouse and Schnoor dams, thereby eliminating the need for fish screens and ladders. The North Gallery diverts up to 2 cfs and the South Gallery diverts up to 1 cfs of Ochoco Creek water through the streambank gravel.

Ryegrass Diversion is an inverted weir that is constructed similar to Breese Diversion, but operates entirely on gravity flow without pumps. It diverts up to 10 cfs at RM 4.7. In addition to diverting Ochoco Creek water (live flow and storage) it also captures Crooked River water spilled for operational reasons from the Crooked River Diversion Canal, which crosses Ochoco Creek less than 0.5 mile upstream. At least 5 to 10 cfs is typically allowed to pass Ryegrass Diversion for diversion downstream or contribution to Crooked River flows. A step pool on the downstream side of the diversion facilitates upstream fish movement.

3.5.6.6 Crooked River Diversion and Headworks

OID diverts Crooked River live flows and Prineville Reservoir storage at the Crooked River Diversion. This is a federally owned facility that is operated by OID as transferred works. It is located about 14 miles downstream of Bowman Dam at about RM 56.8. Flows are directed to the headworks by a 4-foot-high sheet pile diversion weir. The weir has high- and low-flow v-notches to concentrate flows, and a step pool on the downstream side to facilitate upstream and downstream fish movement under all flow conditions. The concrete headworks structure has a capacity of 190 cfs and is fitted with a trash rack and three cast iron slide gates.
During the irrigation season, a portion of the flow reaching the diversion is allowed to pass over the weir for downstream diversion by OID patrons, downstream diversion by other parties, and maintenance of instream flows for fish and wildlife. Reclamation and OID attempt to pass sufficient amounts of water to meet downstream diversion demands while maintaining instream flows determined by Reclamation in accordance with the Crooked River Act. The amount of water passed over the weir to accomplish this varies, depending on flood control requirements, irrigation demands and instream needs. From 2010 through 2017 OID diverted an average of 53,132 acre-feet per year at the Crooked River Diversion.

The Crooked River Headworks were fitted with new fish screens in 2001. These are vertical plate screens with mechanical sweepers. The screens are 80 feet long and 8 feet high, with 3/32-inch holes. They have louvers to regulate through-flow and maintain approach velocity at 0.4 feet/second or less. Fish are directed into a 30-inch-diameter bypass pipe and returned to the Crooked River 375 feet downstream of the diversion.

3.5.6.7 Diversions from Other Crooked River Tributaries

OID's water rights to divert Crooked River water include diversions directly from tributary streams, with no limits on the rate or amount of diversion within any individual tributary. Currently, OID diverts water directly from four tributaries, as described below. All of these diversions are non-federal facilities.

Johnson Creek

The Johnson Creek Canal originates from water pumped out of the Ochoco Main Canal near the east end of OID. The Johnson Creek Canal crosses Johnson Creek (a seasonal stream) at a check-board structure downstream of Johnson Creek Reservoir (a private facility not covered by the DBHCP). The Johnson Creek crossing allows up to the entire flow of Johnson Creek to be diverted into the canal. Water can also be spilled from the canal into Johnson Creek for operational purposes or for downstream diversion by multiple OID patrons. Johnson Creek terminates at the Ochoco Main Canal, and any water not diverted above that point flows into the canal. As Johnson Creek does not support fish, none of the OID structures on the creek has fish screens or fish passage facilities.

Dry Creek

Dry Creek is a tributary to McKay Creek at about RM 4.0. Live flow in Dry Creek occurs only during spring snowmelt in years with sufficient snow accumulation. The primary function of the creek within the OID system is conveyance of water between the canals, but the brief live flow can also be diverted at four locations. Dry Creek does not support fish, so none of the three diversions has screens or provisions for fish passage.

The uppermost diversion from Dry Creek occurs where the Ochoco Main Canal crosses the creek. A check-board structure at this location allows the canal to flow across the creek. When the creek is flowing, this same structure diverts that flow into the canal. With check boards removed, water can be spilled from the canal into the creek for conveyance downstream to other OID canals. The second point of diversion is a push-up dam operated by an OID patron to divert flow directly into a headgate. This structure is used primarily to divert Ochoco Creek and/or Crooked River water that has been spilled into Dry Creek at the Ochoco Main Canal crossing. Downstream of this is a surface pump. Like the push-up dam, it is used primarily to deliver Ochoco Creek water to OID patrons. The final diversion on Dry Creek is also a check-board structure with a surface pump located immediately upstream of the confluence with McKay Creek.

McKay Creek

OID currently diverts water at three locations on McKay Creek and has water rights to divert at another two. All five locations are described as follows.

- **Jones Dam and Siphon** is located at RM 5.8 on McKay Creek. The Ochoco Main Canal passes under the creek in an inverted siphon at this point. A concrete structure with check boards situated above the siphon allows OID to divert McKay Creek flow into the canal. The headgate to the canal is screened to exclude fish, and a ladder enables upstream movement of fish when the check boards are in place and the creek is blocked. Fish movement is unimpeded when the check boards are out of the creek. OID could divert the entire flow of McKay Creek when the flow is within its water right, but OID generally limits its diversion to 40 cfs. OID can also spill water from the Ochoco Main Canal into McKay Creek at this location for operational purposes, such as to prevent the canal from overtopping during fluctuations in demand.
- **Reynolds Siphon** conveys water in the Crooked River Distribution Canal beneath McKay Creek at RM 3.2. OID can spill from the canal into the creek at this location for operational purposes, but there is currently no structure in place to divert water from the creek. Development and operation of a diversion structure at this point is a covered activity to allow for the possibility that it may be needed in the future.
- **Cook Inverted Weir** is located at RM 1.3 on McKay Creek. It is similar in design and construction to the inverted weirs at Breese and Ryegrass diversions. A horizontal steel pipe bedded in concrete diverts water into the Ryegrass Canal. Deliveries to adjacent patrons can also be made directly from the pipe. Screens on the intakes prevent entrainment of fish, and a v-notch in the weir allows upstream and downstream fish movement. This structure is used mainly to recapture flow spilled into McKay Creek upstream at Jones Dam and Reynolds Siphon.
- **Pine Products Siphon** carries the Ryegrass Canal beneath McKay Creek at RM 1.0. OID can spill into the creek for operational purposes, but there is no structure to divert water from the creek. Like the Reynolds Siphon, development and operation of a diversion structure at this point is a covered activity to allow for the possibility that it may be needed in the future.
- **Smith Inverted Weir** diverts water at RM 0.6 on McKay Creek for distribution to OID patrons in the surrounding area. The steel pipe weir is screened to prevent fish entrainment, and it has a v-notch to concentrate low flows and allow fish passage.

Lytle Creek

Lytle Creek is a seasonally flowing tributary to the Crooked River. It carries live flow only during the peak of spring runoff in years of good snowpack. OID uses the creek as a conveyance system similar to Dry Creek and also diverts live flow when it occurs during the irrigation season. The lower 1.3 miles of Lytle Creek are merged with the Ryegrass Canal into a man-made ditch. Water is diverted at 10 locations along Lytle Creek, including the portion shared by the Ryegrass Canal. Lytle Creek does not support fish, and none of the diversion structures has fish screens or ladders. The points of intersection with OID canals are described in order below, starting at the uppermost location on the creek.

Lytle Creek is crossed by the Grimes Flat West Canal (also known as the Lytle Creek West Canal) at the northern end of OID. The canal passes beneath the creek in a siphon. OID can spill water into the creek, but water cannot be diverted from the creek at this location.

Downstream of the Grimes Flat West Canal, the Ochoco Main Canal passes directly through Lytle Creek at a check-board structure. The full flow of Lytle Creek can be diverted into the Ochoco Main Canal at this point, but OID typically spills water into the creek instead to prevent overtopping of the canal and/or for delivery downstream along the creek. Outside the irrigation season, the check boards are removed and the creek is allowed to flow unimpeded.

Two check-board structures (W Lateral and Gramby) and two surface pumps are used to divert water from Lytle Creek directly into headgates between the Ochoco Main Canal and the Crooked River Distribution Canal. The check boards are removed after the irrigation season.

The Crooked River Distribution Canal terminates at Lytle Creek, where water is spilled down a 15-foot chute. No water is diverted at this location.

The Quail Valley Ranch Diversion is a 4-foot-high check-board structure that diverts water for delivery to an OID patron. The check boards are removed after the irrigation season. A pump diverts water below the Quail Valley Ranch Diversion.

At RM 1.3 Lytle Creek merges with the Ryegrass Canal. The common channel below this point is a man-made ditch. Four check-board structures within this reach divert flows for delivery to OID patrons. These check boards are removed after the irrigation season.

3.5.6.8 Return Flow

OID return flows reach the Crooked River at The Gap and the Juniper Canyon flood control channel, and McKay Creek and Lytle Creek at multiple locations. McKay Creek and Lytle Creek then flow into the Crooked River. Return flows reach Ochoco Creek at the D-2 drain east of Prineville and at the Crooked River Diversion Canal crossing (Table 3-7). Water is intentionally spilled into McKay Creek and Lytle Creek from the Ochoco Main Canal, Crooked River Distribution Canal and Ryegrass Canal to maintain proper water levels in the canals, and to prevent McKay Creek from running dry during the irrigation season. Crooked River/Prineville Reservoir water is also spilled directly from the Crooked River Diversion Canal into Ochoco Creek near the Barnes Butte Pumping Plant. Operation of the plant requires more water than the Crooked River Distribution Canal can accept, so the excess is spilled into Ochoco Creek for diversion downstream at the Ryegrass Canal or to contribute to flows in the lower Crooked River.

Table 3-7. Return flows in Ochoco Irrigation District.

Location (RM)	Name	Description	Maximum Rate of Return (cfs)
Crooked River Returns			
49.4	Juniper Canyon Flood Control Channel	Local tailwater during the irrigation season	8.0
39.6	The Gap	Operational spill throughout the irrigation season	18.5
Ochoco Creek Returns			
6.3	OID D-2 Drain	Local tailwater during the irrigation season	2.0
5.1	Crooked River Diversion Canal Spill	Operational spill throughout the irrigation season	75.0
McKay Creek Returns			
5.8	Ochoco Main Canal Spill	Operational spill throughout the irrigation season	100.0
3.9	Dry Creek Live Flow and Spill	Live flow plus operational spill	20.0
3.2	Crooked River Distribution Canal Spill at Reynolds	Operational spill throughout the irrigation season	54.0
1.3	OID D-8 Drain	Local tailwater during the irrigation season	10.0
1.0	Ryegrass Canal Spill	Operational spill throughout the irrigation season	45.0
Lytle Creek Returns			
5.7	Grimes Flat West Canal Spill	Operational spill throughout the irrigation season	unknown
5.0	Ochoco Main Canal Spill	Operational spill throughout the irrigation season	unknown
3.2	OID D-7 Drain	Local tailwater during the irrigation season	unknown
3.0	Crooked River Distribution Canal Spill	Operational spill throughout the irrigation season	unknown
2.3	OID 827 Drain	Local tailwater during the irrigation season	unknown
1.9	OID 825 Drain	Local tailwater during the irrigation season	unknown
1.5	OID 823 Drain	Local tailwater during the irrigation season	unknown
1.3	Ryegrass Canal Spill	Operational spill throughout the irrigation season	40.0

3.5.7 Swalley Irrigation District

3.5.7.1 Overview

Swalley Irrigation District provides water to 662 patrons on 4,467 acres north of Bend and mostly east of the Deschutes River (Figure 3-9). SID operates entirely on natural Deschutes River flows, with no storage capacity. Covered facilities are the Swalley Headworks and Fish Screens at North Canal Diversion Dam. The headworks and fish screens are owned by SID; the 19 patron pumps are owned and operated by individual patrons.

3.5.7.2 Water Rights

SID holds a water right with a priority date of 1899 for a maximum diversion of 87 cfs of live flow from the Deschutes River. The water right originally allowed for diversion of 125 cfs, but Allocation of Conserved Water projects implemented by SID have permanently returned about 39 cfs to the Deschutes River, which is now protected with an instream water right reflecting the original priority date of 1899. By a supplemental decree dated 1933, diversions under the live flow water right are limited during portions of the irrigation season (Table 3-8).

Table 3-8. Maximum diversion rates for live flow under Swalley Irrigation District's water right during the irrigation season.

Period	Maximum Diversion Rate
April 1 – April 30	34 cfs
May 1 – May 14	46 cfs
May 15 – September 14	87 cfs
September 15 – September 30	46 cfs
October 1 – October 31	34 cfs

3.5.7.3 Swalley Headworks

The Swalley Headworks are located on the right abutment of the North Canal Diversion Dam (see Section 3.5.3.5). The headworks are fitted with a gate, trash rack and fish screen that return fish to the Deschutes River about 575 feet below North Canal Diversion Dam. Diversions from April through October are for irrigation. From late November through March, SID provides stock water for periods of 3 to 5 days about every 4 weeks, weather permitting. From 2013 to 2017 SID diverted an average of 26,372 acre-feet per year at the headworks, entirely from live flow.

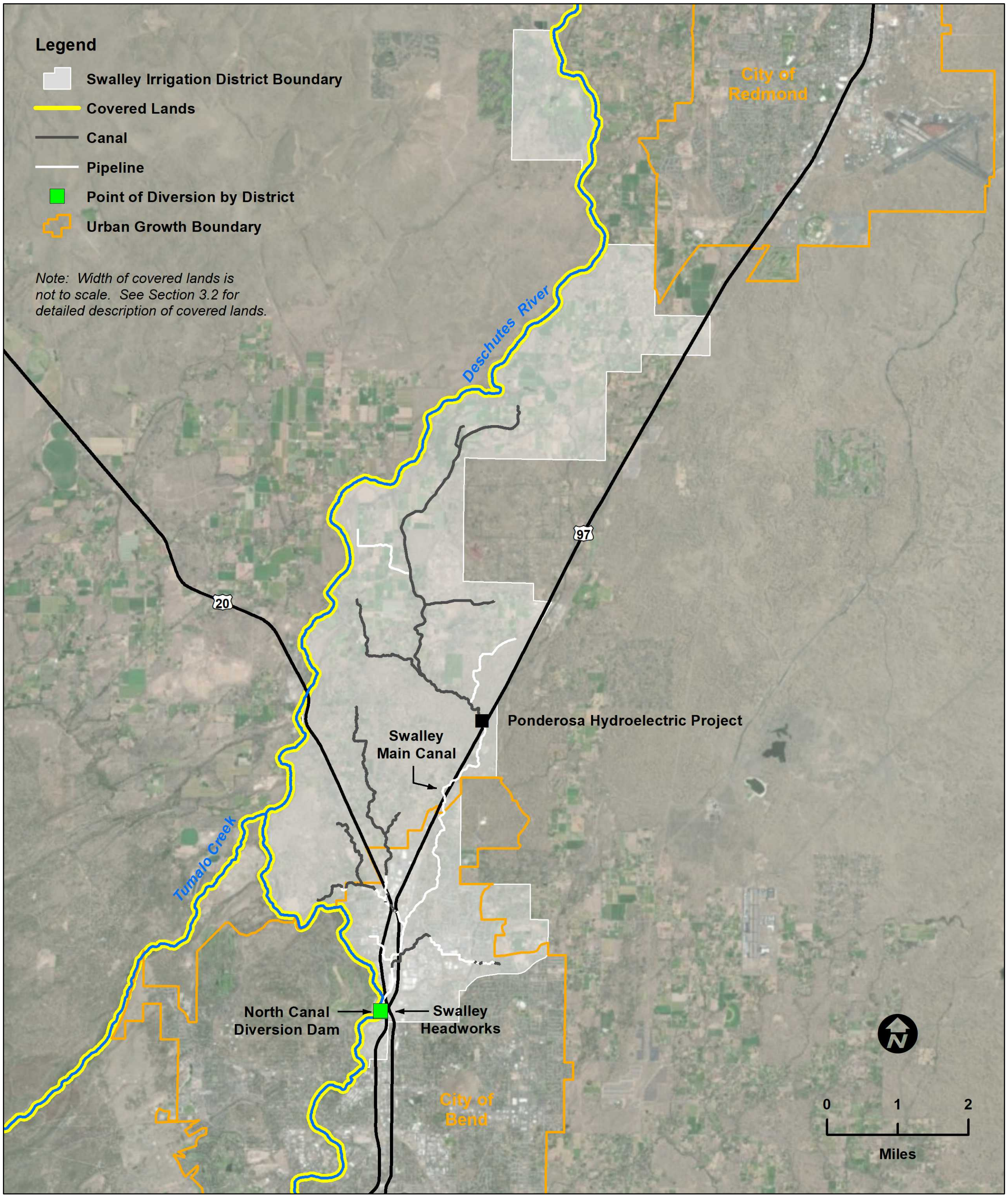

Figure 3-9. Map of Swalley Irrigation District.

3.5.8 Three Sisters Irrigation District

3.5.8.1 Overview

Three Sisters Irrigation District provides water to about 194 farms totaling 7,572 acres east of Whychus Creek, between the City of Sisters and the confluence of Whychus Creek with the Deschutes River (Figure 3-10). Covered TSID facilities include the Whychus Creek Diversion and associated structures, all of which are owned by TSID. One TSID patron will divert water directly from Whychus Creek upstream of TSID's diversion. This will also be a covered activity.

3.5.8.2 Water Rights

TSID's original water right was for a maximum diversion of 158.55 cfs of live flow from Whychus Creek. As a result of recent Allocation of Conserved Water projects implemented by TSID through 2020, 31.18 cfs of the original water right have been returned to instream flow through permanent transfers of water rights, leaving a current water right for irrigation and stock watering of 127.37 cfs. TSID's water right has no designated season of use.

3.5.8.3 Whychus Creek Diversion and Headworks

Whychus Creek Diversion is located at RM 24.2. It is a low concrete structure that fish can swim over. A v-notch near the left abutment (opposite the intake) ensures volitional passage at low flows. The intake has a capacity of 160 cfs and is fitted with a trash rack, fish screens and four headgates. Fish that encounter the screens are returned to the creek about 300 feet downstream of the intake. TSID diverts entirely from live flow. Diversions from April through October are for irrigation. Stock water runs of 30 to 40 cfs are provided intermittently in November and March, weather permitting. From 2011 through 2016 TSID diverted an average of 35,005 acre-feet per year at the Whychus Creek Diversion.

3.5.8.4 Other Whychus Creek TSID Diversion

One TSID patron with an 1895 water right currently receives 0.8 cfs through the Plainview Ditch, a private facility that diverts water from Whychus Creek at about RM 25.8. TSID is working with the patron to convert from Plainview Ditch delivery to a piped diversion operated by the patron. Once the pipe is installed and screened to exclude fish, this diversion of water at Whychus Creek will be a covered activity. Diversion of the 0.8 cfs at the Plainview Ditch in the interim is not a covered activity.

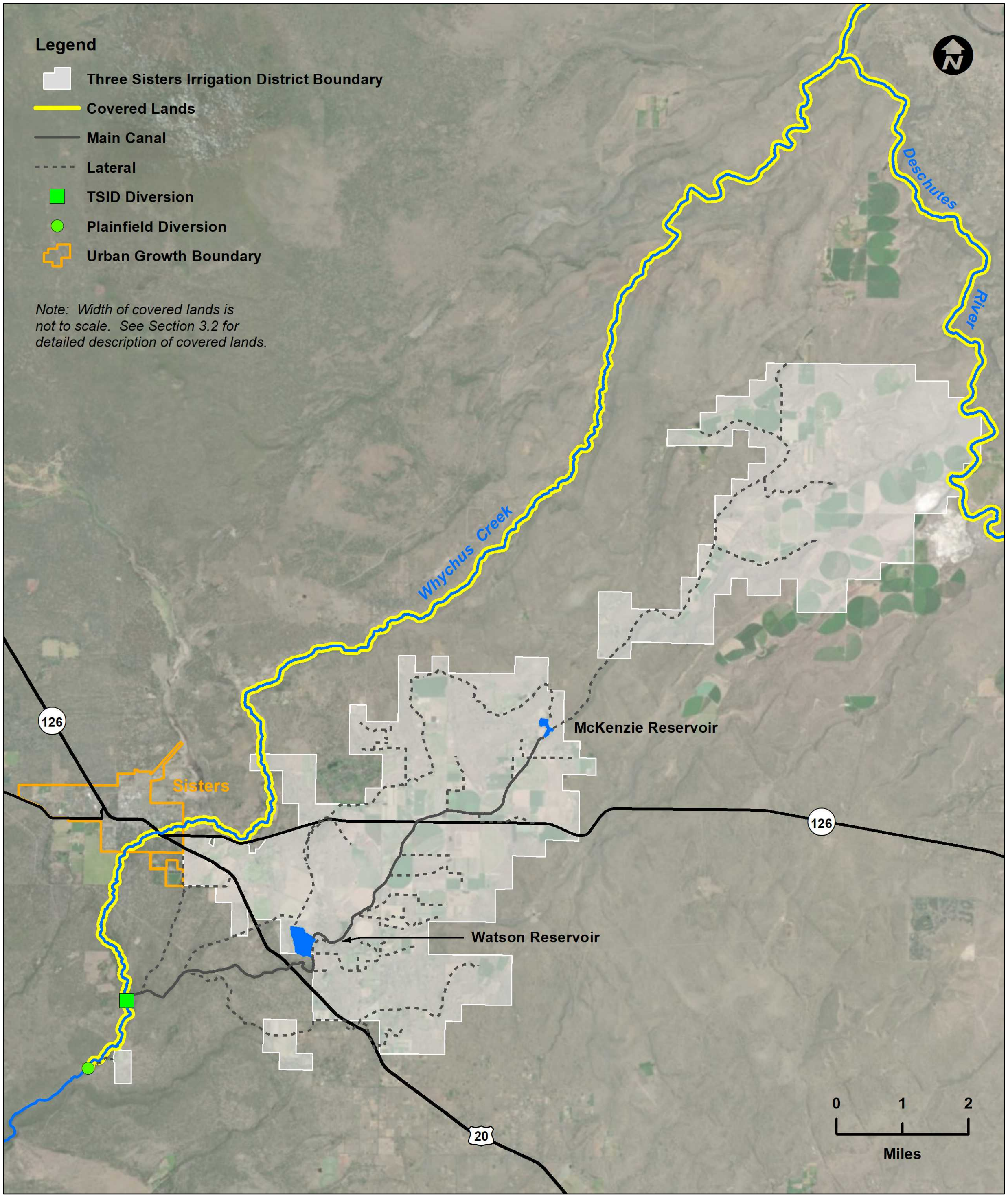

Figure 3-10. Map of Three Sisters Irrigation District.

3.5.9 Tumalo Irrigation District

3.5.9.1 Overview

Tumalo Irrigation District provides water to about 660 agricultural and domestic patrons on about 8,110 acres surrounding the unincorporated community of Tumalo, northwest of Bend (Figure 3-11). TID holds surface water rights on the Deschutes River, Tumalo Creek, Crater Creek, Little Crater Creek, Three Spring Branches and a number of small tributaries to Tumalo Creek. It also has storage rights on Crescent Lake, with storage and supplemental water rights on the Little Deschutes River, Crescent Creek and the drainage area draining into Crescent Lake. The DBHCP covers the operation of a storage reservoir (Crescent Lake Dam and Reservoir), two primary diversion structures (Bend Diversion and Tumalo Diversion), and smaller diversion structures and related canals on Crater and Little Crater creeks.

3.5.9.2 Water Rights

TID's water rights as of the passage of Oregon HB 3111 in 1996 allowed the diversion of 218.871 cfs of live flow from Tumalo Creek and its tributaries, and the diversion of 9.5 cfs of live flow from the Deschutes River. Recent Allocation of Conserved Water projects by TID reduced the Tumalo Creek water right to 208.971 cfs (as of completion of the Tumalo Feed Canal Phase III piping). The Deschutes River water right remains at 9.5 cfs. TID also has an agreement with COID to divert 0.5 cfs of COID's Deschutes River live flow water right at the Bend Diversion and deliver it to COID patrons that cannot be reached from COID's canal.

TID had rights as of the passage of Oregon HB 3111 to 86,050 acre-feet of storage in Crescent Lake on Crescent Creek and 1,100 acre-feet of storage in Tumalo Reservoir. Currently, Allocation of Conserved Water projects have reduced TID's irrigation storage in Crescent Lake by 652 acre-feet and increased instream flow storage in Crescent Lake by the same amount under the partially phased-in implementation of Conserved Water Application CW-37.

Tumalo Creek is TID's primary water source; Crescent Lake and Tumalo Reservoir storage are used when flows in Tumalo Creek are insufficient to meet irrigation demands. The authorized season of use varies by individual water right, but TID's irrigation season is generally April 1 to October 15. Diversion from Tumalo Creek can peak at over 190 cfs in May and June, after which the majority of TID's water comes from Crescent Lake storage diverted at the Bend Diversion. Stock runs of 50 to 60 cfs are taken for 5-day periods about every 6 weeks from November through March, weather and construction permitting. For 5 of the 6 years between 2009 and 2014, TID diverted an average of 53,517 acre-feet per year at its two diversions combined. Diversions in 2012 were not included in this average due to canal piping activities that interrupted diversions in that year.

3.5.9.3 Crescent Lake Dam and Reservoir

Crescent Lake Dam is a 40-foot-high earthen structure at RM 29.0 on Crescent Creek about 84 miles upstream of Bend (see Figure 3-1). It was constructed in 1956 to replace a smaller timber crib structure built in 1922. Like the previous structure, the current dam enlarges a natural lake to form Crescent Lake Reservoir. The current dam has a crest elevation of

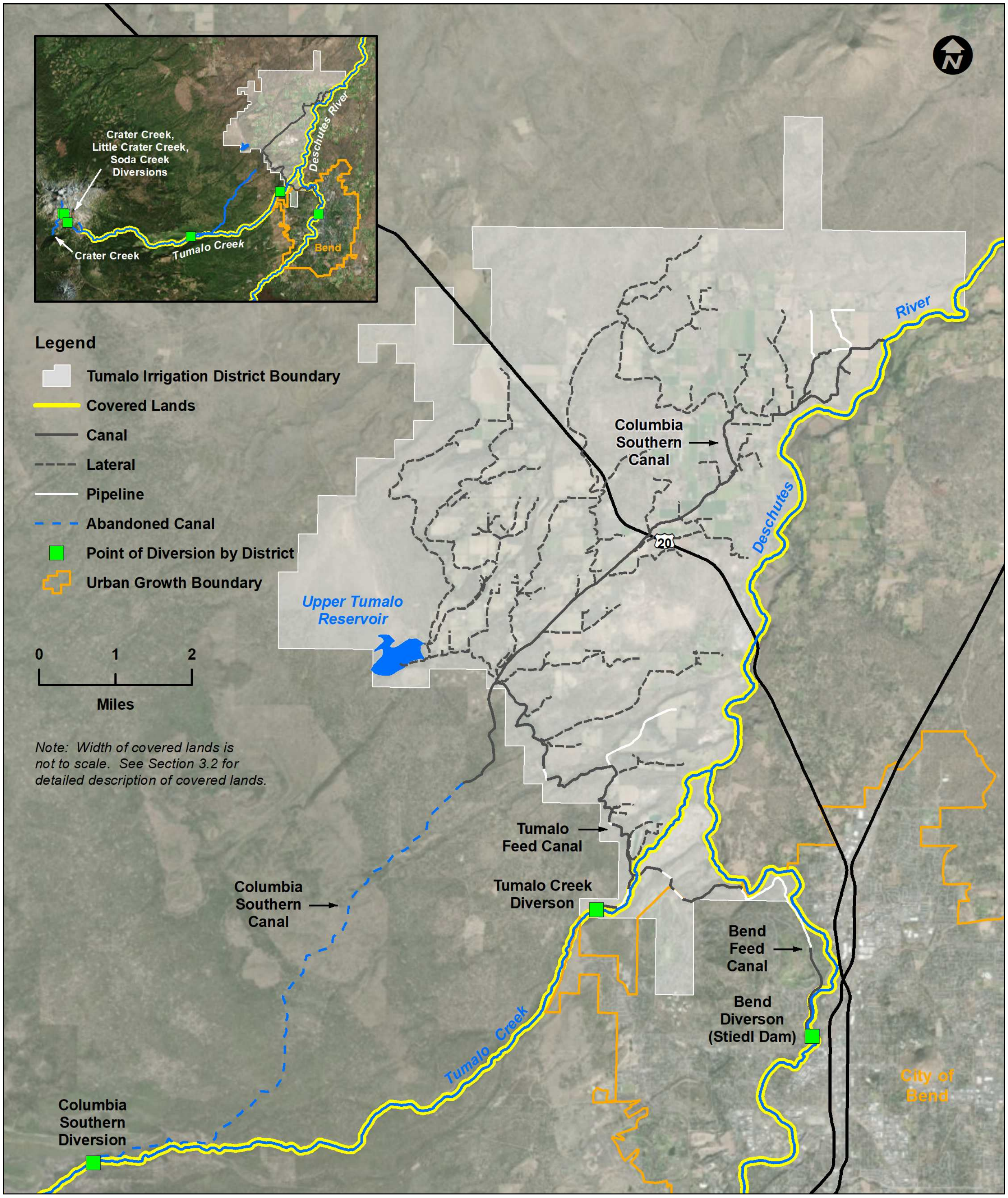

Figure 3-11. Map of Tumalo Irrigation District.

4,860 feet, a length of 450 feet, an uncontrolled spillway, and concrete outlet works with a capacity of 1,325 cfs. The reservoir, which is entirely on National Forest System lands administered by the Deschutes National Forest, has an active storage capacity of 86,900 acre-feet and a surface area of about 4,008 acres at full pool. The dam is owned and operated by TID for irrigation storage and instream flow storage. The reservoir is generally filled from November through June, and then drawn down from July through mid-October. Irrigation water released from Crescent Lake travels down Crescent Creek, the Little Deschutes River and the Deschutes River until it is diverted at the Bend Diversion. Peak releases occur in mid-July through September. According to Conserved Water Agreement CW-37 between TID and the State of Oregon, a flow of at least 5 cfs is maintained in Crescent Creek below Crescent Lake Dam at all times. Since October 2016, TID has maintained minimum flows below Crescent Lake Dam of 20 cfs from December 1 through March 15 and 30 cfs from March 16 through November 30.

Crescent Lake Dam is inspected and tested on a regular basis for structural integrity, proper operation and safety. All scheduled inspections and tests described below are covered by the DBHCP. Some inspections and tests require reduction or temporary cessation of flow through the dam, but a bypass pipe allows approximately 5 cfs to continue flowing around the dam during most covered activities. Unscheduled inspections and tests may also occur to address safety issues that arise at the dam. Unscheduled inspections and tests that meet the descriptions below are covered activities, but unscheduled inspections and tests that require lower flows or longer interruptions of flow will be treated as changed circumstances on a case-by-case basis according to Chapter 9, *Changed Circumstances*.

Facility Infrastructure Inspection: Crescent Lake Dam receives a State of Oregon facility infrastructure inspection every year. This involves only the presence of personnel on and around the dam. The inspections result in no alteration of flow or placement of heavy equipment in the water.

Gate Test (Full Open/Full Close Test): Gate tests are conducted annually between October 1 and November 30 and take less than one day to complete. They require the flow to be increased and decreased up to 40 cfs over a period of 4 hours. The minimum flow during the test is zero cfs, but the bypass pipe allows 5 cfs to continue around the dam into lower Crescent Creek.

Gallery and Conduit Inspection: These are conducted every 5 years between October 1 and November 30, and take about 4 hours to complete**.** They require flow through the dam to be completely stopped, but the bypass pipe allows 5 cfs to continue around the dam into lower Crescent Creek.

Some inspections result in the identification of needed repairs. Like inspections, repairs can require temporary reduction or cessation of flow through the dam. Minor repair activities, as described below, are also covered by the DBHCP. Repair activities that do not meet the definition of minor activities are considered changed circumstances.

Minor Repairs: These are repair activities at Crescent Lake Dam that require: a) complete cessation of flow (with no bypass flow) for no more than 4 hours, b) flows of less than 10 cfs for no more than 8 consecutive hours, or c) flows of less than 10 cfs for no more than 24 hours cumulative over a one-week period.

Lastly, certain routine maintenance activities at the dam also require temporary interruption of flow. These maintenance activities are described below and are covered by the DBHCP.

Removal of Rock from Ramp Flume: Rocks are cleared from the ramp flume as needed. Historically this has occurred about every few years. It requires complete cessation of flow through the dam for up to 2 hours. This activity can be done concurrent with scheduled gallery and conduit inspection, although concurrent scheduling is not always possible.

Removal of Rocks from Tailrace: This activity is also conducted as needed and has historically occurred about once every 10 years. Flow through the dam is stopped for up to 4 hours while heavy equipment is operated in the tailrace (downstream side of the dam). A bypass flow of about 5 cfs is maintained during the entire procedure.

3.5.9.4 Bend Diversion and Headworks

TID diverts water from the Deschutes River at the Bend Diversion (also known as Steidl Dam), a 6-foot-high overflow structure at RM 165.9 (roughly 5 miles upstream of Tumalo Creek). It was originally built in 1922 and extensively upgraded in 1975. The headworks consist of an intake structure with a trash rack and control gate. Vertical, perforated stainless-steel flat-plate fish screens with automatic wiper brushes were installed at the intake in 2004. A fish ladder allows volitional upstream and downstream passage at the diversion.

Water diverted at the Bend Diversion is a combination of Deschutes River live flow (up to 9.5 cfs) and Crescent Lake Reservoir storage. Live flow is diverted at Bend throughout the irrigation season. Storage is released from Crescent Lake Reservoir and diverted at Bend when the combination of Deschutes River live flow and Tumalo Creek live flow does not meet TID's demand (in most years this occurs periodically in April and May and consistently from late June or July through September).

3.5.9.5 Tumalo Creek Diversion and Headworks

Tumalo Creek flows are currently diverted at the Tumalo Creek Diversion, about 2.8 miles above the confluence with the Deschutes River. The diversion was originally constructed in 1913-14 and reconstructed in 1975 and 2010-11. The diversion is an overflow structure that raises the creek level about 4 feet to facilitate gravity flow into the headworks. Like the Bend Diversion, the Tumalo Creek Diversion intake has vertical, perforated stainless-steel flat-plate fish screens with automatic wiper brushes. They were installed in 2005. The intake has a capacity of 190 cfs. A fish ladder installed in 2010 provides upstream and downstream passage. All water diverted at the Tumalo Creek Diversion is live flow from Tumalo Creek, Tumalo Creek tributaries, Crater Creek, and Crater Creek tributaries.

Prior to 1998, up to 200 cfs of Tumalo Creek flow was diverted into the Columbia Southern Canal at about RM 12. However, since TID increased the capacity of the Tumalo Diversion, all of TID's Tumalo Creek water right is diverted at that location and none is currently diverted at the Columbia Southern Diversion. Nevertheless, TID retains the rights to divert at the Columbia Southern Diversion and could reactivate it during the term of the DBHCP.

3.5.9.6 Crater Creek, Little Crater Creek and Soda Creek Diversions and Canal

Small instream diversion structures direct water from Crater Creek, Little Crater Creek and Soda Creek into an unlined ditch along the south side of Broken Top Mountain. The ditch then conveys the water about 2 miles into the middle fork of Tumalo Creek at RM 1.7, for diversion by TID downstream at the Tumalo Creek Diversion. The canal has a capacity of 15 to 20 cfs and functions mainly to capture snowmelt during the spring.

3.5.10 City of Prineville Activities

3.5.10.1 Overview

Prineville is the county seat and largest municipality in Crook County, Oregon. Located at the confluence of Ochoco Creek and the Crooked River (Figure 3-12) it encompasses an area of 10.9 square miles and has a population of about 9,900. The City was incorporated in 1880. The DBHCP covers the City's withdrawal of groundwater for municipal use, the discharge of effluent from the City's water treatment plant and surface water diversions for irrigation of City lands.

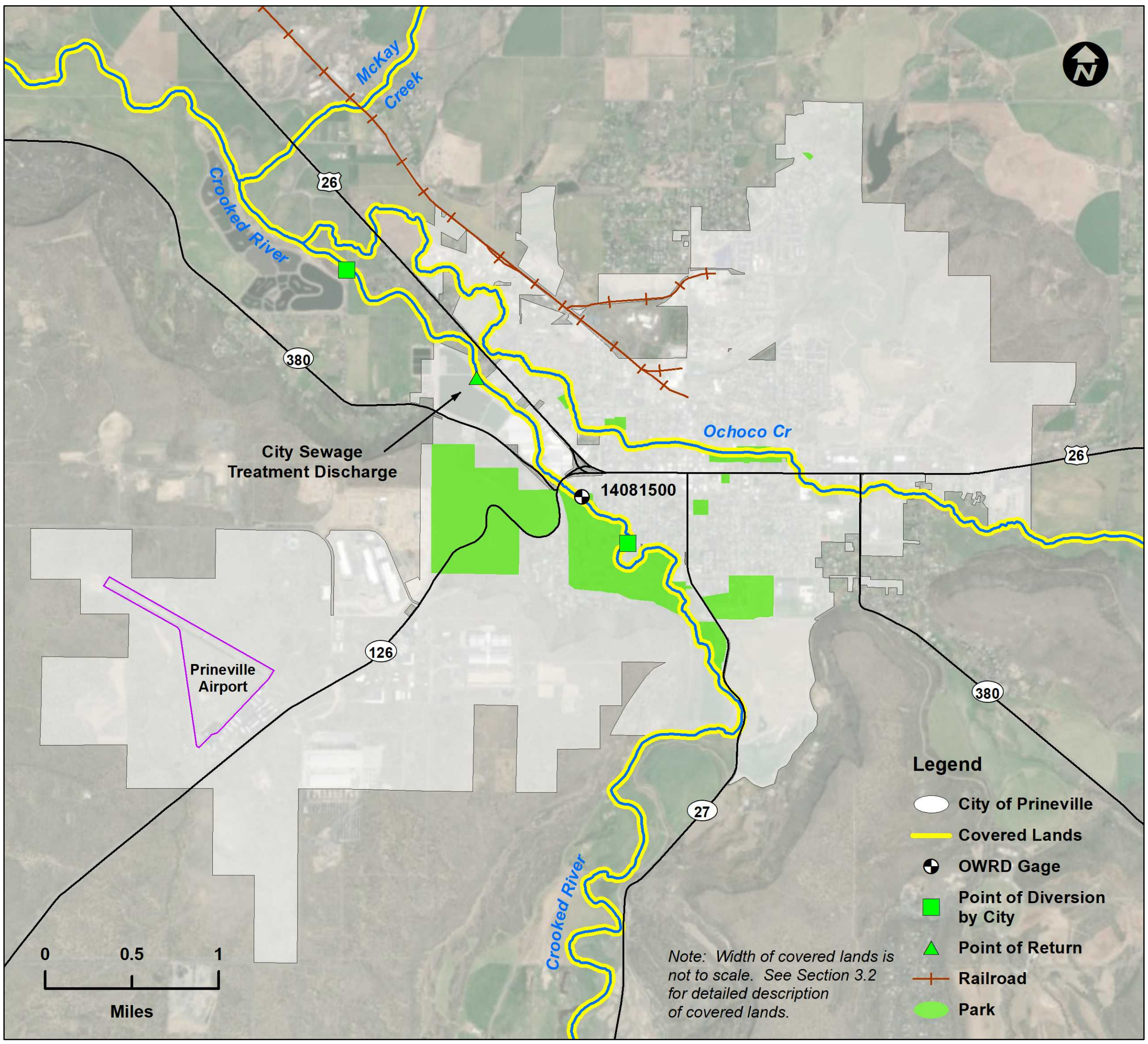

Figure 3-12. Map of Prineville, Oregon.

3.5.10.2 Municipal Groundwater Withdrawal

Current and projected future groundwater withdrawals by the City are covered activities in the DBHCP. The City's municipal water system currently consists of 12 wells, five storage tanks and 42 miles of distribution mains that provide water to 3,825 residential, commercial, industrial and bulk customers (service connections). All but about 300 homes within the City are served by the water system. Current capacity of the 12 wells is 6.5 cfs, 2,908 gpm, or 4.2 million gallons per day (mgd). Eight of the wells draw water from the two alluvial aquifer systems beneath the Prineville Valley floor. Seven of these extract groundwater year round from a deep, confined aquifer (between 150 feet and 400 feet below the surface). During periods of peak water demand (July and August), the one shallower well (4th Street Shallow) extracts groundwater from 15 to 30 feet below the surface. The four additional wells, which are located west of the City, draw from the deep, semi-confined aquifer in the ancestral Crooked River channel deposits.

The City holds eight water right certificates, three water right permits, and one water right transfer order that authorize the appropriation of groundwater for municipal purposes. These groundwater rights allow appropriation of up to 13.3 mgd, or approximately 9,223 gpm. The City holds two additional groundwater rights for group domestic and domestic expanded use that are currently inactive. The City also holds an industrial right for the use of groundwater associated with the Clear Pine facility.

Use of water under three of the City's permits is contingent on the City providing required mitigation. The Deschutes Groundwater Mitigation Program (OAR 690-505 and 690-521) was developed to maintain scenic waterway flows in the Deschutes Groundwater Study Area, while allowing new groundwater uses. The Oregon Water Resources Department determined, pursuant to the mitigation program, that the City's first permit for the use of Airport Wells #1 through #4 (Permit G-17577) has a mitigation obligation of 496.8 acre-feet of water in the Crooked River zone of impact. The City intends to meet this obligation through incremental mitigation and "offset" as it incrementally develops this right over time. To date, the City has provided 263.6 acre-feet of mitigation and offset for Permit G-17577.

The City's second permit for the use of Airport Wells #1 through #9 in the Crooked and General Zones of Impact (Permit G-18155) has a mitigation obligation of 944.3 acre-feet of water. The City is providing incremental mitigation and offset for this permit as well. To date, the City has provided 340.3 acre-feet of mitigation and offset for Permit G-18155.

The City's third permit for use of the valley floor well field (up to 25 wells; Permit G-18154) has a mitigation obligation of 1,292 acre-feet of water. The City is providing incremental mitigation for this permit and to date has provided 4 acre-feet of mitigation for Permit G-18154.

In addition to the development of groundwater described above, the City also intends to use its existing groundwater rights to develop an aquifer storage and recovery (ASR) project, whereby water can l be stored in the airport area aquifer during the non-peak season when there is less demand on the basin's water resources and can then be withdrawn as "stored groundwater" during periods of high demand. The City has authorization from Oregon Water Resources Department to test ASR under ASR Limited License LL-026.

3.5.10.3 Discharge of Municipal Effluent to the Crooked River

The direct and indirect discharge of municipal effluent to the Crooked River is a covered activity in the DBHCP. The City's sewage collection system includes over 30 miles of pipes ranging in size from 4 to 48 inches in diameter, and eight sewage pump (lift) stations. The sewage treatment facility consists of two plants with adequate capacity to meet anticipated needs through 2037, although minor improvements are planned to improve system efficiency (Anderson Perry 2017). Discharge of effluent from the sewage treatment facility is allowed under the conditions of the City's NPDES Permit No. 101433, ODEQ Permit No. 973920, and Environmental Protection Agency (EPA) NPDES Permit No. OR0023612. The NPDES permit allows discharge of treated effluent at four locations: a) directly to the Crooked River at RM 46.8, b) as irrigation to the City-owned Meadow Links Golf Course, c) as irrigation to City-owned pastureland, and d) into a series of recently created wetlands adjacent to the Crooked River. Discharge directly to the Crooked River at RM 46.8 occurs only from November 1 through April 30, only when river flows are greater than 15 cfs, and only when dilution is at least 15:1 (receiving water volume to discharge volume). Effluent that cannot be discharged directly to the Crooked River between November 1 and April 30 is stored in a lagoon at the treatment plant site for discharge to one of the other three sites. From May 1 through October 31 treated effluent is only discharged to the other three sites. The DBHCP covers the effects of these discharges on water temperature and flow in the Crooked River.

3.5.10.4 Surface Water Diversions

The City has three authorized points of diversion of Crooked River water that are covered by the DBHCP. One diverts Crooked River water from the Peoples' Irrigation Ditch, the second pumps up to 0.01 cfs directly from the Crooked River at RM 48.4, and the third pumps up to 1.0 cfs from the Crooked River at RM 45.9 to irrigate Meadow Lakes Golf Course. Primary irrigation for the golf course is provided by the City's sewage treatment effluent. When sewage treatment plant effluent is insufficient, water from the Crooked River is used.

3.6 DBHCP Implementation

The DBHCP covers the activities of nine separate Permittees (eight irrigation districts and the City). The activities of each Permittee are conducted independent of the activities of the other Permittees, are geographically separated from the activities of the other Permittees, and have impacts on the covered species that are clearly discernable from the impacts of the other Permittees. This approach of separating the covered activities by Permittee is mirrored in the conservation strategy of the DBHCP. Each Permittee will implement one or more conservation measures to minimize and mitigate the effects of its covered activities on the covered species. These conservation measures are listed in Table 3-9 and described in detail in Chapter 6, *Habitat Conservation*. In the same way that the impacts of each Permittee on the covered species are independent of the other Permittees, the benefits of each Permittee's conservation measures are independent of the other Permittees. Each conservation measure will be the responsibility of a single Permittee or small group of Permittees, and each measure will be specific to the impacts of the implementing Permittee(s). The individual benefits of each conservation measure will be realized regardless of whether the other measures are implemented. It is anticipated that all conservation measures will be implemented as required and the full benefits of all will be realized, but the separate implementation of the measures by each Permittee is integral to establishing clear lines of accountability and facilitating compliance by all parties.

For purposes of compliance, each Permittee will only be responsible for implementing the conservation measures assigned to it in Table 3-9. Any Permittee that fails to implement a conservation measure for which it is responsible could be found out of compliance with the DBHCP, but noncompliance by one Permittee would not extend to other Permittees. The failure of one Permittee to comply with the DBHCP will not prevent another Permittee from remaining in compliance. Four conservation measures involve joint implementation by multiple Permittees, but in the event of non-compliance by a particular Permittee, the individual responsibilities of each Permittee may be delineated. All other conservation measures have single designated Permittees responsible for their implementation. The DBHCP also requires monitoring, reporting and adaptive management to track compliance and effectiveness of the conservation measures. These are described in detail in Chapter 7, *Monitoring, Reporting and Adaptive Management*, where they are linked directly to specific conservation measures. Like the conservation measures, each provision for monitoring, reporting and adaptive management is the responsibility of a single Permittee.

The Permittees are entering an Inter-District Coordination Agreement, included in Appendix B, to further govern the implementation of the DBHCP. The agreement clarifies and provides a process for confirming the Permittees' responsibilities in the event that one or more Permittees choose to terminate or amend their incidental take coverage under the Permits and their obligations under the DBHCP, or if one or more Permits is revoked and one or more of the Permittees seeks reinstatement of the Permit(s) with respect to their covered activities.

The separate implementation of the conservation measures and the clear lines of accountability are possible because of the geographic and legal separation of the Permittees and their irrigation facilities. Each Permittee conducts its covered activities at its own facilities and has sole authority among the Permittees over those activities. No Permittee has the authority to direct the activity of another Permittee. The individual effects of those covered activities on the covered species have been identified and distinguished from the effects of other Permittees, and each conservation measure has been designed to address only the effects of an individual Permittee. This direct connection from covered activity to impact to conservation measure enables a clear understanding of the effects of the covered activities, the benefits of the conservation measures and the responsibilities for implementation of the measures.

Table 3-9. Deschutes Basin Habitat Conservation Plan conservation measures, monitoring provisions and Permittee responsibilities.

Water Body	Target Species	Conservation Measure	Adaptive Management	Responsible Party	Notes
Crane Prairie Reservoir and Deschutes River upstream of Wickiup Reservoir	OSF	CP-1	CP-1.1, CP-1.2, CP-1.3	COID	COID operates Crane Prairie Reservoir as per agreement with AID and LPID.
Wickiup Reservoir and Deschutes River from Wickiup Dam to Bend	OSF	WR-1	WR-1.1	NUID	NUID may make available water from Wickiup Reservoir to other districts, but NUID has sole responsibility for operation of the reservoir.
Upper Deschutes River, Crescent Creek and Little Deschutes River	OSF	UD-1		AID, COID, LPID, NUID, SID and TID	This is a conservation fund that is funded by six of the Permittees. Funding responsibility of each individual Permittee is described in an inter-district agreement.
Deschutes River downstream of Bend	Steelhead, Bull Trout, Sockeye	DR-1		AID, COID and SID	Three districts will coordinate to protect winter flows downstream of Bend. Each district's responsibility in coordinating the protection of flows is set forth in the measure.
Crescent Creek and Little Deschutes River	OSF	CC-1, CC-2, CC-3		TID	TID has sole responsibility for covered activities that affect OSF in Crescent Creek and Little Deschutes.
Whychus Creek	Steelhead and Bull Trout	WC-1, WC-2, WC-3, WC-4, WC-5, WC-6, WC-7		TSID	TSID has sole responsibility for covered activities in Whychus Creek.
Crooked River	Steelhead and Bull Trout	CR-1		OID	OID will contribute to instream flows in the Crooked River during the irrigation season.
	Steelhead and Bull Trout	CR-5			OID will provide financial support for screening of diversions.
	Steelhead and Bull Trout	CR-4		OID, NUID and City	This is a conservation fund that is funded by three of the Permittees. Funding responsibility of each individual Permittee is set forth in the measure.
	Steelhead and Bull Trout	CR-6		NUID	NUID will contribute to instream flows in the Crooked River during the irrigation season.
	Steelhead	CR-7		OID and NUID	OID and NUID will each allow spring pulse flows to pass down the Crooked River without being diverted.

Water Body	Target Species	Conservation Measure	Adaptive Management	Responsible Party	Notes
Ochoco Creek	Steelhead and Bull Trout	CR-2		OID	OID has sole responsibility for covered activities in Ochoco Creek.
McKay Creek	Steelhead and Bull Trout	CR-3		OID	OID has sole responsibility for covered activities in McKay Creek.

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FINAL

DESCHUTES BASIN HABITAT CONSERVATION PLAN

Chapter 4 – Current Conditions of the Covered Lands and Waters

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4 – CURRENT CONDITIONS OF THE COVERED LANDS AND WATERS

4.1 Overview

The covered lands lie entirely within the Deschutes Basin of Central Oregon. The Deschutes River is the second largest tributary to the Columbia River in the State of Oregon. It has a drainage area of roughly 10,700 square miles and enters the Columbia River near the town of Biggs, about 100 miles upstream of Portland, Oregon. Major tributaries to the Deschutes River, from mouth to headwaters, include White River, Warm Springs River, Trout Creek, Shitike Creek, Willow Creek, Metolius River, Crooked River (with its tributaries Ochoco and McKay creeks), Whychus Creek, Tumalo Creek, Little Deschutes River (with its tributary Crescent Creek) and Fall River.

The Deschutes Basin lies between the Cascade Mountains to the west and the Ochoco Mountains to the east. Elevations within the basin vary from 164 feet at Biggs to over 11,000 feet at Mt. Hood. Orographic effects of the Cascade Mountains produce a wide range in precipitation across the basin, from 90 inches or more per year along the Cascade Crest to fewer than 9 inches per year in Redmond, Deschutes County (WRCC 2017). Most surface flow in the Deschutes Basin originates from snowmelt at higher elevations that is collected as direct surface runoff (particularly in the Ochoco Mountains) or groundwater discharge from numerous springs that originate on the east slopes of the Cascades. The highly-permeable volcanic deposits in the western two-thirds of the Deschutes Basin cause rapid infiltration of rain and snowmelt, followed by groundwater movement to springs that emerge at lower elevations (Gannett and Lite 2004). The large relative contribution of groundwater to surface flow tends to reduce the seasonal extremes in flow (spring highs and late summer lows) that are characteristic of other basins in the Pacific Northwest. There are exceptions to this, however, particularly in the upper Crooked River and Little Deschutes River subbasins, where most snowmelt results in surface runoff that peaks rapidly and briefly in the spring, but diminishes substantially by mid-summer. The Lower Crooked River, like the Deschutes River, receives considerable inflow from groundwater discharge year round.

The Deschutes Basin encompasses all or part of nine Oregon counties (Crook, Deschutes, Harney, Hood River, Jefferson, Klamath, Lake, Sherman and Wasco). Crook, Deschutes, Jefferson, Sherman and Wasco counties make up the majority of the basin, and along with Klamath County they contain all of the covered lands. The basin is generally rural, with a total population in 2010 of roughly 332,000 (Portland State University 2016). More than half the population resides in Deschutes County, which reported 157,733 residents in 2010. Of these, 102,854 (31 percent of the basin population) lived within Bend and Redmond, the two largest cities.

Land use is predominantly agricultural, forestry and wildland recreation. Roughly 51 percent of the basin is public land; most of this is federally-owned and managed by the USDA Forest Service (USFS) or USDI Bureau of Land Management (BLM). Another 652,406 acres lie within the Warm Springs Reservation, which is occupied and governed by the Confederated Tribes of the Warm Springs.

The covered lands are divided into six separate geographic units for purposes of the DBHCP: Upper/Middle Deschutes River, Crescent Creek/Little Deschutes River, Whychus Creek, Lower Deschutes River, Trout Creek, and Crooked River subbasin (Crooked River/Ochoco Creek/McKay Creek/Lytle Creek). Key reference points on the covered lands are Lake Billy Chinook (RM 110 to 120) at the confluence of Deschutes, Crooked and Metolius rivers, The City of Bend (RM 164 to 175), The City of Prineville at the confluence of Crooked River and Ochoco Creek, and Sunriver at the confluence of Deschutes and Little Deschutes Rivers (Figure 4-1).

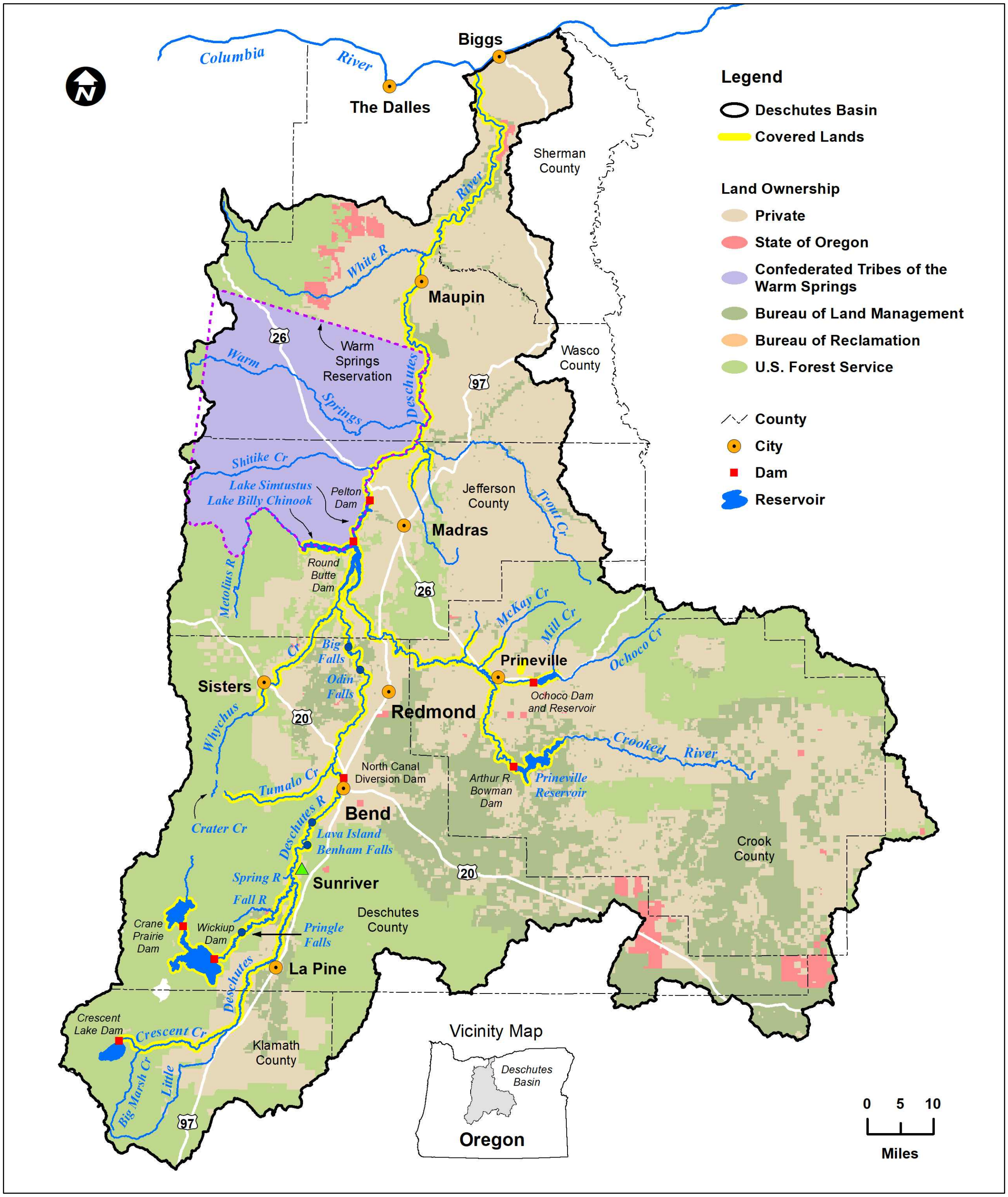

Figure 4-1. **Map of the Deschutes Basin.**

4.2 Upper and Middle Deschutes River

4.2.1 Geography and Land Use

The Upper and Middle Deschutes River reaches extend from the headwaters northwest of La Pine, Oregon to the Pelton Reregulating Dam (the downstream limit of the Pelton Round Butte Hydroelectric Project) at RM 100. Various sources (NPCC 2004) have split the Upper and Middle Deschutes reaches at Big Falls (RM 132), which is the upstream limit of anadromous fish access on the mainstem Deschutes River. An equally valid distinction can be made at North Canal Diversion Dam in Bend (RM 165) to reflect the significant change in summer flow that occurs at that point due to irrigation diversions. This latter approach, which is used for the DBHCP, is consistent with Gannet et al. (2001) who divided the Upper and Middle Deschutes River reaches at the Bend Gage (Gage 14070500; RM 164.3).

Principal tributaries to the Upper Deschutes River are Fall River (confluence at RM 204.5), Little Deschutes River (confluence at RM 192.5), and Spring River (confluence at RM 191.0). Fall and Spring rivers are spring-fed drainages that flow only short distances before entering the Deschutes River. The Little Deschutes River, in contrast, drains about 1,050 square miles over of a course of 97 miles (see Section 4.3, Crescent Creek and Little Deschutes River). Tributaries to the Middle Deschutes River are Tumalo Creek (confluence at RM 160.4), Whychus Creek (RM 123), Crooked River, and Metolius River. The Crooked and Metolius rivers enter the Deschutes River at Lake Billy Chinook, the principal reservoir of the Pelton Round Butte Hydroelectric Project.

Stream gradient in the Deschutes River upstream of Benham Falls (RM 181) is generally low (< 1%) except at Pringle Falls (RM 217). Meander rate is high, resulting in frequent side channels, sloughs and oxbows. Instream habitat structure and complexity are generally low (NPCC 2004). Streambank conditions, particularly from Wickiup Dam to Fall River, reflect the recent history of managed flows that exposes beds and banks to frost heave during the winter and erosive high flows during the spring and summer. Riparian areas along the Upper Deschutes River, which lies predominantly on National Forest System lands, are mostly dominated by conifer forest. Downstream of Benham Falls the bed and banks of the river become increasingly dominated by exposed lava flow and boulders, riparian slopes become steeper, and the channel becomes more confined. Riparian vegetation also becomes sparser and lower in stature (transitioning from trees to shrubs and grasses) as annual precipitation decreases along the Middle Deschutes River.

Land use along the Deschutes River upstream of Bend is predominantly forestry, recreation, agriculture and rural residential. Within the Bend urban growth boundary the river corridor is highly developed for residential, commercial and recreational use. Downstream of Bend the predominant land uses are cultivated agriculture, grazing, recreation, hydropower and rural residential. The Deschutes River is designated under the Federal Wild and Scenic Rivers Act of 1968 as Recreational from Wickiup Dam to Sunriver (RM 186), and from Lava Island (RM 175) to Bend (RM 172). It is designated as Scenic from Sunriver to Lava Island and from Odin Falls (RM 140) to Lake Billy Chinook (RM 120).

Two of the five irrigation reservoirs covered by the DBHCP impound water within the mainstem of the Upper Deschutes River. These are Crane Prairie Reservoir, which is created by Crane Prairie Dam at RM 238.5, and Wickiup Reservoir that lies behind Wickiup Dam at RM 226.8. Five of the eight covered irrigation districts (AID, COID, LPID, NUID and SID) divert all or most of their irrigation water from the mainstem Deschutes River within or immediately upstream of Bend. Another district (TID) diverts a significant portion of its irrigation water within this reach as well.

4.2.2 Hydrology

The headwaters of the Deschutes and Little Deschutes rivers lie within the Cascade Range and Newberry Volcano Deposits hydrogeologic unit described by Lite and Gannett (2002), while middle elevations of both rivers (down to their confluence near La Pine) fall within the Quaternary Sediment unit. Both units are characterized by highly-permeable materials with rapid infiltration rates. Most precipitation that falls in the upper basin becomes groundwater before reemerging at multiple springs and seeps. Direct surface runoff makes up a relatively small percentage of the flow in the Upper Deschutes River. The net effect of this is an unregulated flow regime that shows considerably less seasonal variation than many other Cascade Mountain streams. Current stream flows are also heavily influenced by irrigation activities, however, and show considerably more seasonal variation than unregulated flows. The storage, release and diversion of irrigation water result in flows upstream of Bend that are generally high in the late spring and summer and low in the fall, winter and early spring. Flows downstream of Bend are low during the late spring and summer irrigation season because most flow (natural and released storage) is diverted into six canals and multiple small diversions on the Deschutes River and one canal on Tumalo Creek (see Chapter 3, *Scope of the HCP* for a description of covered diversions). The rates of diversion at each of the covered facilities vary during the irrigation season in accordance with the respective water rights, but peak diversions typically occur between May 16 and September 15. During the fall, winter and early spring, flows in the Middle Deschutes are also reduced from natural conditions by irrigation storage, but natural inflow from tributaries and springs downstream of the reservoirs moderates the influence of storage somewhat and winter flows are not nearly as low at Bend as they are between Wickiup Dam and Fall River. Middle Deschutes River flows fluctuate periodically during the winter when water is diverted into four of the canals (Central Oregon, Pilot Butte, Swalley and Tumalo) for periods of 1 week or less each month to supply water for livestock.

The current hydrology of the Upper and Middle Deschutes River is illustrated by flow data for the past 38 years (Figures 4-2 through 4-5). The effects of the irrigation activities are most apparent in the Upper Deschutes and decrease in relative magnitude with downstream distance due to the counteracting influences of tributary and groundwater inflows. Immediately downstream of Wickiup Dam (Figure 4-2) flows are highest in the summer and lowest in the winter. The same general trend is evident 45 miles downstream at Benham Falls (Figure 4-3), but the total flow is increased roughly 500 cfs due to input from surface tributaries and groundwater discharge. Another 17 miles downstream, just below Bend (Figure 4-4), the annual flow pattern is quite different due to irrigation diversions. Winter flows in the Deschutes River below Bend are not appreciably different from those at Benham Falls because there is limited inflow and diversion between these two points, but summer flows are much lower below Bend due to irrigation diversions. This same pattern persists to the gage at Culver (Figure 4-5), 40 miles downstream of Bend at the top of Lake Billy Chinook, but the total flow at Culver is higher due to inflow from Tumalo Creek, Whychus Creek and groundwater discharge.

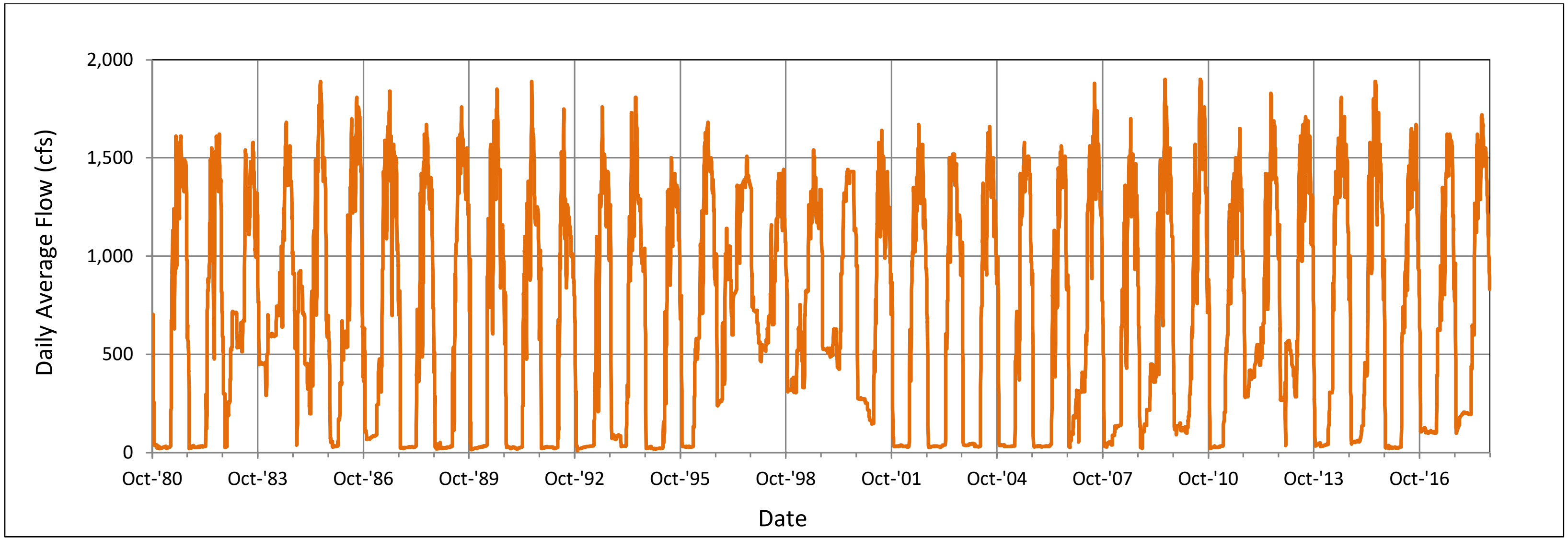

Figure 4-2. Reported flow in the Deschutes River downstream of Wickiup Dam (RM 226) from 1981 through 2018. Source: OWRD 2020a.

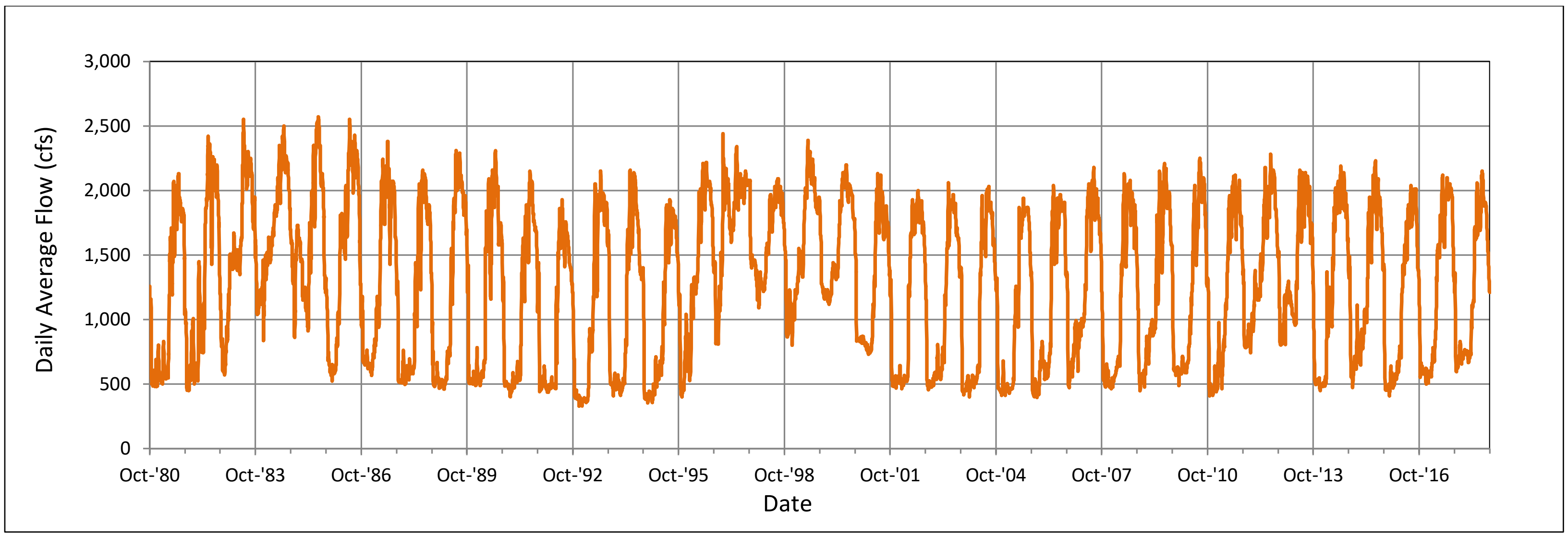

Figure 4-3. Reported flow in the Deschutes River at Benham Falls (RM 181) from 1981 through 2018. Source: OWRD 2020b.

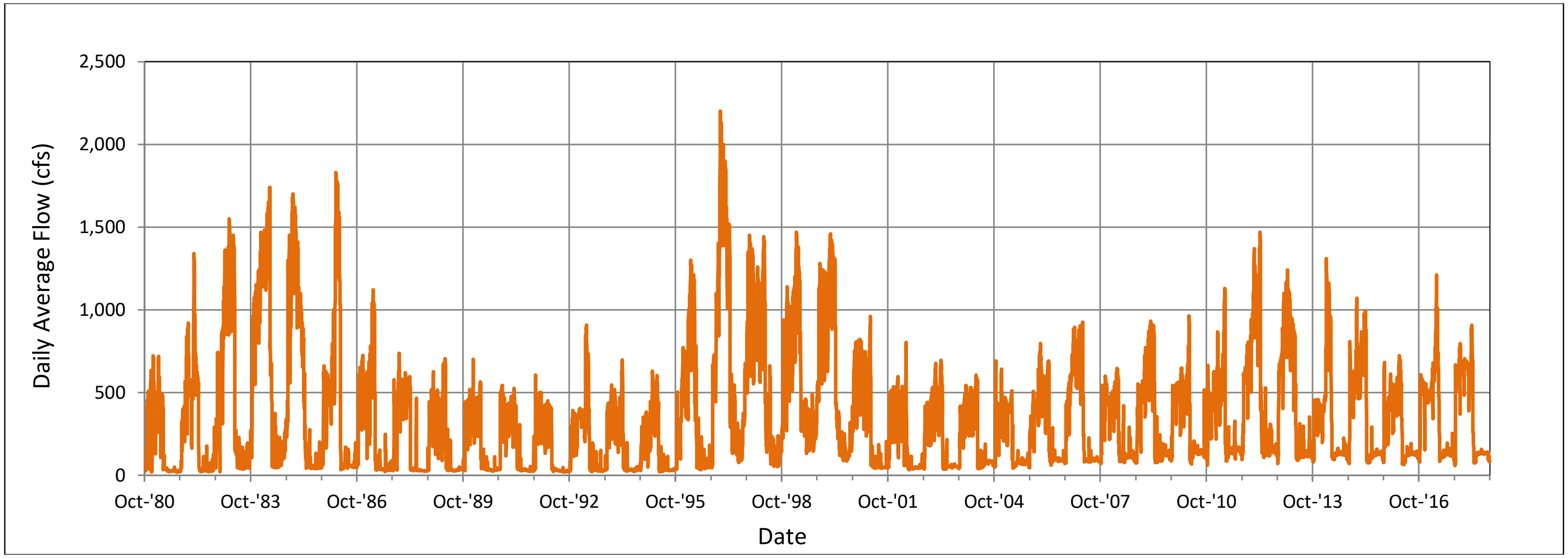

Figure 4-4. Reported flow in the Deschutes River downstream of Bend (RM 164) from 1981 through 2018. Source: OWRD 2020c.

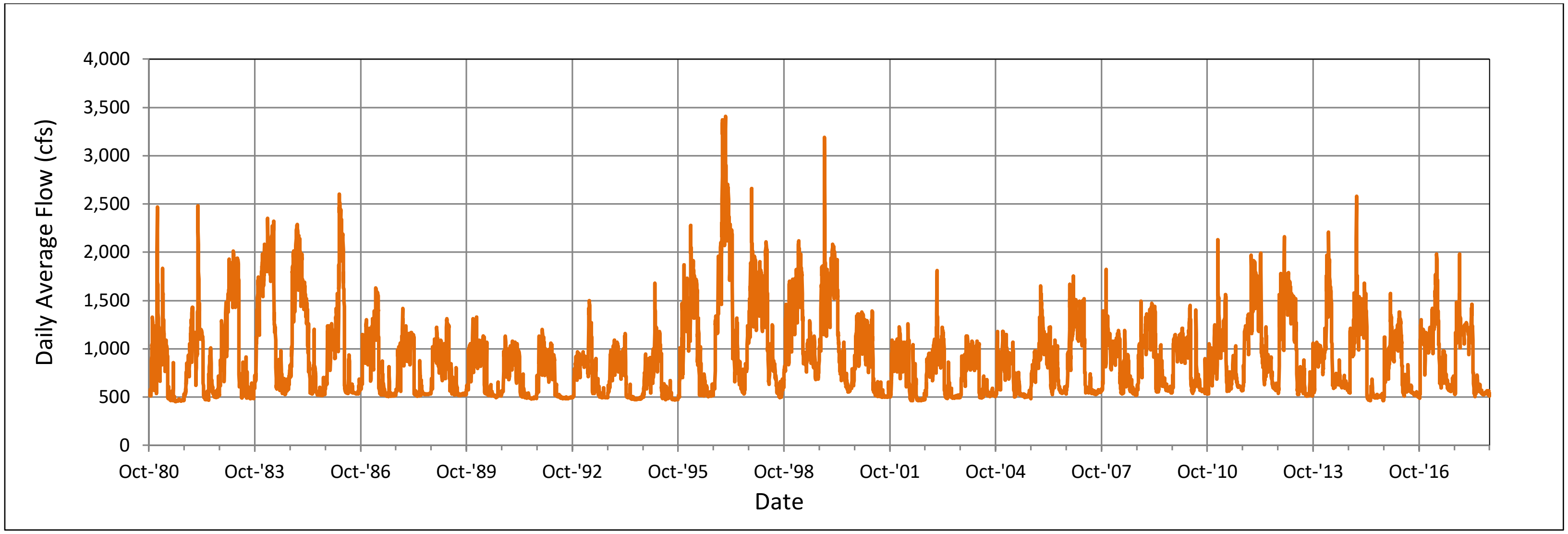

Figure 4-5. Reported flow in the Deschutes River at Culver (RM 120) from 1981 through 2018. Source: OWRD 2020d.

4.2.3 Water Temperature

Water temperatures in the Upper and Middle Deschutes River show a strong seasonal trend reflective of local weather patterns, with additional influences from the storage, release and diversion of irrigation water (Figures 4-6 through 4-9). The 7-day running average of daily maximum water temperatures (7-DADM) is typically 3 to 5 °C from December through February, and 18°C or higher in July and August (Table 4-1). Daily maximum water temperatures also vary longitudinally in the river. From 2011 through 2016, water leaving Wickiup Reservoir in December (Figure 4-7) averaged 2.5°C warmer than water entering the reservoir (Figure 4-6), while water leaving the reservoir in July averaged 7.5°C cooler than water entering during the same month. This is largely due to the dampening effect of the reservoir, which has a maximum volume of 200,000 acre-feet and a release structure that is up to 78 feet below the surface at full pool. Water temperature data are not available for inflows to Crane Prairie Reservoir, but that reservoir, which is considerably shallower than Wickiup, likely has a warming effect during the summer that accounts for the high temperatures of water entering Wickiup.

Downstream of Wickiup Reservoir, winter water temperatures generally decrease with downstream distance while summer water temperatures increase. The 7-DADM at Benham Falls (Figure 4-8) averaged 0.4°C less than below Wickiup Reservoir (Figure 4-7) in December and 3.3°C warmer than below Wickiup Reservoir in July (Table 4-1). Infusions of cool water from Tumalo Creek (RM 160) and a number of springs downstream of Big Falls (RM 132) counteract the general trend of increasing summer temperature with downstream movement. Water temperature data collected upstream and downstream of Tumalo Creek (Figures 4-10 and 4-11) show the slight decrease in peak summer temperatures provided by cold Tumalo Creek water. Similarly, data from multiple points between RM 133 and RM 120 in 2013 (Figures 4-12 and 4-13) illustrate the significant cooling effect of spring discharge to the river in this reach. About 1 mile upstream of Big Falls at Lower Bridge (RM 133), the 7-DADM was above 18°C for 102 days and above 20°C for 65 days (Figure 4-12). About 5 miles downstream of Big Falls at Foley (RM 128) the river was cooler; the 7-DADM was above 18°C for 41 days and above 20°C for 4 days. Another 8 miles downstream at the Culver Gage (RM 120), the reported 7-DADM only exceeded 16°C briefly during 2013.

The 112.5 miles of Deschutes River from Wickiup Dam to Lake Billy Chinook are identified as water temperature limited under Section 303(d) of the Clean Water Act for exceeding the year-round maximum 7-DADM of 18°C for salmon and trout rearing and migration (ODEQ 2017). Crane Prairie and Wickiup reservoirs are also identified as water temperature limited for exceeding the year-round maximum 7-DADM of 12°C for bull trout spawning and juvenile rearing. Fish use designation for the Upper and Middle Deschutes River is salmon and trout rearing and migration (ODEQ 2017). Resident trout are present in the Deschutes River from the headwaters to the mouth, but bull trout, steelhead and salmon are absent above Big Falls (RM 132).

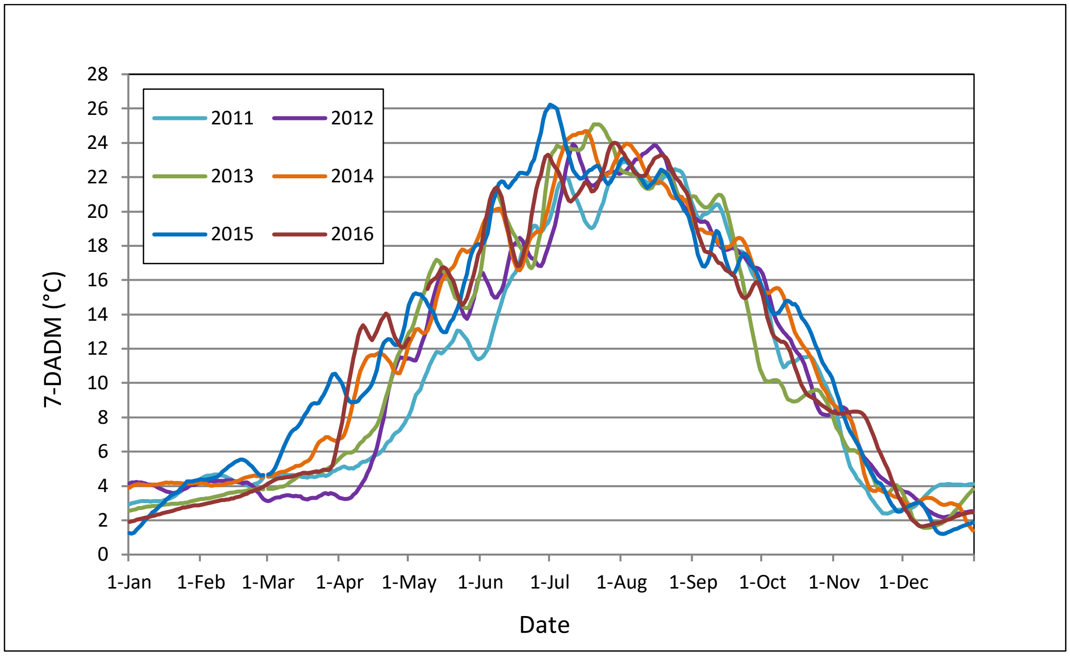

Figure 4-6. Seven-day averages of daily maximum water temperatures (7-DADM) in the Deschutes River below Crane Prairie Reservoir (RM 238). Source: Reclamation 2017a.

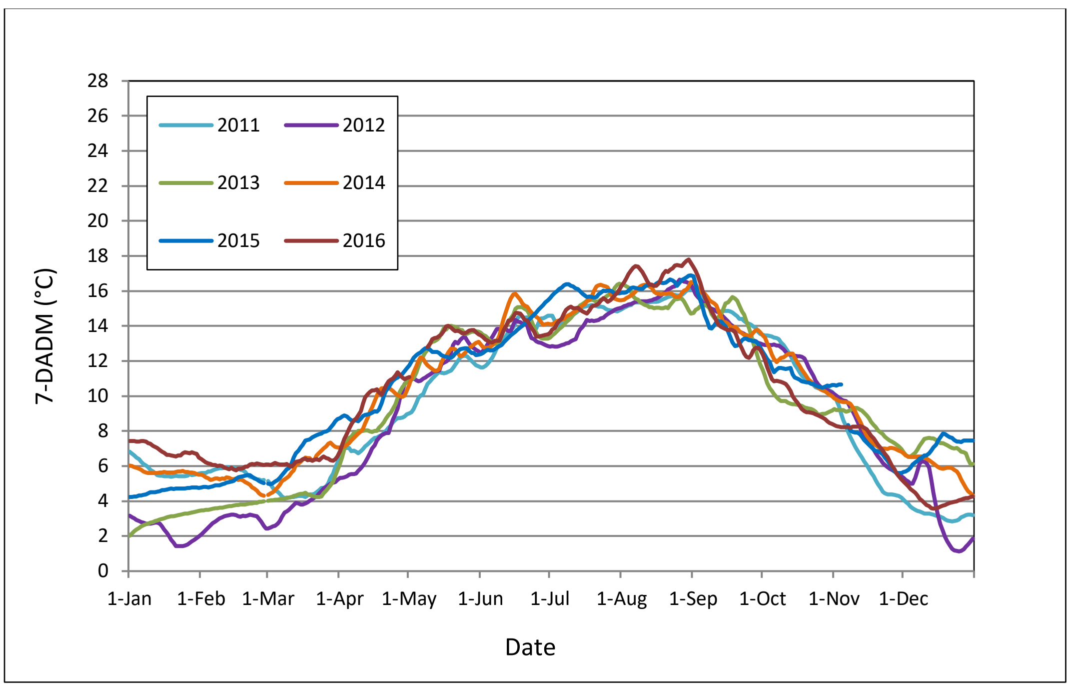

Figure 4-7. Seven-day averages of daily maximum water temperatures (7-DADM) in the Deschutes River below Wickiup Reservoir (RM 223). Source: Reclamation 2017a.

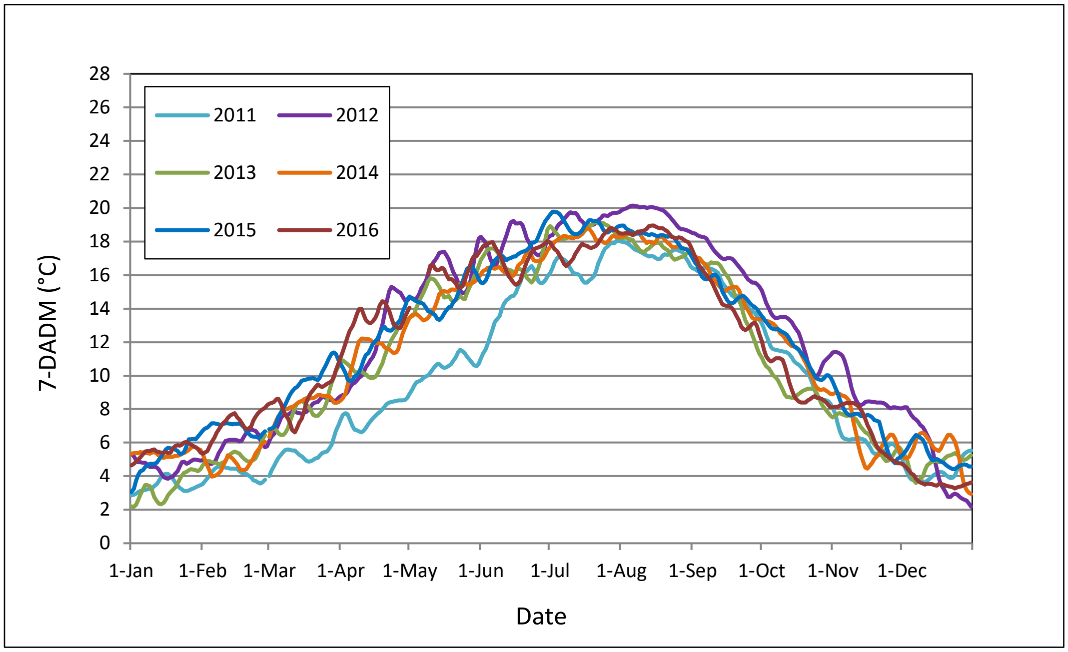

Figure 4-8. Seven-day averages of daily maximum water temperatures (7-DADM) in the Deschutes River at Benham Falls (RM 181). Source: Reclamation 2017a.

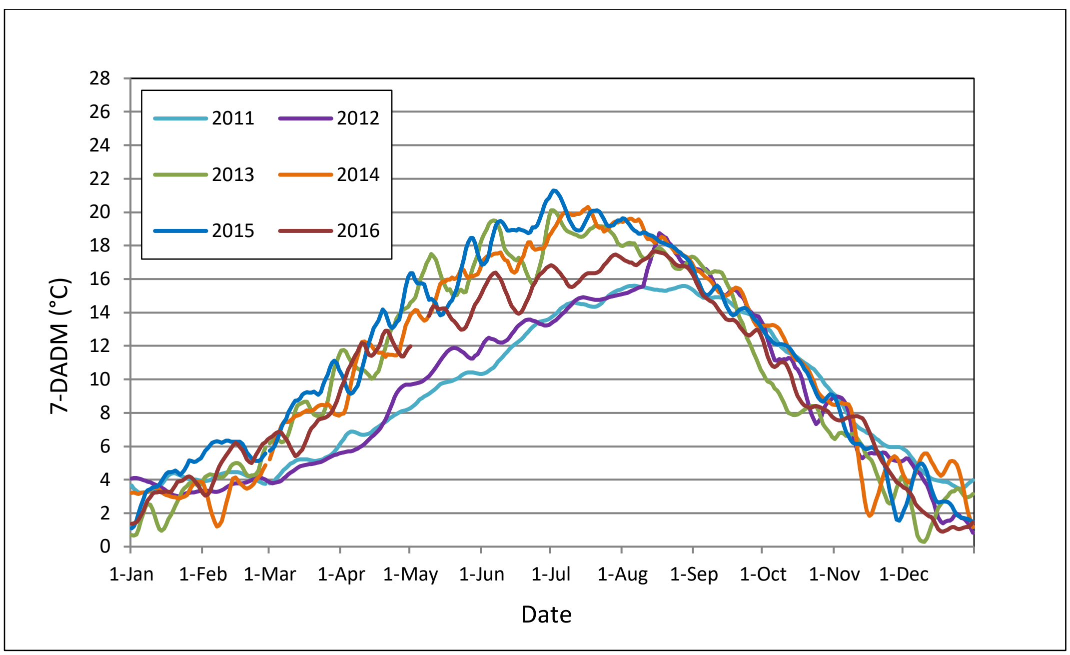

Figure 4-9. Seven-day averages of daily maximum water temperatures (7-DADM) in the Deschutes River below Bend (RM 164). Source: Reclamation 2017a.

Table 4-1. Monthly averages for the 7-day average of daily maximum water temperature (7-DADM) in the Deschutes River from 2011 through 2016.

MONTH	7-DADM Monthly Average (°C)			
	Deschutes River below Crane Prairie Reservoir	Deschutes River below Wickiup Reservoir	Deschutes River at Benham Falls	Deschutes River below Bend
JAN	3.3	4.7	4.6	3.3
FEB	4.1	4.8	5.7	4.4
MAR	5.1	5.4	7.9	6.9
APR	9.0	8.6	11.2	10.2
MAY	14.5	12.3	14.4	13.6
JUN	18.7	13.8	16.7	15.8
JUL	22.5	15.0	18.3	17.3
AUG	22.0	16.0	18.2	17.3
SEP	17.8	14.4	15.4	14.7
OCT	11.6	11.0	10.7	10.2
NOV	5.5	7.6	7.0	5.9
DEC	2.6	5.1	4.7	3.1

Source: Reclamation 2017a.

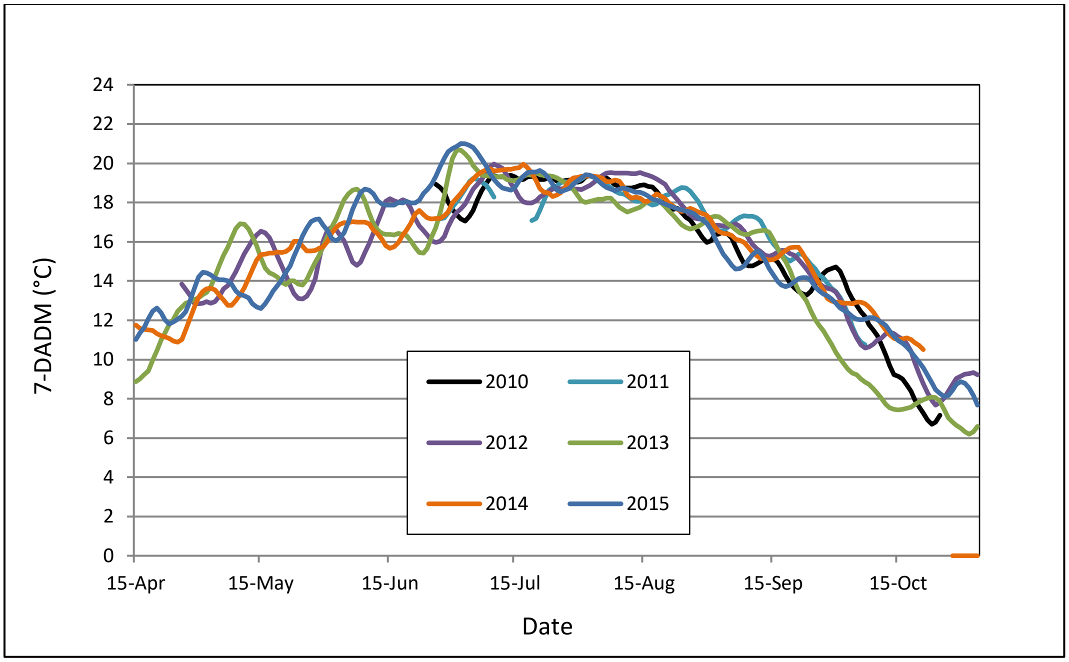

Figure 4-10. Seven-day averages of daily maximum water temperatures (7-DADM) in the Deschutes River upstream of Tumalo Creek (RM 160.25), mid-April through October. Source: UDWC 2016.

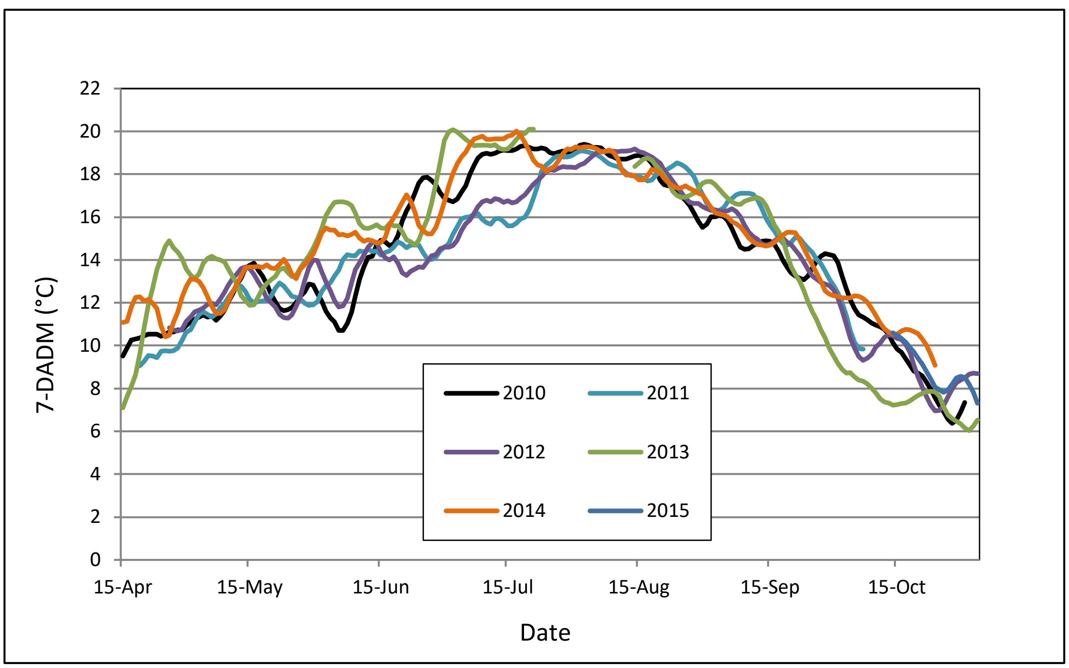

Figure 4-11. Seven-day averages of daily maximum water temperatures (7-DADM) in the Deschutes River downstream of Tumalo Creek (RM 160.00) from mid-April through October. Source: UDWC 2016.

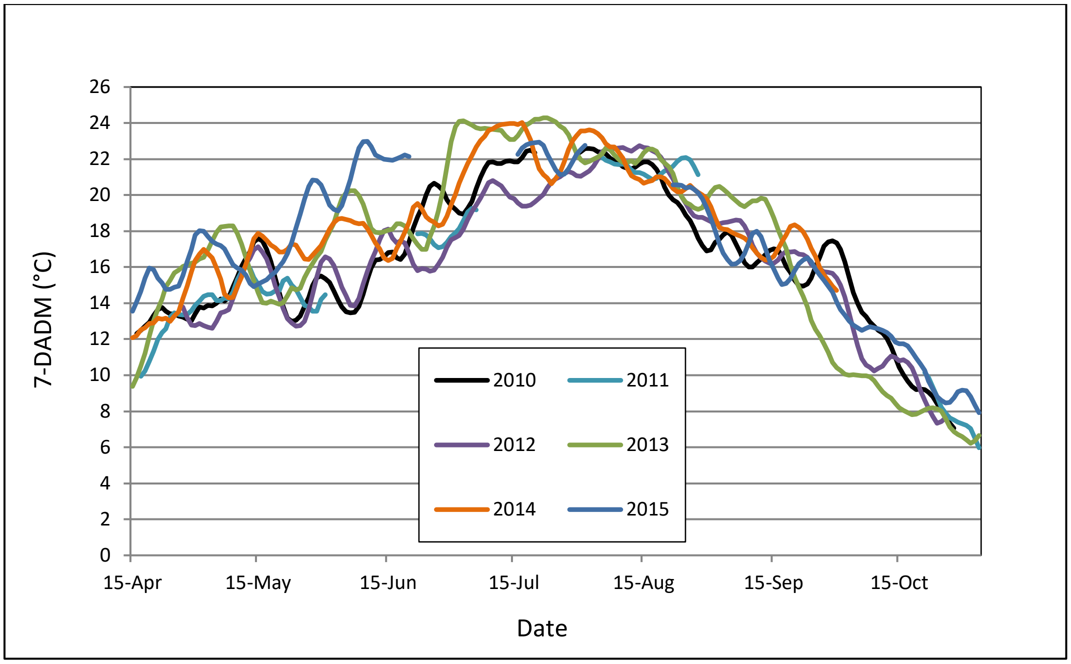

Figure 4-12. Seven-day averages of daily maximum water temperatures (7-DADM) in the Deschutes River at Lower Bridge (RM 133) from mid-April through October. Source: UDWC 2016.

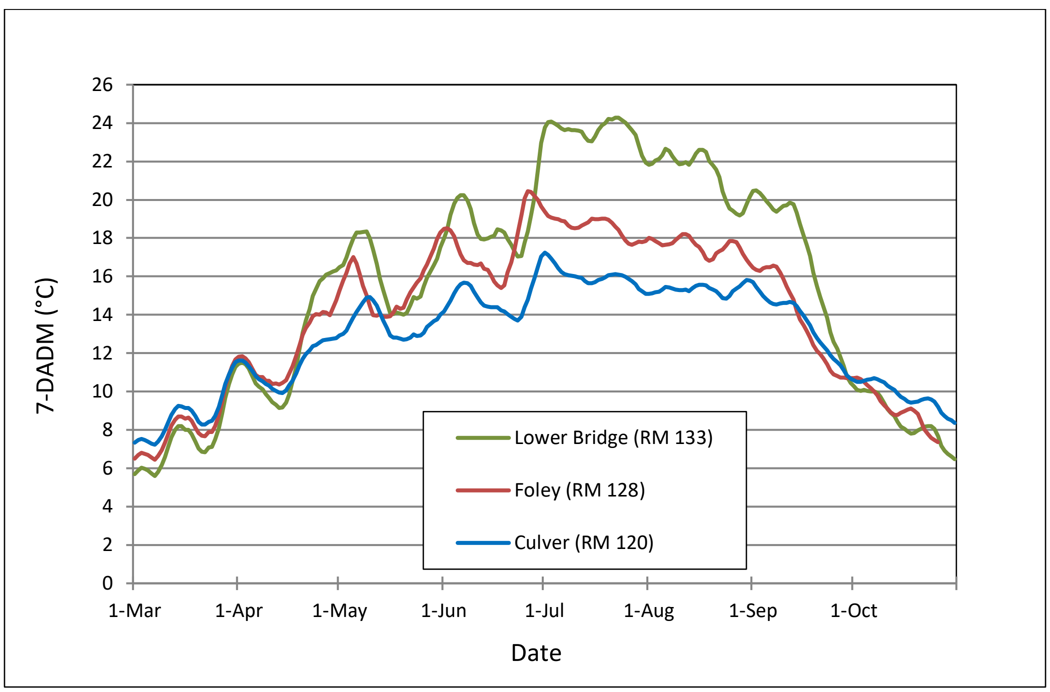

Figure 4-13. Seven-day averages of daily maximum water temperatures (7-DADM) at three locations in the Middle Deschutes River from March through October 2013. Source: UDWC 2016.

4.2.4 Water Quality

Waters in the Deschutes Basin upstream of Bend are designated under Oregon Administrative Rules (OAR) 340 Division 41 for all beneficial uses except hydropower, commercial navigation and transportation (Table 4-2). Portions of the Deschutes River upstream of Bend are listed as water quality limited for flow modification, habitat modification, dissolved oxygen (DO), chlorophyll a and pH (Table 4-3). Flow modification is associated with the storage and release of water at Crane Prairie and Wickiup reservoirs, which has altered the seasonal hydrology of the river. Habitat modification has resulted from a combination of flow modification, riparian land use (agricultural, forestry, residential, commercial and recreational), aquatic recreation (boating) and direct removal of instream large wood (USFS 1996).

Table 4-2. Designated beneficial uses for surface waters of the Deschutes Basin.

Beneficial Uses	Deschutes River *(Mouth to Pelton Regulating Dam)*	Deschutes River *(Pelton Regulating Dam to Bend Diversion Dam)* and Crooked River	Deschutes River *(above Bend Diversion Dam)* and Metolius River	All Other Basin Stems
Public Domestic Water Supply[1]	X	X	X	X
Private Domestic Water Supply[1]	X	X	X	X
Industrial Water Supply	X	X	X	X
Irrigation	X	X	X	X
Livestock Watering	X	X	X	X
Fish and Aquatic Life	X	X	X	X
Wildlife and Hunting	X	X	X	X
Fishing	X	X	X	X
Boating	X	X	X	X
Water Contact Recreation	X	X	X	X
Aesthetic Quality	X	X	X	X
Hydro Power		X		
Commercial Navigation and Transportation				

Source: ODEQ 2003.

Table 4-3. Upper and Middle Deschutes River reaches covered by the DBHCP that are identified in Oregon's 2012 Integrated Report as water quality limited.

Reach	Pollutant	Season	Criteria	Status	
				Category	Description
RM 102.3 - 106.3	Chlorophyll a	Summer	Reservoir, river, estuary, non-thermally stratified lake: 0.015 mg/l	5	Water quality limited, 303(d) list, TMDL needed
RM 102.3 - 106.3	pH	Summer	pH 6.5 to 8.5	5	Water quality limited, 303(d) list, TMDL needed
RM 168.2 - 189.4	Chlorophyll a	Summer	Reservoir, river, estuary, non-thermally stratified lake: 0.015 mg/l	5	Water quality limited, 303(d) list, TMDL needed
RM 116.0 - 222.2	Dissolved Oxygen	Jan 1 – May 15	Spawning: Not less than 11.0 mg/L or 95% of saturation	5	Water quality limited, 303(d) list, TMDL needed
RM 171.7 - 223.3	Dissolved Oxygen	Year round	Cold water: Not less than 8.0 mg/l or 90% of saturation	5	Water quality limited, 303(d) list, TMDL needed
RM 126.4 - 162.6	Flow Modification	Undefined	The creation of tastes or odors or toxic or other conditions that are deleterious to fish or other aquatic life or affect the potability of drinking water or the palatability of fish or shellfish may not be allowed.	4C	Water quality limited, not a pollutant
RM 168.2 - 189.4	Flow Modification	Undefined		4C	Water quality limited, not a pollutant
RM 189.4 - 222.2	Flow Modification	Undefined		4C	Water quality limited, not a pollutant
RM 168.2 - 189.4	Habitat Modification	Undefined	The creation of tastes or odors or toxic or other conditions that are deleterious to fish or other aquatic life or affect the potability of drinking water or the palatability of fish or shellfish may not be allowed.	4C	Water quality limited, not a pollutant
RM 189.4 - 222.2	Habitat Modification	Undefined		4C	Water quality limited, not a pollutant
RM 110.8 - 223.3	Temperature	Year round	Salmon and trout rearing and migration: 7-DADM ≤ 18.0°C	5	Water quality limited, 303(d) list, TMDL needed
RM 223.3 - 244.8	Temperature	Year round	Bull trout spawning and juvenile rearing: 7-DADM ≤ 12°C	5	Water quality limited, 303(d) list, TMDL needed

Source: ODEQ 2017.

Elevated levels of total dissolved gas (TDG) have been reported for the Deschutes River below Wickiup Dam (ODEQ 2011; Symbiotics 2009). High concentrations of atmospheric gasses (primarily nitrogen and oxygen) in aquatic habitats are known to cause the formation of gas bubbles in the blood and tissue of fish and other aquatic organisms that can be harmful or fatal (Rulifson and Pine 1976; Weitkamp and Katz 1980). Covered fish species are absent from the Deschutes River for nearly 100 miles downstream of Wickiup Dam, but Oregon spotted frogs, which can also be susceptible to gas bubble disease (Colt et al. 1984, 1987) have been reported roughly 7 miles downstream of the dam at Bull Bend (RM 219). The Oregon State standard for TDG is a maximum of 110 percent of saturation relative to atmospheric pressure (OAR 340-041-0031). ODEQ (2011) reported TDG levels from 109 to 115 percent saturation in samples collected by Reclamation in the tailrace below the stilling basin in July of 1995, 2001, 2004 and 2007. Symbiotics (2009) collected continuous TDG readings (every 15 minutes for a period of 24 hours) in the tailrace below the stilling basin in 2009, once in April and twice monthly from May to September. These TDG readings ranged from 107 percent saturation to 119 percent saturation, with readings toward the lower end of the range generally occurring in May and June and readings toward the higher end of the range generally occurring in late July, August, and September. In the Symbiotics (2009) data, TDG exceeded 110 percent whenever releases from the dam exceeded 1,000 cfs.

Additional measurements of TDG were made for several miles below Wickiup Dam during peak irrigation releases in September of 2013 and 2014 (Carlson 2013, 2014). In both years, TDG concentrations greater than 100 percent were reported, but no concentrations of 110 percent or more were observed (Table 4-4). TDG concentrations showed a gradual decrease with downstream movement, and dropped to less than 104 percent before the confluence with the Little Deschutes River.

Table 4-4. Results of monitoring for total dissolved gas (TDG) in the Deschutes River downstream of Wickiup Dam in 2013 and 2014.

Location	River Mile	Date	Time	Flow Below Wickiup Dam (cfs)	Water Temp (°C)	BP (mmHg)	ΔP (mmHg)	DO (mg/L)	O_2 (% Sat)	N_2 (% Sat)	TDG (% Sat)
Below Wickiup Dam	226.8	8/27/2013	13:20	1,390	14.6	651	44	9.60	111.0	106.0	107.0
		7/29/2014	14:00	1,535	15.0	653	53	9.47	109.2	108.2	108.1
Downstream from Wickiup Dam 0.1 mile	226.7	8/27/2013	13:45	1,390	14.6	651	53	9.90	114.0	107.0	108.0
Tenino Boat Ramp	226.2	8/27/2013	12:50	1,390	14.6	651	46	9.90	114.0	106.0	107.0
Between Tenino and Wyeth	221.6	8/27/2013	12:20	1,390	15.2	652	44	10.20	119.0	104.0	107.0
Wyeth Campground	217.8	8/27/2013	11:30	1,390	15.4	653	43	10.00	116.0	104.0	107.0
		7/29/2014	12:50	1,535	17.0	657	38	9.75	117.2	103.1	105.8
Pringle Falls Campground	216.5	8/27/2013	14:40	1,390	16.4	652	34	9.50	113.0	103.0	105.0
		7/29/2014	15:10	1,535	17.0	656	37	9.25	111.2	104.4	105.6
La Pine State Park	209.4	7/29/2014	19:00	1,535	17.1	657	24	8.94	107.6	102.9	103.7

Source: Carlson 2013, 2014.

4.3 Crescent Creek and Little Deschutes River

4.3.1 Geography and Land Use

Crescent Creek is the largest tributary to the Little Deschutes River, which is in turn the largest tributary to the Upper Deschutes River. Crescent Creek flows into the Little Deschutes River at RM 57, about 12 miles south of La Pine. The Little Deschutes River flows into the Deschutes River at RM 193, within the unincorporated residential and resort community of Sunriver (Figure 4-14). Like the Upper Deschutes River, Crescent Creek and the Little Deschutes River have generally low gradients (< 1%) and very high rates of meander with numerous side channels, sloughs and oxbows. Crescent Lake Reservoir, which is owned and operated by Tumalo Irrigation District, lies behind Crescent Dam at RM 29 on Crescent Creek. It is the only regulating reservoir in the Little Deschutes subbasin. Water is diverted for irrigation at a number of locations along lower Crescent Creek and the Little Deschutes River, none of which is associated with the DBHCP.

National Forest System lands dominate the upper elevations of the Little Deschutes subbasin while lower elevations, including most lands directly adjacent to Crescent Creek and the Little Deschutes River, are privately owned and used for forestry, agriculture, grazing, recreation and residential development. Riparian areas on NFS lands are mostly forested and stream beds and banks are relatively undisturbed. In contrast, riparian areas and streambanks on many private lands, particularly those along the Little Deschutes River near the communities of Crescent, La Pine and Sunriver, are highly modified and degraded by agriculture, cattle grazing and development (NPCC 2004). The 11.5 miles of Crescent Creek downstream of Crescent Lake Dam are designated *Recreational* under the Federal Wild and Scenic Rivers Act of 1968.

4.3.2 Hydrology

Crescent Creek and the Little Deschutes River have a combined drainage area of 1,050 mi^2. They lie within the La Pine subbasin, a geologic formation characterized by several hundred feet of low-permeability, fine grained sediment (Lite and Gannett 2002). Unlike other streams within the upper Deschutes Basin, where flows are supported largely by spring discharge, Crescent Creek and the Little Deschutes have unregulated flows that show strong seasonal variation driven by surface runoff. Unregulated surface flows typically peak during spring runoff and intermittent storm events, and drop to prolonged annual lows in mid- to late summer. This natural fluctuation is dampened by the operation of Crescent Lake Reservoir, but a strong seasonal pattern is still apparent (Figures 4-15 and 4-16). Historical operation of Crescent Lake Reservoir reduced the monthly median flow during the long storage season that was dampened with downstream distance by natural inflow from tributary streams; operation of the reservoir also caused a more pronounced increase in flow during the irrigation season that persisted for the entire distance from Crescent Dam to the lower Little Deschutes River (Figure 4-17).

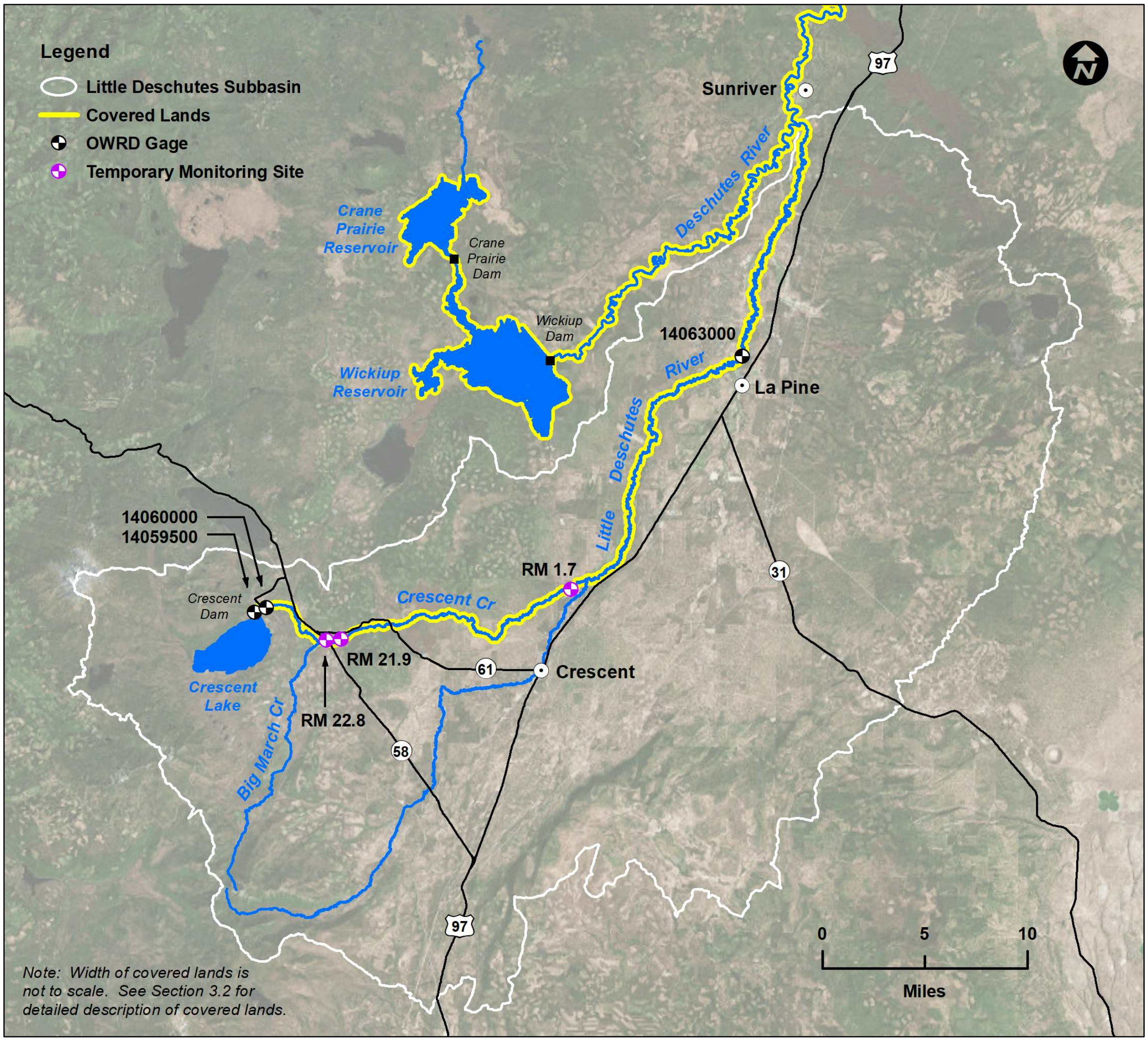

Figure 4-14. Map of the Little Deschutes Subbasin.

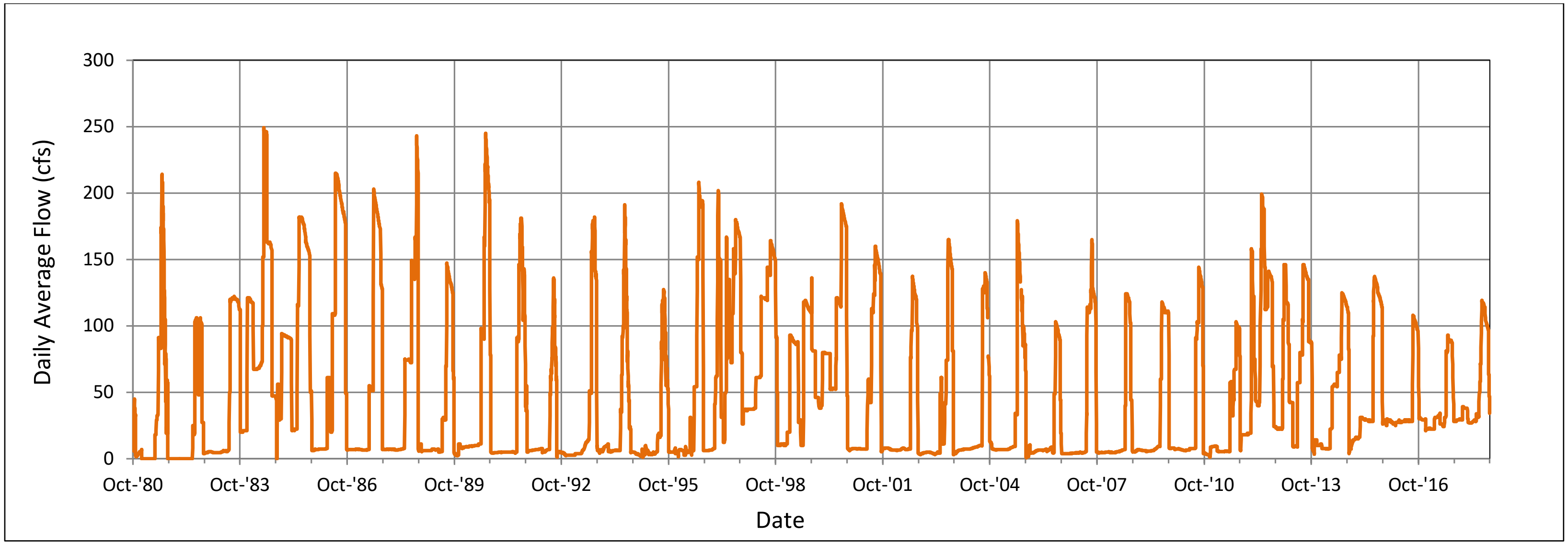

Figure 4-15. Reported flow in Crescent Creek below Crescent Dam from 1981 through 2018. Source: OWRD 2020e.

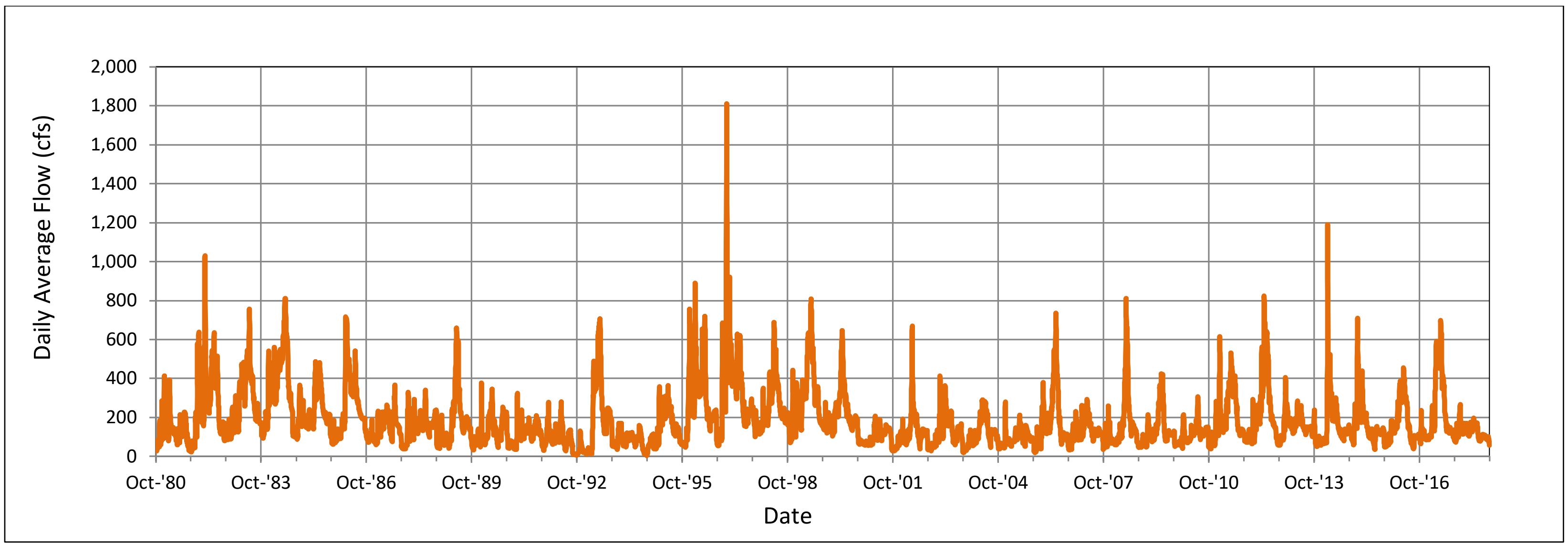

Figure 4-16. Reported flow in the Little Deschutes River near LaPine (RM 26) from 1981 through 2018. Source: OWRD 2020f.

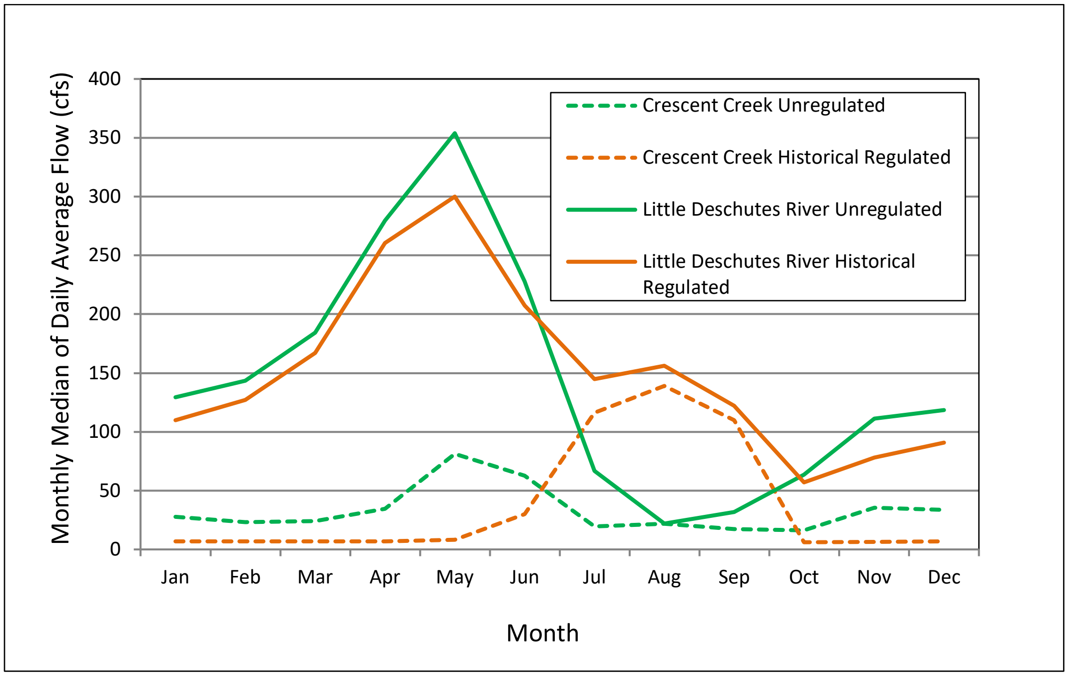

Figure 4-17. Monthly median flows in Crescent Creek (RM 29) and the Little Deschutes River near LaPine (RM 26) from 1983 through 2014. Source: R2 and Biota Pacific 2016.

4.3.3 Water Temperature

Continuous water temperature data are available for Crescent Creek below Crescent Dam (Figure 4-18) and the Little Deschutes River at La Pine (Figure 4-19). Data from 2011 through 2016 at both locations show a strong and consistent seasonal trend in 7-DADM. In Crescent Creek, the 7-DADM drops to as low as 3°C during the late winter, and reaches as high 20 to 22 °C in mid-summer. The 7-DADM shows a similar trend in the Little Deschutes River at La Pine, except that temperatures tend to be lower in the winter and higher in the summer at La Pine, often exceeding 22°C.

Crescent Creek (RM 0.0 to 11.0) and the Little Deschutes River (RM 0.0 to 68.8) are identified as water temperature limited under Section 303(d) of the Clean Water Act for exceeding the year-round maximum 7-DADM of 18°C for salmon and trout rearing and migration (ODEQ 2017). Crescent Creek is also identified as water temperature limited for exceeding the year-round maximum 7-DADM of 12°C for bull trout spawning and juvenile rearing from RM 11.0 to 30.1. Resident rainbow trout are present in the covered reaches of Crescent Creek and the Little Deschutes River, but bull trout and salmon are absent.

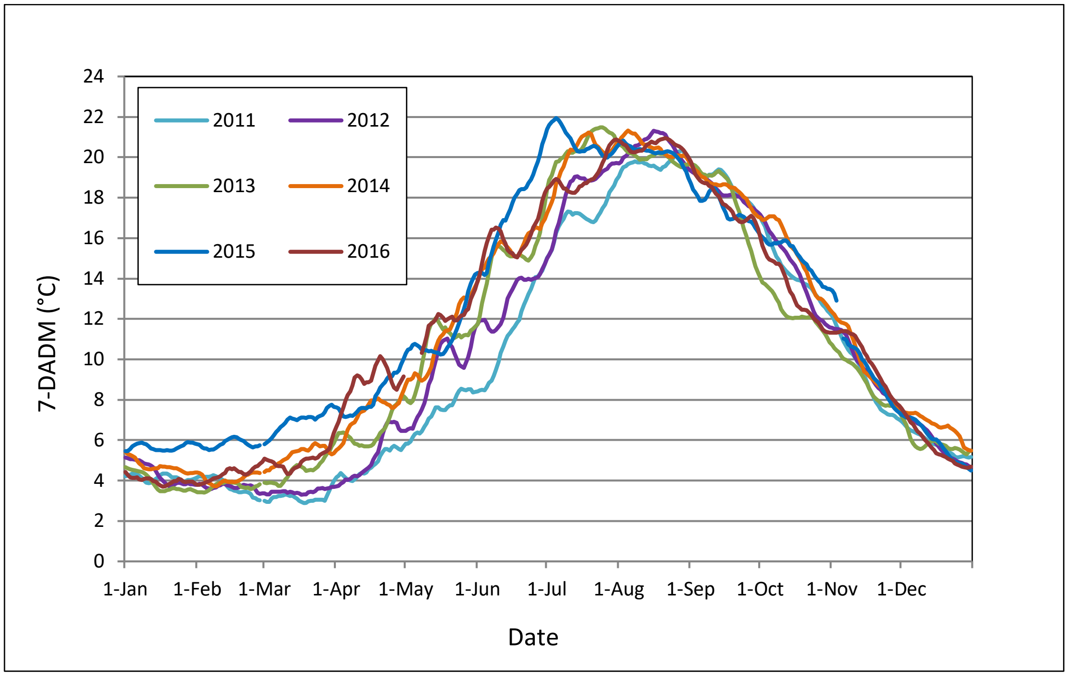

Figure 4-18. Seven-day averages of daily maximum water temperatures (7-DADM) in Crescent Creek below Crescent Dam. Source: Reclamation 2017b.

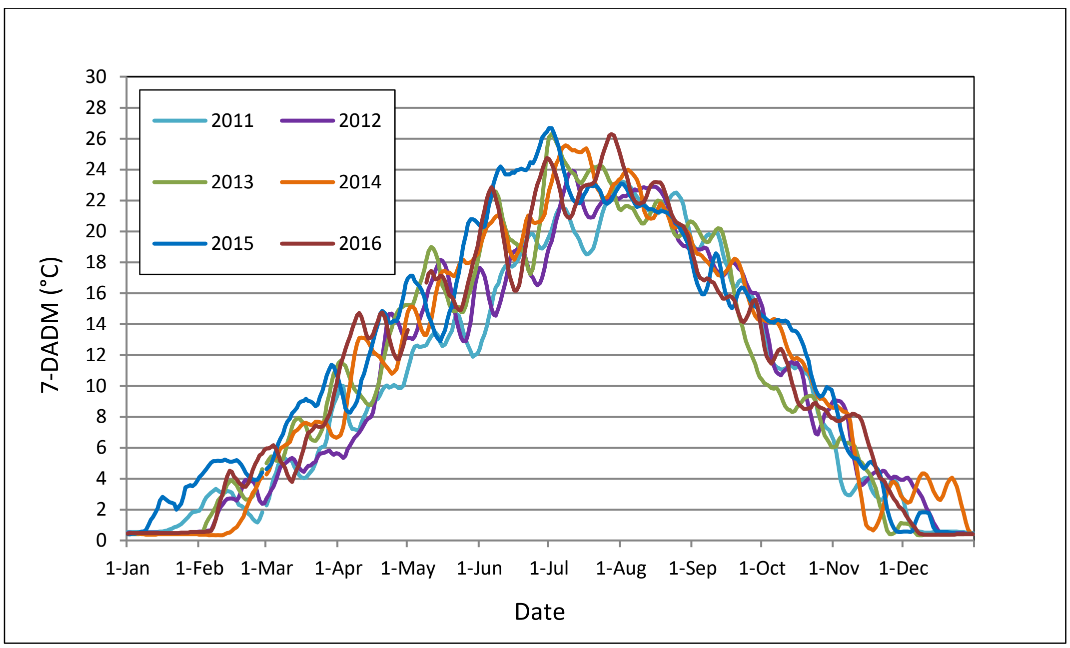

Figure 4-19. Seven-day averages of daily maximum water temperatures (7-DADM) in Little Deschutes River at La Pine. Source: Reclamation 2017b.

4.3.4 Water Quality

The lower 73.6 miles of the Little Deschutes River are listed as water quality limited for failing to meet the year round cold water DO criterion of 8.0 mg/L or 95 percent saturation (Table 4-5). The lower 68.8 miles of the Little Deschutes River also fail to meet the January 1 to May 15 salmonid spawning DO criterion of 11.0 mg/L or 95 percent saturation.

Table 4-5. Crescent Creek and Little Deschutes River reaches covered by the DBHCP that are identified in Oregon's 2012 Integrated Report water quality limited.

Water Body / Reach	Pollutant	Season	Criteria	Status	
				Category	Description
Crescent Creek					
RM 0.0 - 11.0	Temperature	Year round	Salmon and trout rearing and migration: 7-DADM ≤ 18.0°C	5	Water quality limited, 303(d) list, TMDL needed
RM 11.0 - 30.1	Temperature	Year round	Bull trout spawning and juvenile rearing: 7-DADM ≤ 12°C	5	Water quality limited, 303(d) list, TMDL needed
Little Deschutes River					
RM 0.0 - 68.8	Dissolved oxygen	Jan 1 – May 15	Spawning: Not less than 11.0 mg/L or 95% of saturation	5	Water quality limited, 303(d) list, TMDL needed
RM 0.0 - 73.6	Dissolved oxygen	Year round	Cold water: Not less than 8.0 mg/l or 90% of saturation	5	Water quality limited, 303(d) list, TMDL needed
RM 0.0 - 68.8	Temperature	Year round	Salmon and trout rearing and migration: 7-DADM ≤ 18.0°C	5	Water quality limited, 303(d) list, TMDL needed

Source: ODEQ 2017.

4.4 Tumalo Creek

4.4.1 Geography and Land Use

Tumalo Creek headwaters lie within the Three Sisters Wilderness Area near Broken Top Mountain, and the creek flows into the Deschutes River a short distance downstream of Bend at RM 160 (Figure 4-20). The upper three-fourths of the steep, narrow, forested watershed lie within the Deschutes National Forest; the lower fourth is predominantly agricultural and rural residential land within Tumalo Irrigation District. Portions of the upper and middle watershed have been impacted by wildfire in recent years, but instream habitat conditions remain generally good (NPCC 2004). Spring and summer flows in Tumalo Creek are augmented by 15 to 20 cfs diverted by ditch into the Middle Fork from Crater, Little Crater and Soda creeks. Water is diverted out of Tumalo Creek and into the Tumalo Feed Canal for irrigation at RM 2.8. There is no in-channel storage or other regulation of flows in Tumalo Creek.

4.4.2 Hydrology

The entire Tumalo Creek watershed lies within the Cascade Range and Newberry Volcano Deposits hydrogeologic unit described by Lite and Gannett (2002). Subsurface permeability in Tumalo Creek is less than in other portions of the upper Deschutes Basin, and this gives Tumalo Creek a greater reliance on surface runoff and a more pronounced, although still relatively modest seasonal fluctuation in flow. Upstream of the TID diversion at RM 2.8, the unregulated Tumalo Creek shows a substantial and predictable peak during spring runoff, moderate flows during the summer, and annual low flows during the winter (Figure 4-21). Downstream of the diversion, the lower 2.8 miles of creek experience substantially reduced spring and summer flows, but fall and winter flows are relatively unaffected.

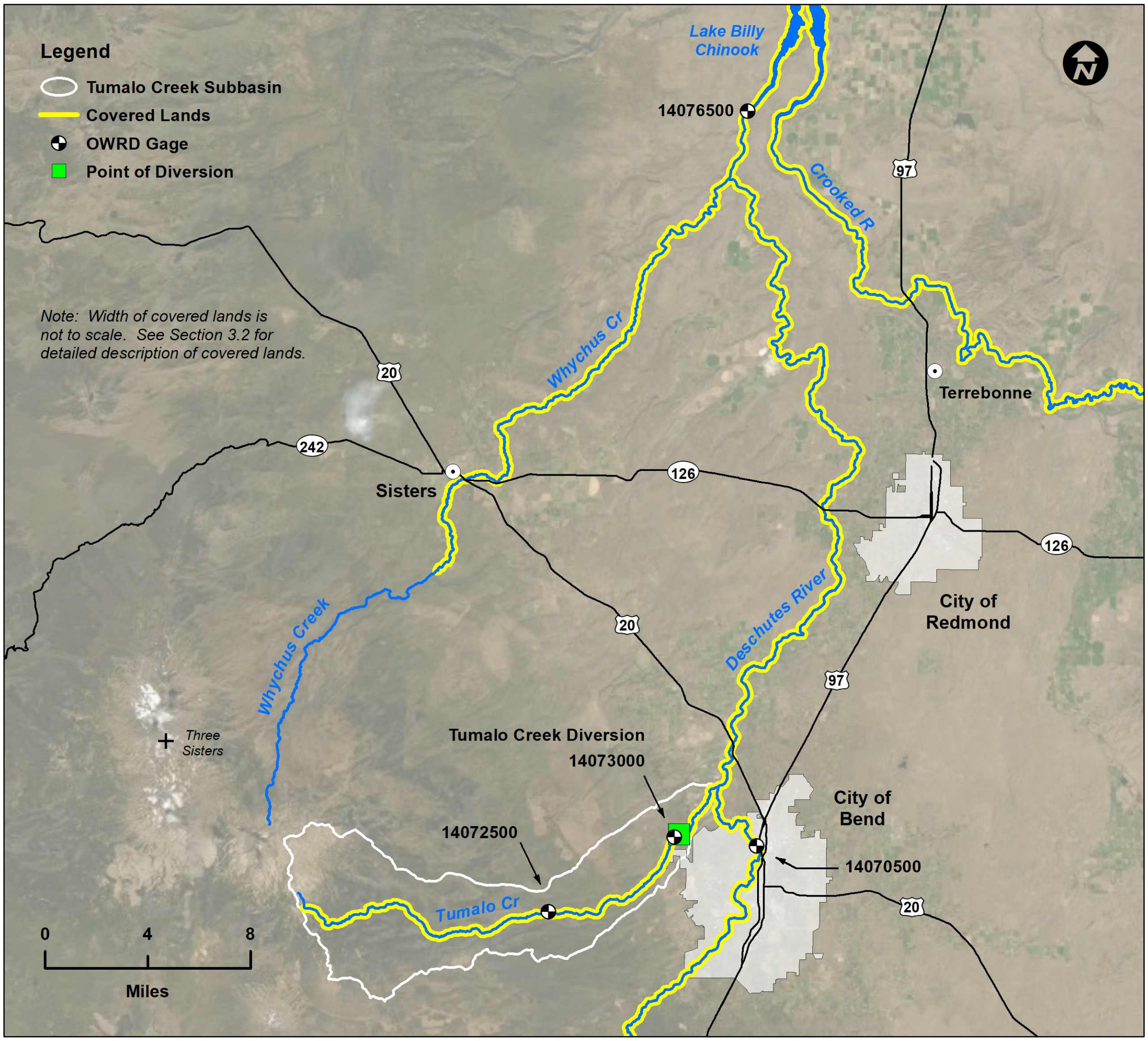

Figure 4-20. Map of the Tumalo Creek Subbasin.

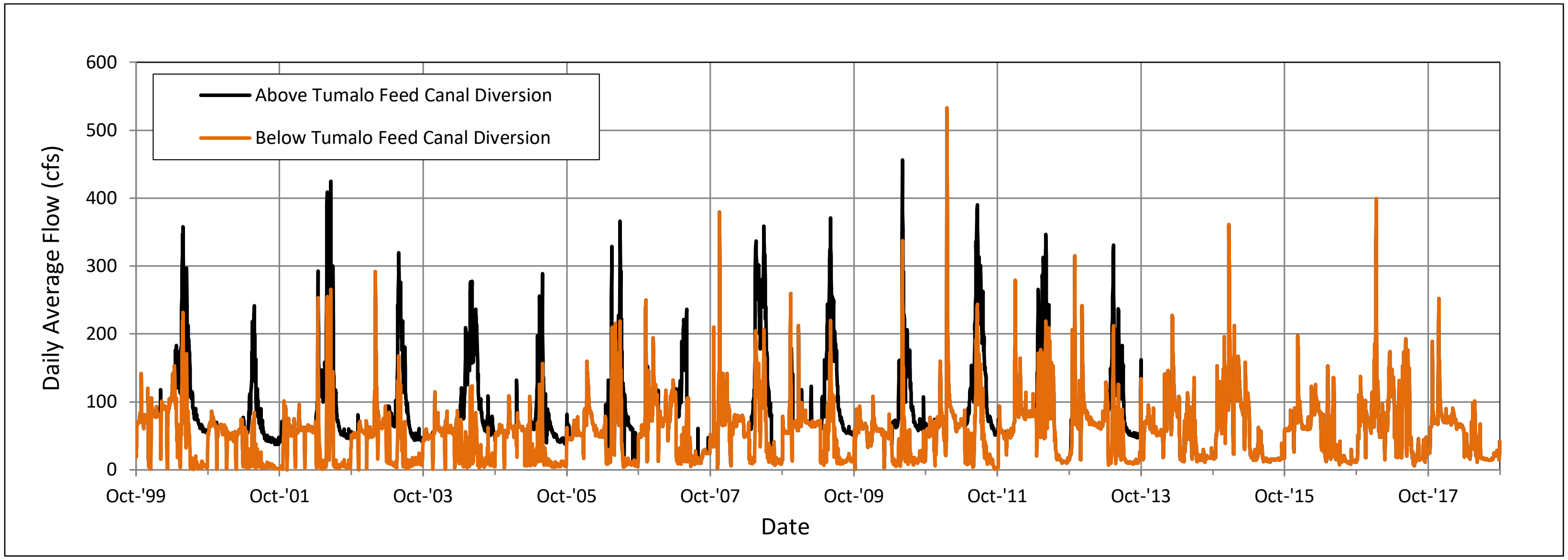

Figure 4-21. Reported flow in Tumalo Creek above and below Tumalo Feed Canal Diversion (RM 2.8) from 2000 through 2018. Source: OWRD 2020g. (Note: The reporting period for Tumalo Creek is shorter than for other covered waters due to limited availability of historical data.)

4.4.3 Water Temperature

Continuous water temperature data for lower Tumalo Creek since 2011 show a seasonal pattern typical of the Deschutes Basin (Figure 4-22). The 7-DADM ranges from a low near 0°C in December and January to a high between 14°C and 16°C in July and August of most years. While available data do not show the 7-DADM exceeding 18°C in the past 6 years, the lower 12.5 miles of Tumalo Creek are identified as water temperature limited under Section 303(d) of the Clean Water Act for exceeding the year-round maximum 7-DADM of 18°C for salmon and trout rearing and migration (ODEQ 2017).

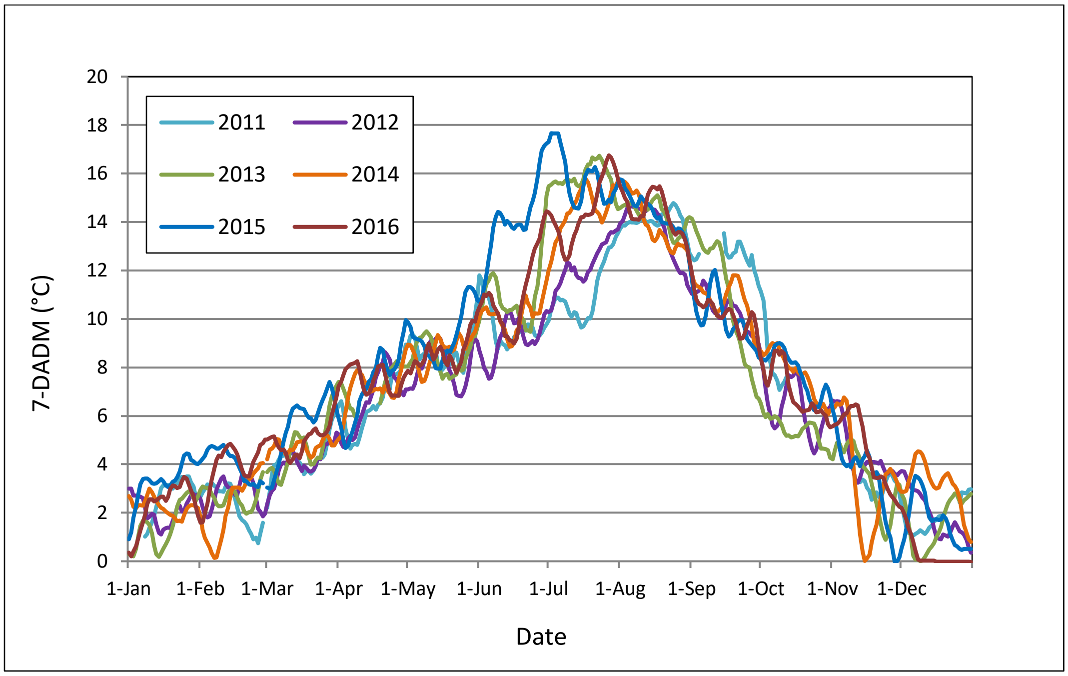

Figure 4-22. Seven-day averages of daily maximum water temperatures (7-DADM) in Tumalo Creek below the Tumalo Feed Canal. Source: Reclamation 2017c.

4.4.4 Water Quality

The lower 11.2 miles of Tumalo Creek are listed as water quality limited due to flow modifications deleterious to fish or other aquatic life (Table 4-6).

Table 4-6 Tumalo Creek reaches covered by the DBHCP that are identified in Oregon's 2012 Integrated Report as water quality limited.

Reach	Pollutant	Season	Criteria	Status	
				Category	Description
RM 0.0 - 12.5	Temperature	Year Round (Non-spawning)	Salmon and trout rearing and migration: 7-DADM ≤ 18.0°C	5	Water quality limited, 303(d) list, TMDL needed
RM 0.0 - 11.2	Flow Modification	Undefined	The creation of tastes or odors or toxic or other conditions that are deleterious to fish or other aquatic life or affect the potability of drinking water or the palatability of fish or shellfish may not be allowed.	4C	Water quality limited, not a pollutant

Source: ODEQ 2017.

4.5 Whychus Creek

4.5.1 Geography and Land Use

Whychus Creek (previously known as Squaw Creek) originates at an elevation of over 10,000 feet on the east slopes of the Three Sisters Peaks, and enters the Deschutes River at elevation 2,100 feet between Big Falls and Lake Billy Chinook (Figure 4-23). Over a course of 35 miles the creek drains over 250 mi^2 of forestland, irrigated farmland, unirrigated rangeland, residential development and commercial development. It flows through the City of Sisters, Oregon at about RM 23. The major tributaries to Whychus Creek are Snow Creek, Pole Creek, and Indian Ford Creek.

Water is diverted from Whychus Creek for irrigation and stock watering at multiple locations between RM 25.9 and RM 2.7. The largest diverter is Three Sisters Irrigation District (RM 24.2), which stores water in two out-of-channel reservoirs (Watson and McKenzie Canyon). There is no in-channel storage of flow in Whychus Creek. Portions of the stream have been heavily modified (channelized) for flood control purposes and impacted by cattle grazing, to the detriment of aquatic, riparian and floodplain habitat functions (NPCC 2004). Flow restoration, physical habitat restoration and removal of man-made barriers are ongoing (Mork 2014).

4.5.2 Hydrology

Natural flows in Whychus Creek are influenced predominantly by headwater snowmelt, with additional contributions from surface tributaries and groundwater exchange in the lower reaches. Natural flows upstream of the City of Sisters consistently peak at 200 to 400 cfs in June and drop to 60 cfs or less in late winter (Figure 4-24). Extreme peak flows as high as 1,000 cfs have been reported during episodic winter storms. Between the TDIS diversion at RM 24.2 and the City of Sisters the creek loses about 5 to 10 cfs to groundwater. Downstream of Sisters the natural flow is increased by a number of surface tributaries and springs, including Indian Ford Creek (RM 21.9), multiple small springs near Camp Polk Road (RM 17), and Alder Springs that contributes as much as 90 cfs to the lower 1.4 miles of the creek. Irrigation diversions by TSID and others beginning at about RM 26 reduce flows considerably from April through October and to a lesser extent from November through March (Figures 4-25 and 4-26).

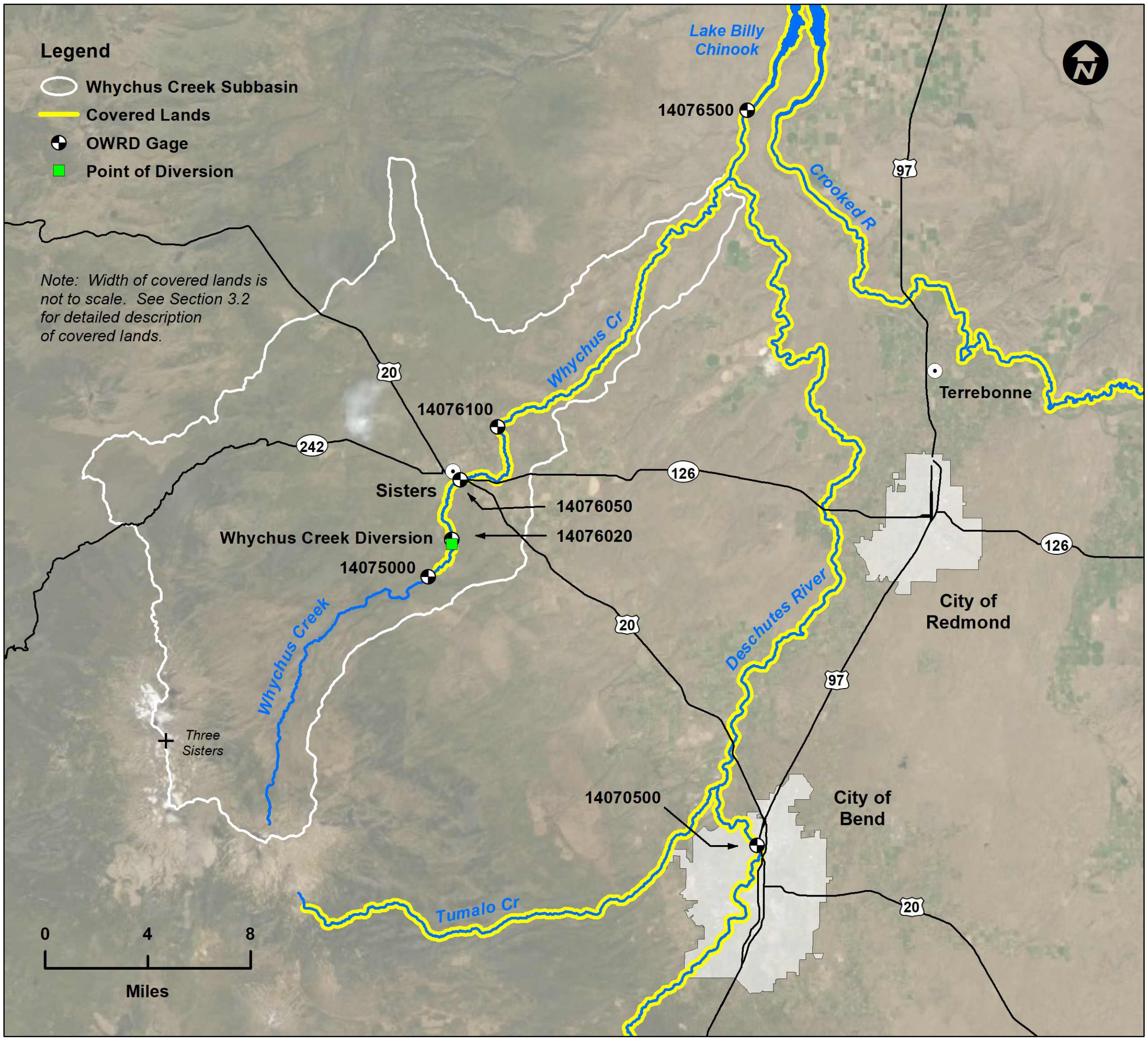

Figure 4-23. Map of the Whychus Creek Subbasin.

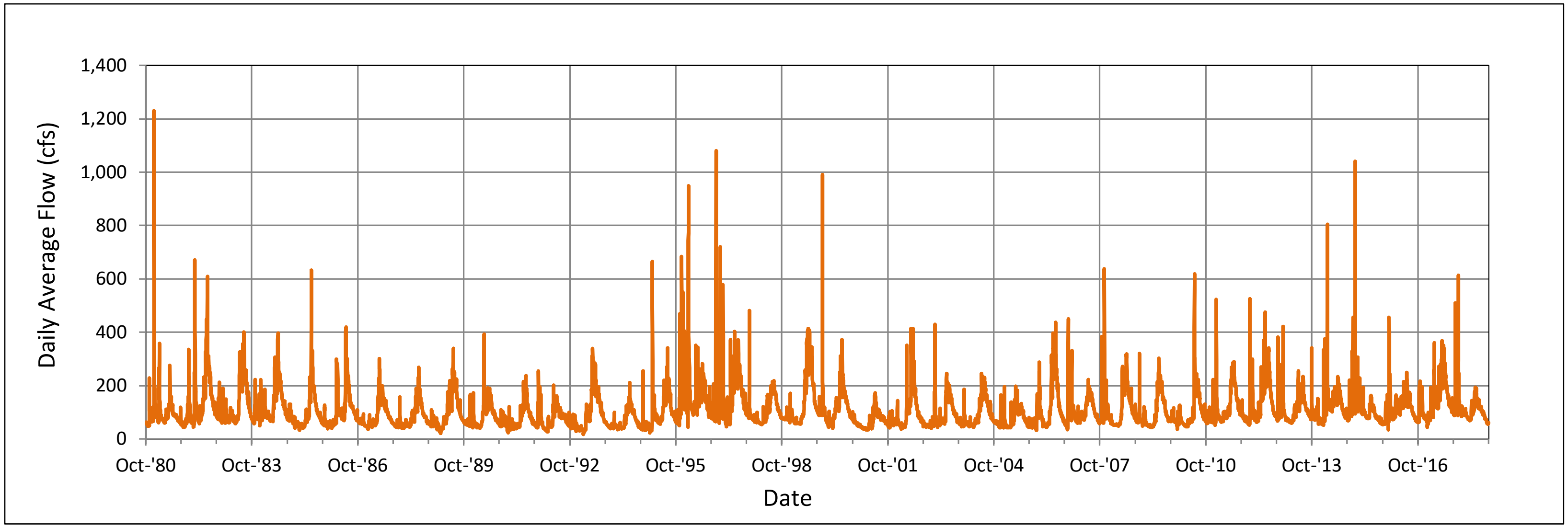

Figure 4-24. Reported flow in Whychus Creek at Gage 14075000 upstream of TSID diversion from 1981 through 2018. Source: OWRD 2020h.

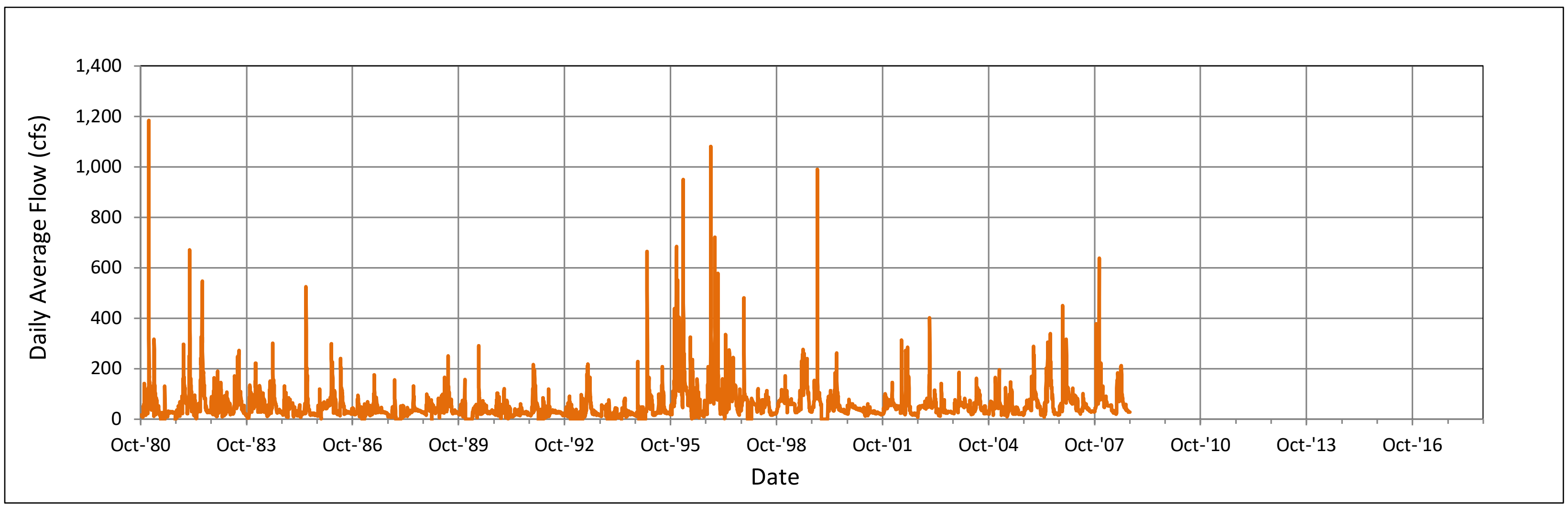

Figure 4-25. Estimated flow in Whychus Creek downstream of TSID diversion from 1981 to 2008. Source: OWRD 2020i. (Note: The reporting period for Whychus Creek is shorter than for other covered waters due to lack of historical data after 2008.)

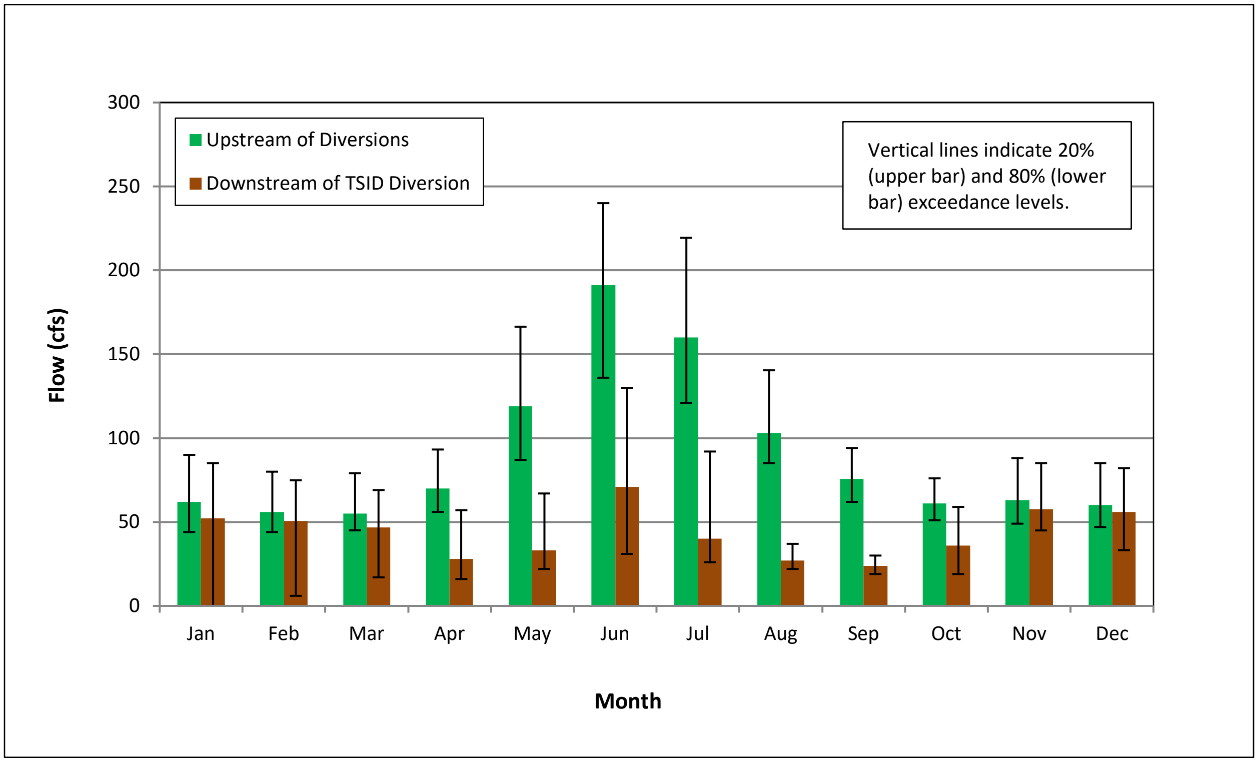

Figure 4-26. Monthly medians of daily average flows in Whychus Creek upstream and downstream of major irrigation diversions from 1983 through 2011.

4.5.3 Water Temperature

Summer water temperatures in Whychus Creek increase with downstream movement due to the combined effects of reduced flow and increased solar radiation. The 7-DADM in the forested upper reach of the creek generally remains below 16°C throughout the year (Figure 4-27). Downstream of the forest, between the TSID Diversion and the City of Sisters, reductions in both flow and riparian shade result in 7-DADM levels that exceed 16°C in June, July and August of some years and have reached as high as 19°C (Figure 4-28). Downstream of Sisters, water temperatures continue to increase and the 7-DADM regularly exceed 20°C in mid-summer (Figure 4-29). In lower Whychus Creek, discharge from Alder Springs (RM 1.4) provides a cooling effect that keeps the 7-DADM from exceeding 16°C (Figure 4-30). Whychus Creek is identified as water temperature limited under Section 303(d) of the Clean Water Act for exceeding the year-round maximum 7-DADM of 18°C for salmon and trout rearing and migration from the mouth to RM 40.3 (ODEQ 2017).

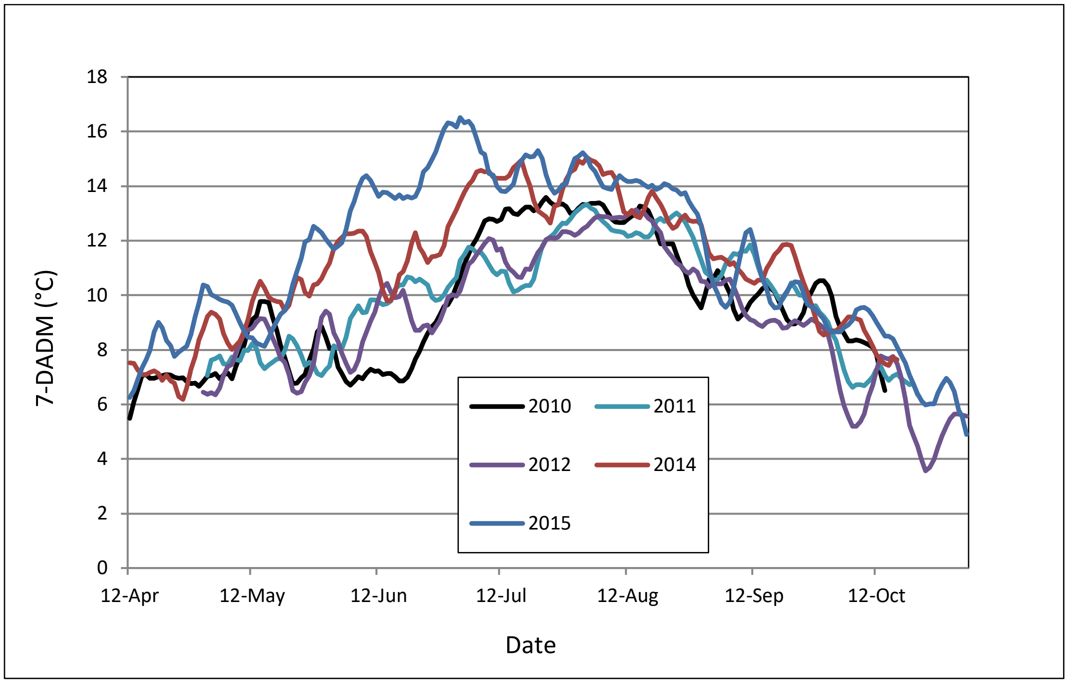

Figure 4-27. Seven-day averages of daily maximum water temperatures (7-DADM) in Whychus Creek upstream of Three Sisters Irrigation District Diversion at Gage 14075000 during the irrigation season. Source: UDWC 2016.

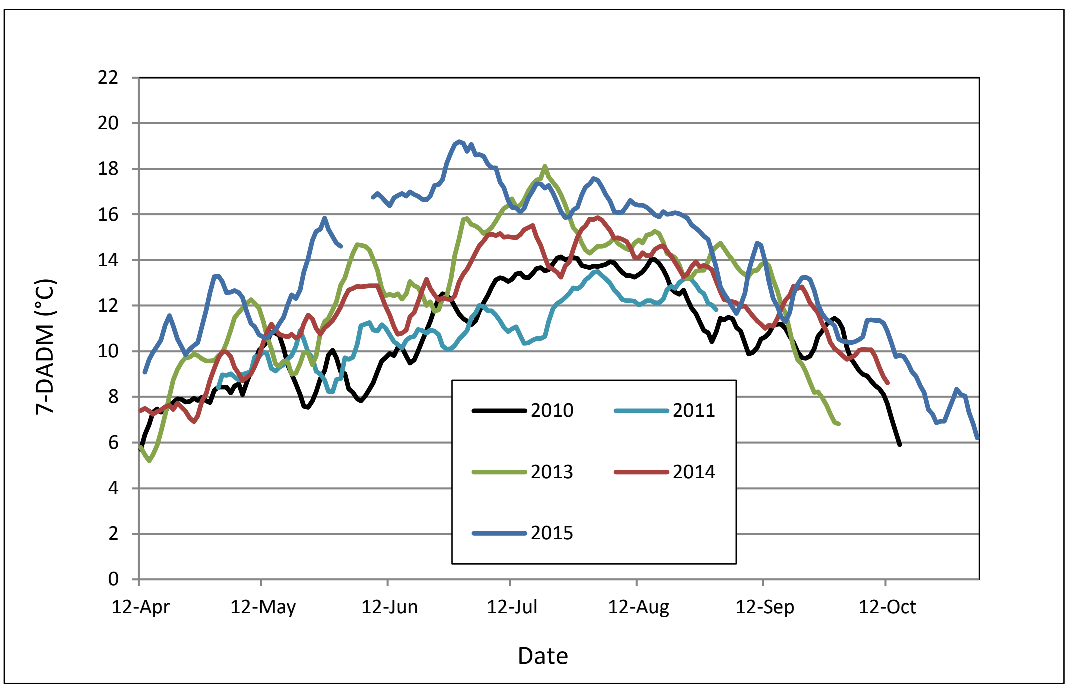

Figure 4-28. Seven-day averages of daily maximum water temperatures (7-DADM) in Whychus Creek downstream of Three Sisters irrigation District Diversion at Forest Road 4606 during the irrigation season. Source: UDWC 2016.

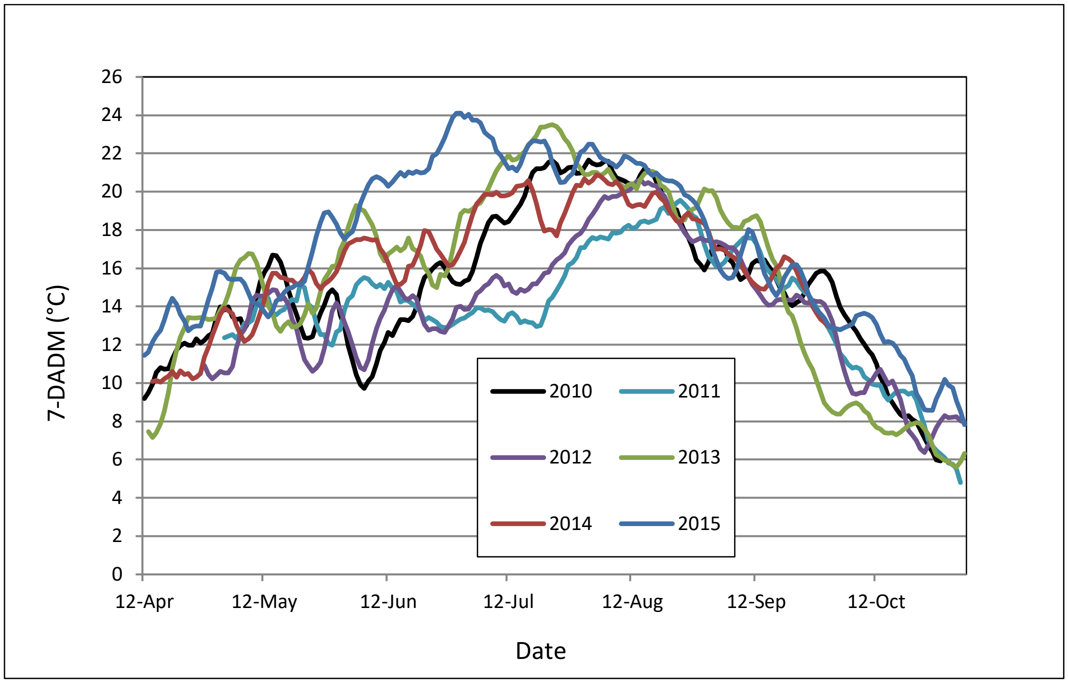

Figure 4-29. Seven-day averages of daily maximum water temperatures (7-DADM) in lower Whychus Creek at Forest Road 6360 (approximate RM 6.00) during the irrigation season. Source: UDWC 2016.

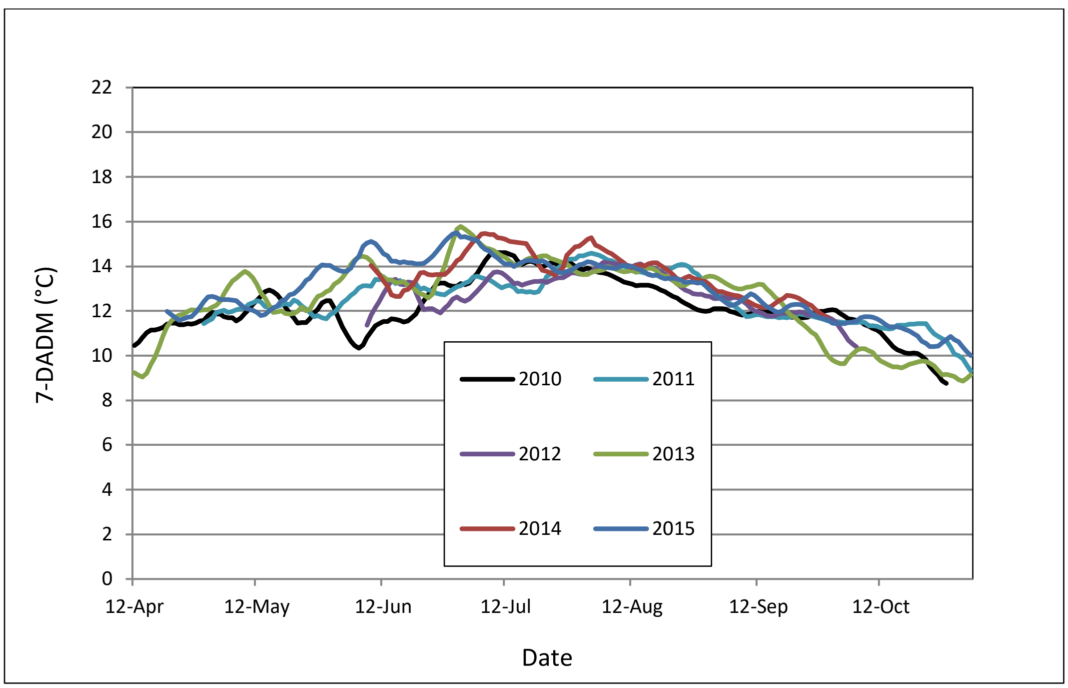

Figure 4-30. Seven-day averages of daily maximum water temperatures (7-DADM) in Whychus Creek near the mouth (RM 0.25) during the irrigation season. Source: UDWC 2016.

4.5.4 Water Quality

Whychus Creek is listed as water quality limited due to flow modifications that are deleterious to fish or other aquatic life from RM 1.9 to RM 23.7 (Table 4-7).

Table 4-7. Whychus Creek reaches covered by the DBHCP that are identified in Oregon's 2012 Integrated Report as water quality limited.

Reach	Pollutant	Season	Criteria	Status	
				Category	Description
RM 0.0 - 40.3	Temperature	Year Round (Non-spawning)	Salmon and trout rearing and migration: 7-DADM ≤ 18.0°C	5	Water quality limited, 303(d) list, TMDL needed
RM 1.9 - 23.7	Flow Modification	Undefined	The creation of tastes or odors or toxic or other conditions that are deleterious to fish or other aquatic life or affect the potability of drinking water or the palatability of fish or shellfish may not be allowed.	4C	Water quality limited, not a pollutant

4.6 Lower Deschutes River

4.6.1 Geography and Land Use

The Lower Deschutes River covers 100 miles from Pelton Reregulating Dam to the mouth at the Columbia River (Figure 4-1). Most of this reach is confined to a deep, narrow, steep-sided valley with very low sinuosity and a uniform gradient of about 0.23 percent (Fassnacht et al. 2003). Stream width averages 236 feet and varies from 30 to 560 feet. Channel stability is high, with very little migration from year to year and few side channels (Curran and O'Connor 2003, cited in NPCC 2004). Riparian vegetation in this arid region is generally limited to a narrow band of alder, willows and grasses directly adjacent to the river channel. Major tributaries to the Lower Deschutes River are White River, Warm Springs River and Shitike Creek from the west; and Trout Creek and Willow Creek from the east.

Land ownership along the Lower Deschutes River is a combination of tribal (Warm Springs Reservation), public (BLM and State of Oregon within the river canyon) and private (in the surrounding uplands). Land use is mostly range, agriculture (irrigated and dry land) and recreational. Population density along the Lower Deschutes River is very low. The entire reach from Pelton Reregulating Dam to the mouth is designated as *Recreational* under the Federal Wild and Scenic Rivers Act of 1968. The Lower Deschutes River is influenced by operation of the Pelton Round Butte Hydroelectric Project, as well as by covered irrigation activities (storage, release, diversion and return of water) occurring upstream of Pelton Round Butte. There is no storage or diversion of irrigation water covered by the DBHCP downstream of Pelton Reregulating Dam.

4.6.2 Hydrology

Flow in the Deschutes River increases more than twofold between Culver (RM 120; Figure 4-5) and Madras (RM 100; Figure 4-31), mostly due to inflow that originates as spring discharge to the Metolius River and Lower Crooked River. The net effects of this large, relatively constant inflow are a reduction in the relative influence of upstream irrigation activities (i.e., less difference between regulated and unregulated flows) and less seasonal fluctuation in flow compared to the Middle Deschutes River.

4.6.3 Water Temperature

The large volume and predominantly groundwater origin of flow in the Deschutes River at Madras keep water temperatures in the river naturally low. The selective water withdrawal system at the Pelton Round Butte Project, which allows managers to control the temperature of water leaving Lake Billy Chinook, minimizes any reservoir-related change in water temperature. As a result, the 7-DADM in the Deschutes River near Madras stays between 6 and 16 °C year-round (Figure 4-32). Downstream, however, naturally high levels of solar radiation and limited inflow of additional cool groundwater allow the river to warm. Near the mouth of the river at Moody, the 7-DADM often exceeds 20°C in mid-summer (Figure 4-33).

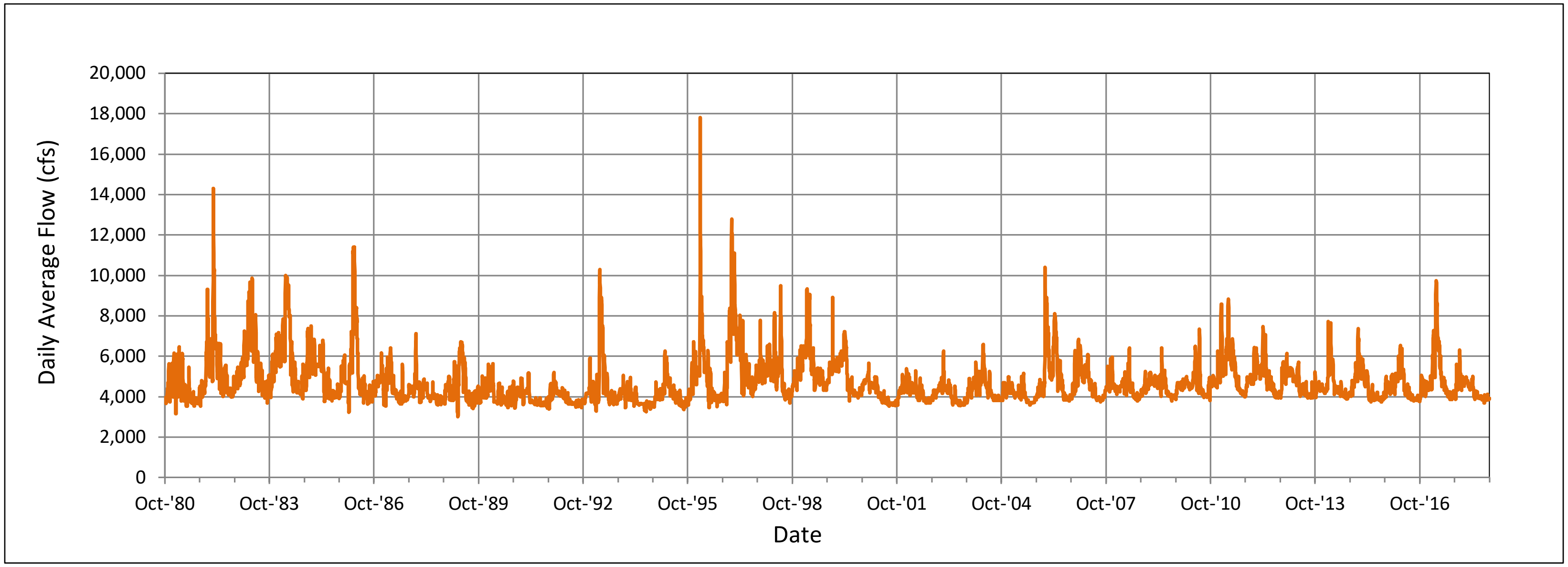

Figure 4-31. Reported flow in the Deschutes River downstream of Madras (RM 100) from 1981 through 2018. Source: OWRD 2020j.

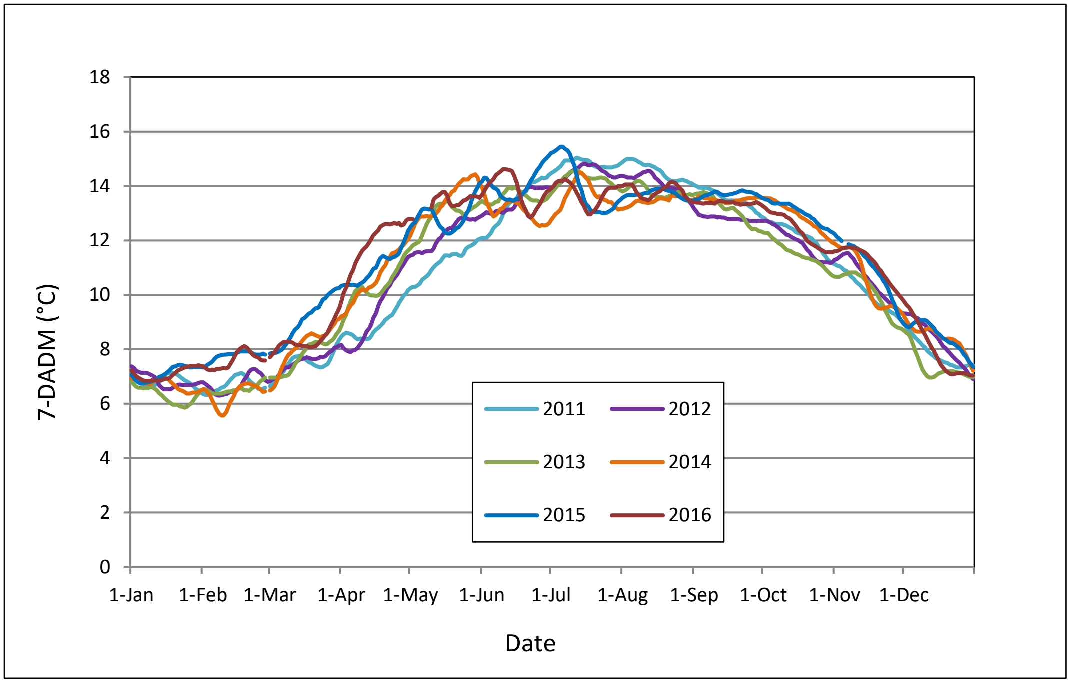

Figure 4-32. Seven-day averages of daily maximum water temperatures (7-DADM) in the lower Deschutes River near Madras, Oregon (Gage 14092500) from 2011 through 2016. Source: USGS 2017a.

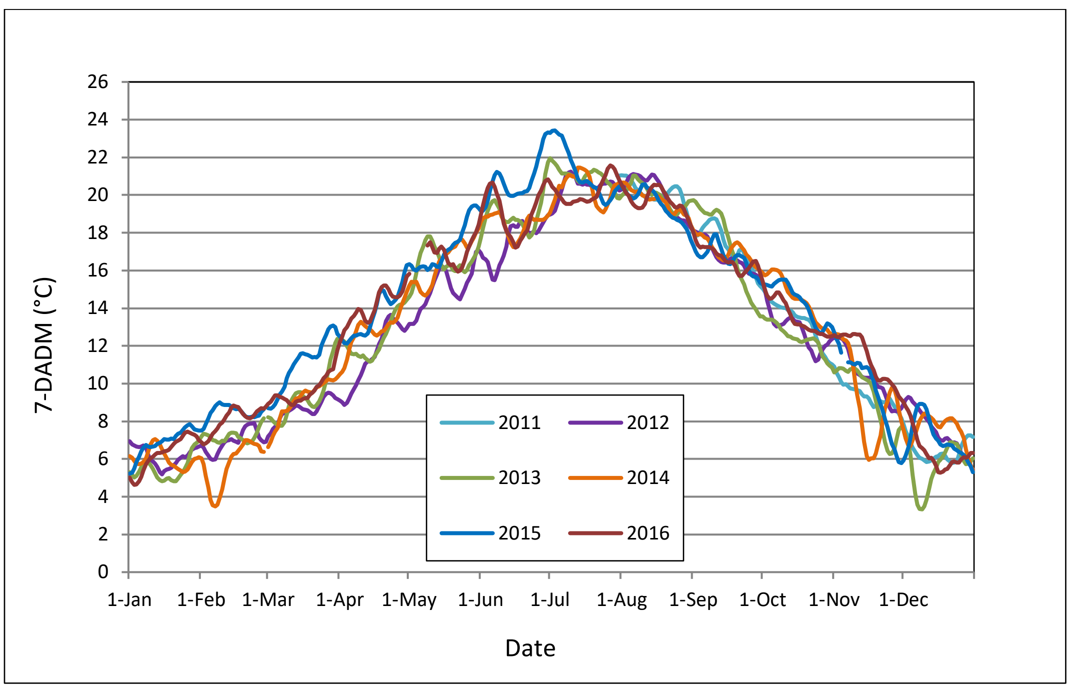

Figure 4-33. Seven-day averages of daily maximum water temperatures (7-DADM) in the lower Deschutes River at Moody, near Biggs, Oregon (Gage 14103000) from 2011 through 2016. Source: USGS 2017b.

The Lower Deschutes River is identified as water temperature limited under Section 303(d) of the Clean Water Act for exceeding the summer maximum 7-DADM of 17.8°C for salmon and trout rearing and migration from the mouth to RM 46.4 (ODEQ 2017). It is also listed as water quality limited for exceeding the maximum 7-DADM of 12.8°C for salmon and trout spawning from RM 46.4 to 99.8. The lower Deschutes River is designated for salmon and trout rearing and migration use from the mouth to about RM 84. Between RM 84 and RM 110 it is designated for core cold-water habitat use. Designated salmon and steelhead spawning use in the lower 84 miles of river occurs from 15 October to 15 May, and from RM 84 to Pelton Reregulating Dam (RM 99.8) it occurs from 15 October to 15 June.

NUID operates eight irrigation returns to the Middle and Lower Deschutes River (see Section 3.5.5.7, *Return Flows*). These returns convey very small amounts of water, operate infrequently and/or flow directly into one of the Pelton Round Butte Project reservoirs. All eight returns have maximum flows that amount to 1 percent or less of the flow in the receiving water at the point of return, and thus all are incapable of altering the temperature of the receiving water more than 0.1°C (R2 and Biota Pacific 2013a).

4.6.4 Water Quality

Portions of the Lower Deschutes River are listed as water quality limited for DO and pH (Table 4-8). From Pelton Reregulating Dam to RM 83.8, the river is listed for falling below the minimum DO concentration of 11.0 mg/l for salmonid spawning. From the Reregulating Dam to RM 46.4, the river falls outside the fall/winter/spring pH range of 6.5 to 8.5. From RM 46.4 to the mouth, the river falls outside the same pH range during the summer.

Table 4-8. Lower Deschutes River reaches covered by the DBHCP that are identified in Oregon's 2012 Integrated Report as water quality limited.

Reach	Pollutant	Season	Criteria	Status	
				Category	Description
RM 83.8 - 99.8	DO	Oct 15 - Jun 15	Spawning: Not less than 11.0 mg/L or 95% of saturation	5	Water quality limited, 303(d) list, TMDL needed
RM 0.0 - 46.4	pH	Summer	pH 6.5 to 8.5	5	Water quality limited, 303(d) list, TMDL needed
RM 46.4 - 99.8	pH	Fall / Winter / Spring	pH 6.5 to 8.5	5	Water quality limited, 303(d) list, TMDL needed
RM 0.0 - 46.4	Temperature	Sep 1 - Jun 30	Spawning: 7-DADM ≤ 12.8 C	5	Water quality limited, 303(d) list, TMDL needed
RM 0.0 - 46.4	Temperature	Summer	Rearing: 7-DADM ≤ 17.8 C	5	Water quality limited, 303(d) list, TMDL needed
RM 46.4 - 99.8	Temperature	Sep 1 - Jun 30	Spawning: 7-DADM ≤ 12.8 C	5	Water quality limited, 303(d) list, TMDL needed

Source: ODEQ 2017.

4.7 Trout Creek

4.7.1 Geography and Land Use

Trout Creek is an eastside tributary to the Deschutes River in Jefferson, Crook and Wasco counties (Figure 4-34). With its headwaters at an elevation of 5,900 feet in the Ochoco Mountains northeast of Prineville, it has a drainage area 670 mi^2. It flows into the Deschutes River at RM 87, about 13 miles downstream of Pelton Reregulating Dam. Mud Springs Creek is a tributary to Trout Creek with a drainage area of about 94 mi^2. It is the lowest tributary to Trout Creek, entering about 2.5 miles upstream of where Trout Creek enters the Deschutes River. Sagebrush Creek is a small tributary to Mud Springs Creek that drains 7.4 mi^2 and enters Mud Springs Creek at about RM 1.6.

Land ownership in the Trout Creek watershed is 88 percent private and 12 percent federal (Watershed Professionals Network 2002). Land use is predominantly rangeland (86%) and forestry (12%). Steelhead trout have access to most of Trout Creek and the lower 1.6 miles of Mud Springs Creek. Sagebrush Creek enters Mud Springs Creek upstream of the anadromous barrier.

NUID maintains two irrigation returns at the north end of its distribution system in an area known as Agency Plains. The Lateral 58-11 Drain flows into Sagebrush Creek at about RM 1.4 (Figure 4-34). The Lateral 61-11 Drain flows directly into Mud Springs Creek at RM 8.0, about 6.4 miles above the anadromous barrier. Both returns spill variable amounts of water throughout the irrigation season (April through September). The 58-11 spills up to 5 cfs and the 61-11 spills of up to 2 cfs. Both returns also spill up to 50 cfs for less than one day at the start of the irrigation season. Water is diverted from Trout Creek and Mud Springs Creek at several dozen locations for irrigation and other uses (Watershed Professionals Network 2002); none of these diversions is covered by the DBHCP.

4.7.2 Hydrology

Flows in Trout and Mud Springs creeks have distinctly different seasonal patterns (Figure 4-35). Trout Creek flows typically peak in spring during snowmelt and drop to annual lows in mid-summer. From 2000 through 2016, the monthly median of the daily average flow for April in Trout Creek was almost six times the monthly median for July. In contrast, Mud Springs Creek fluctuates little from one season to the next. Of particular note is that from July through November, Mud Springs Creek contributes the majority of the flow in lower Trout Creek. Both creeks experience periodic peak flows during storm events (Figures 4-36 and 4-37).

Comparison of reported flows from 2000 to 2016 with OWRD estimates of natural flows (Figures 4-38 and 4-39) illustrates the hydrologic influence of the return flows. From June through November in both creeks, nearly all the reported flow is from sources other than the natural flow. A significant portion of this reported flow originates from the returns, and much of the rest likely comes from springs that discharge into Mud Springs Creek below Agency Plains in the vicinity of the 61-11 Return.

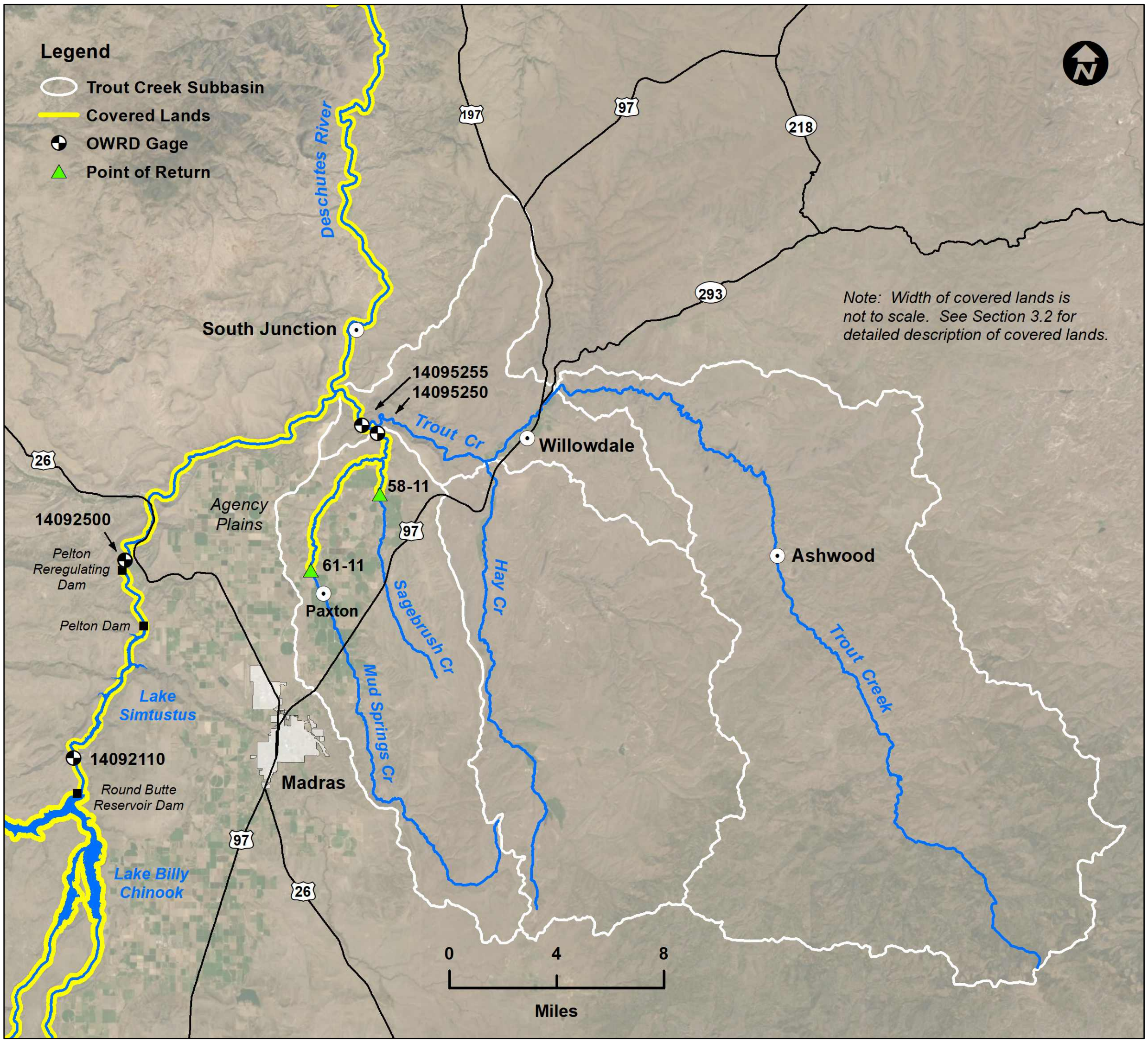

Figure 4-34. Map of the Trout Creek Subbasin.

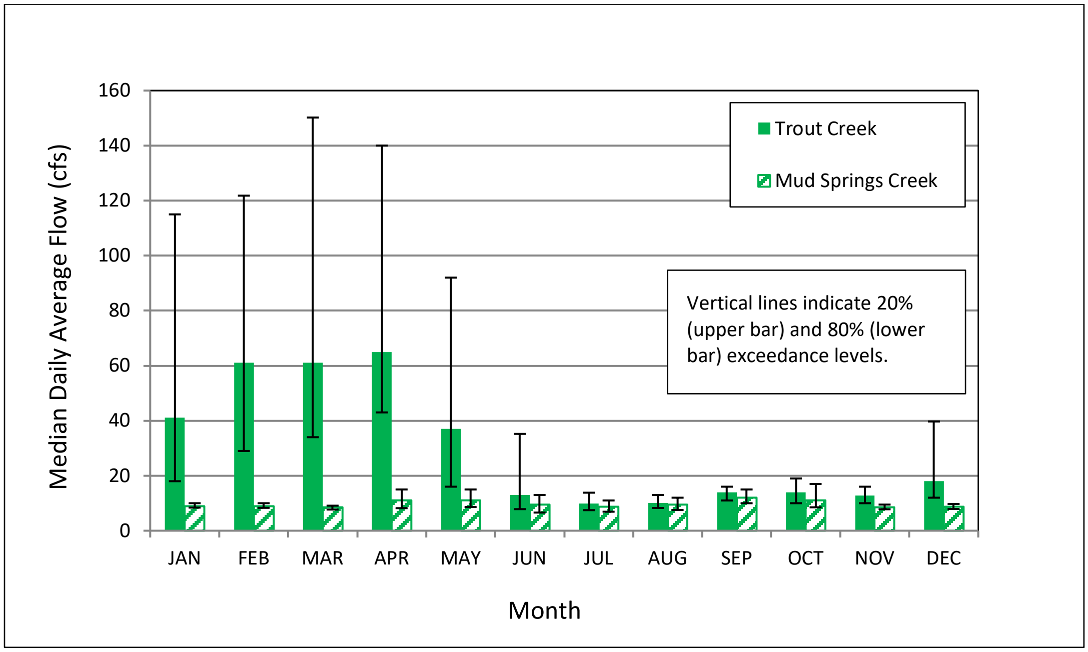

Figure 4-35. Monthly medians of daily average flows in Trout Creek (Gage 14095255) and Mud Springs Creek (Gage 14095250) from 2000 through 2018.
Source: OWRD 2020k. (Note: The reporting period is shorter than for other covered waters due to lack of historical data prior to 2000.)

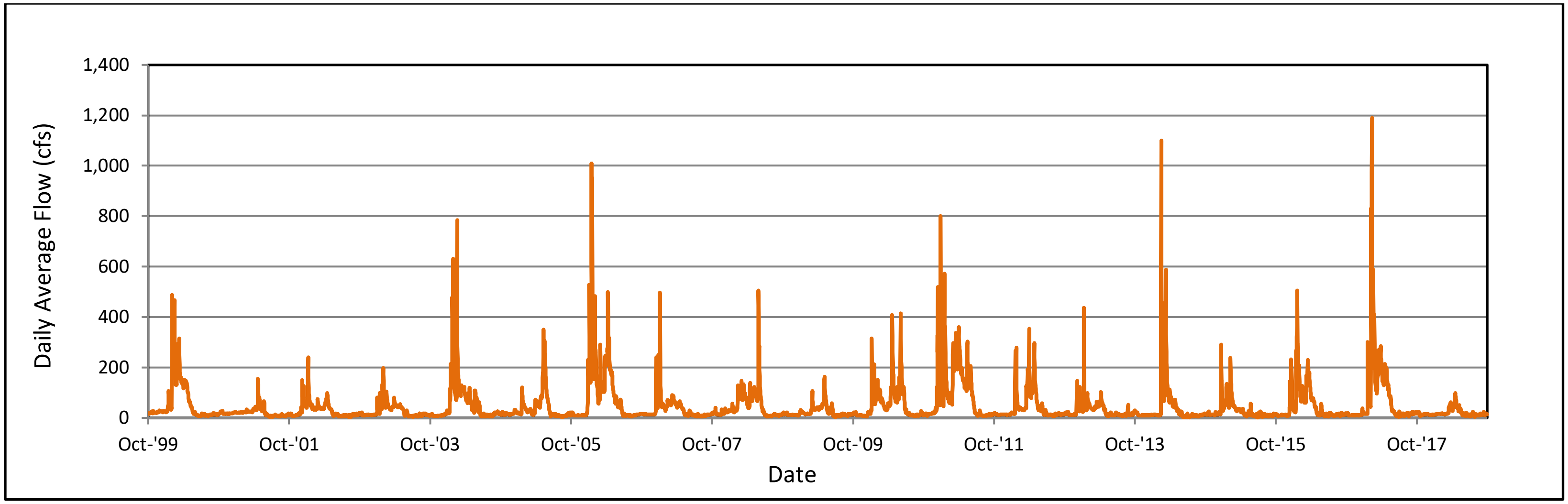

Figure 4-36. Reported flow in Trout Creek near Gateway, Oregon from 2000 through 2018. Source: OWRD 2020k. (Note: The reporting period for Trout Creek is shorter than for other covered waters due to lack of historical data prior to 2000.)

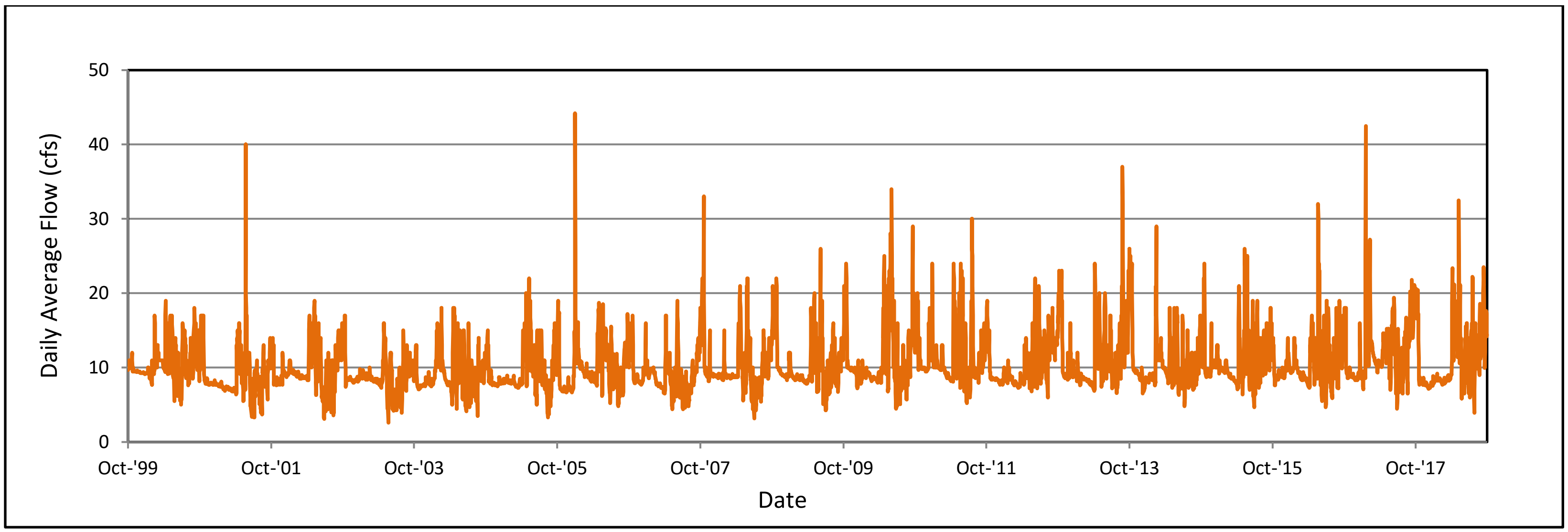

Figure 4-37. Reported flow in Mud Springs Creek near Gateway, Oregon from 2000 through 2018. Source: OWRD 2020k. (Note: The reporting period for Mud Springs Creek is shorter than for other covered waters due to lack of historical data prior to 2000.)

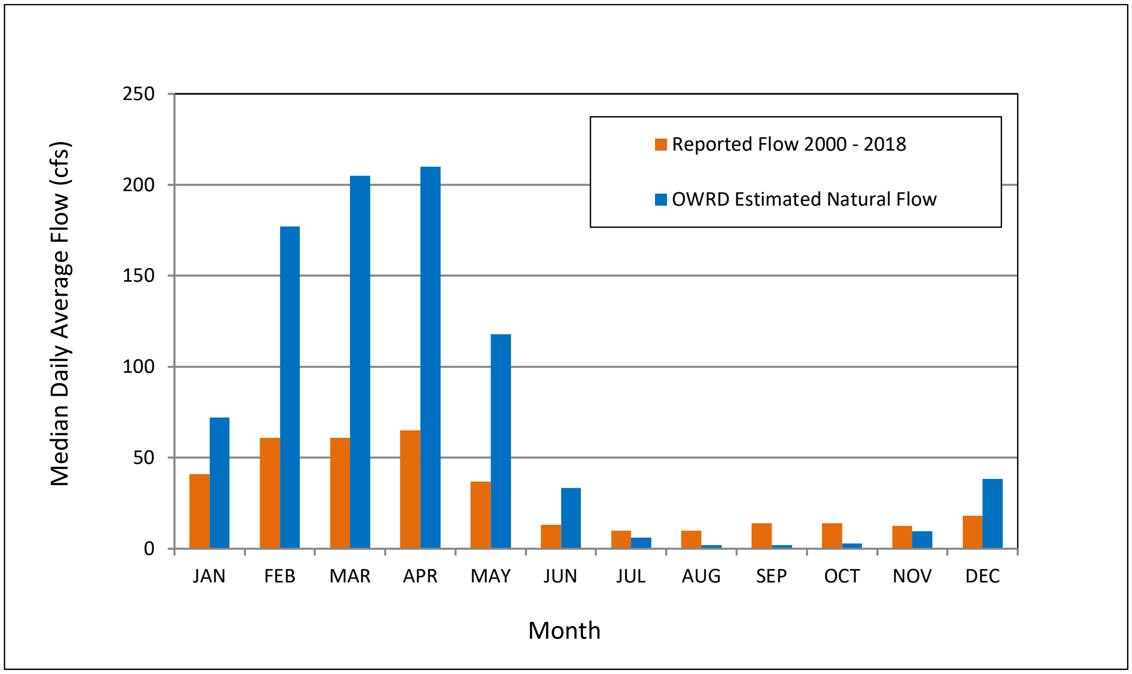

Figure 4-38. Comparison of reported flow (2000-2018) and estimated natural flow in Trout Creek. Source: OWRD 2020k, 2020l.

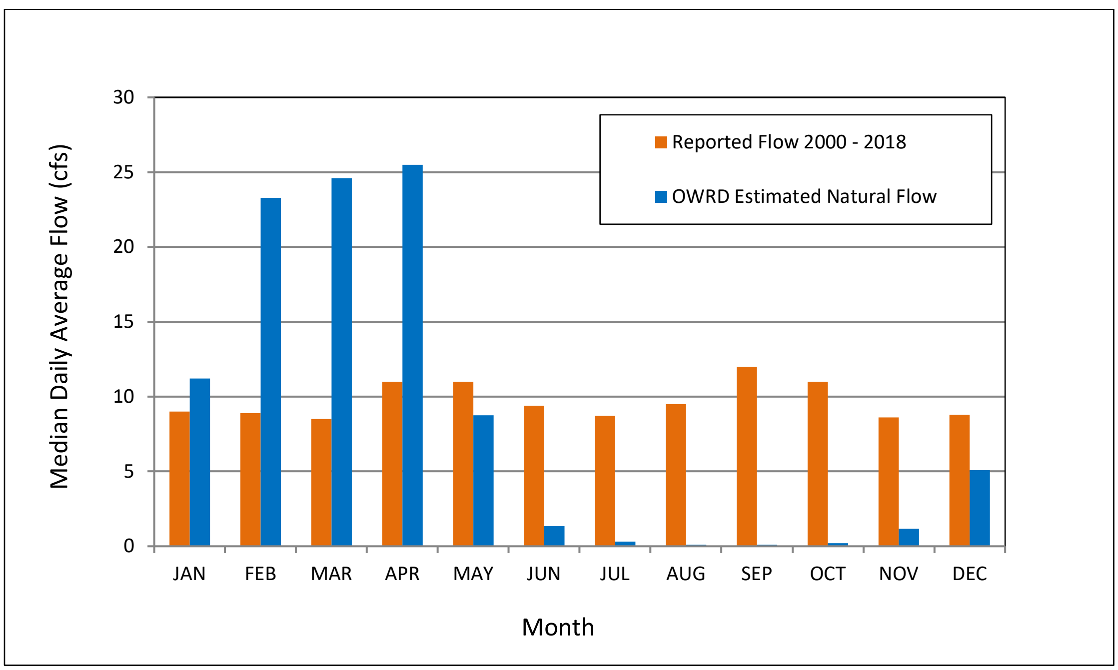

Figure 4-39. Comparison of reported flow (2000-2018) and estimated natural flow in Mud Springs Creek. Sources: OWRD 2020k, 2020l.

4.7.3 Water Temperature

Water temperatures in Mud Springs Creek and lower Trout Creek show a seasonal pattern typical of the Deschutes Basin. Temperatures (7-DADM) remain below 10°C for most of the winter and exceed 20°C by mid-summer (Figures 4-40 and 4-41). Peak summer temperatures in July can be over 22°C. Seasonal patterns in both creeks are consistent from year to year, but temperatures can fluctuate 2°C or more from week to week at any time of year. A comparison of flow and water temperature data for 2015 and 2016 shows that while the two creeks have different seasonal flow patterns they have very similar temperatures year round (Figures 4-42 and 4-43). Mud Springs Creek is slightly warmer than Trout Creek in the winter and slightly cooler in the summer.

Trout Creek is listed as water quality limited for temperature under Section 303(d) of the Clean Water Act for exceeding the year-round maximum 7-DADM of 18°C for salmon and trout rearing and migration from the mouth to RM 50.8 (ODEQ 2017). This temperature listing is based on data from multiple locations, including the gaging station near the mouth of the creek where the 7-DADM typically exceeds 18°C from early May to early September (Figure 4-40). In addition to its designated use for salmon and trout rearing and migration, Trout Creek is designated for salmon and steelhead spawning use from 1 January to 15 May. Temperatures in the lower creek often exceed the criterion for salmonid spawning (12.8°C) from early April to mid-October.

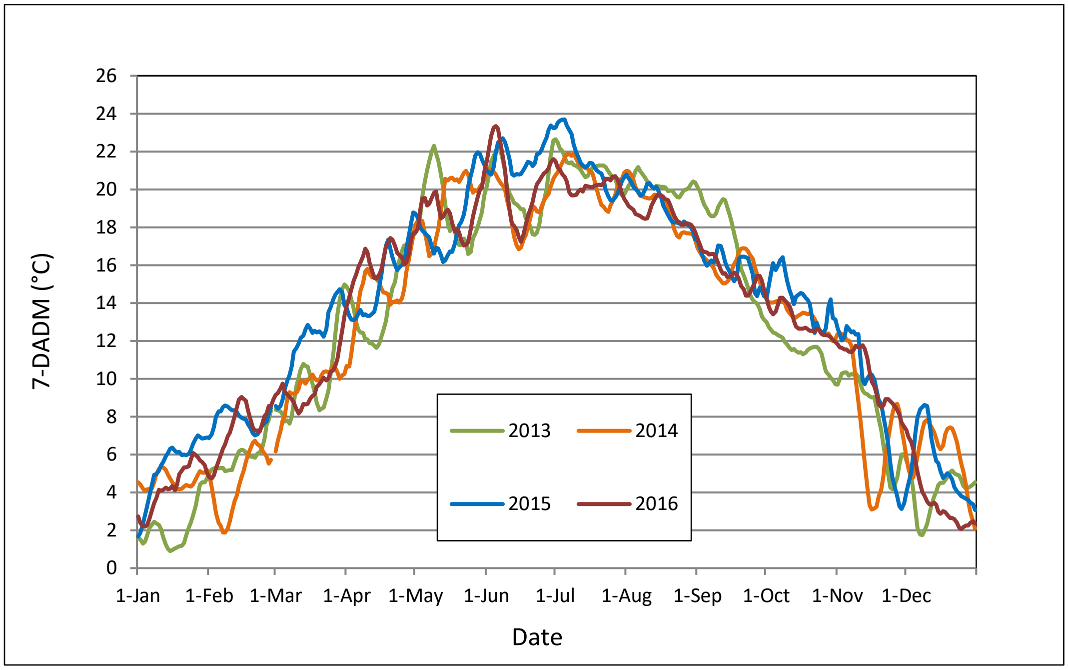

Figure 4-40. Seven-day averages of daily maximum water temperatures (7-DADM) in Trout Creek at Gateway. Source: Reclamation 2017d.

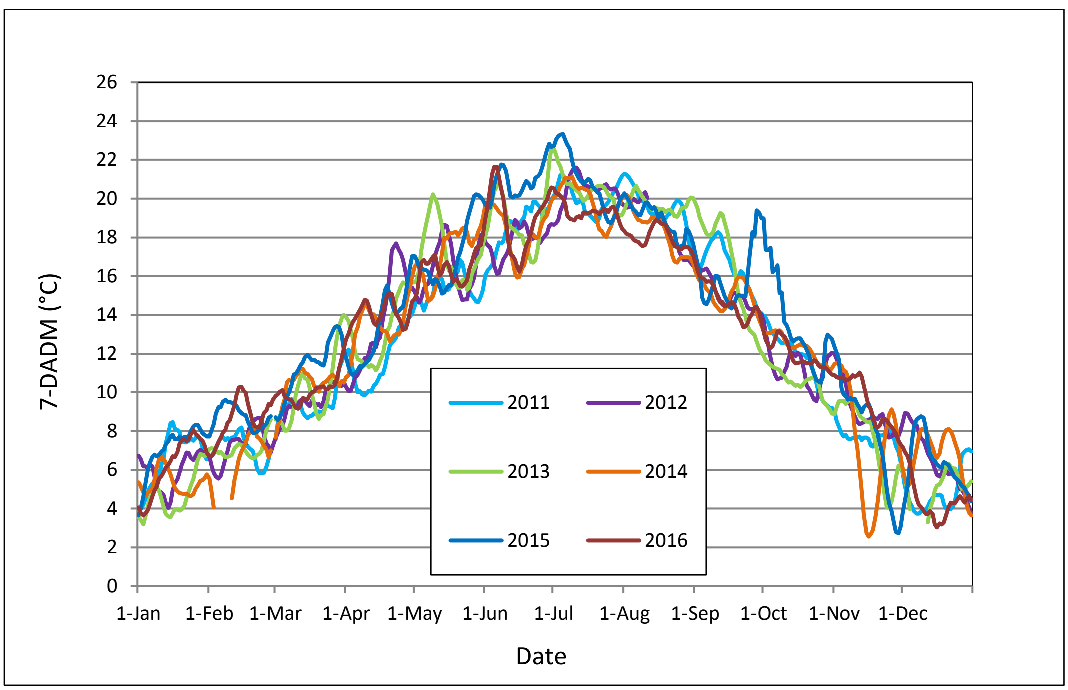

Figure 4-41. Seven-day averages of daily maximum water temperatures (7-DADM) in Mud Springs Creek at Gateway. Source: Reclamation 2017d.

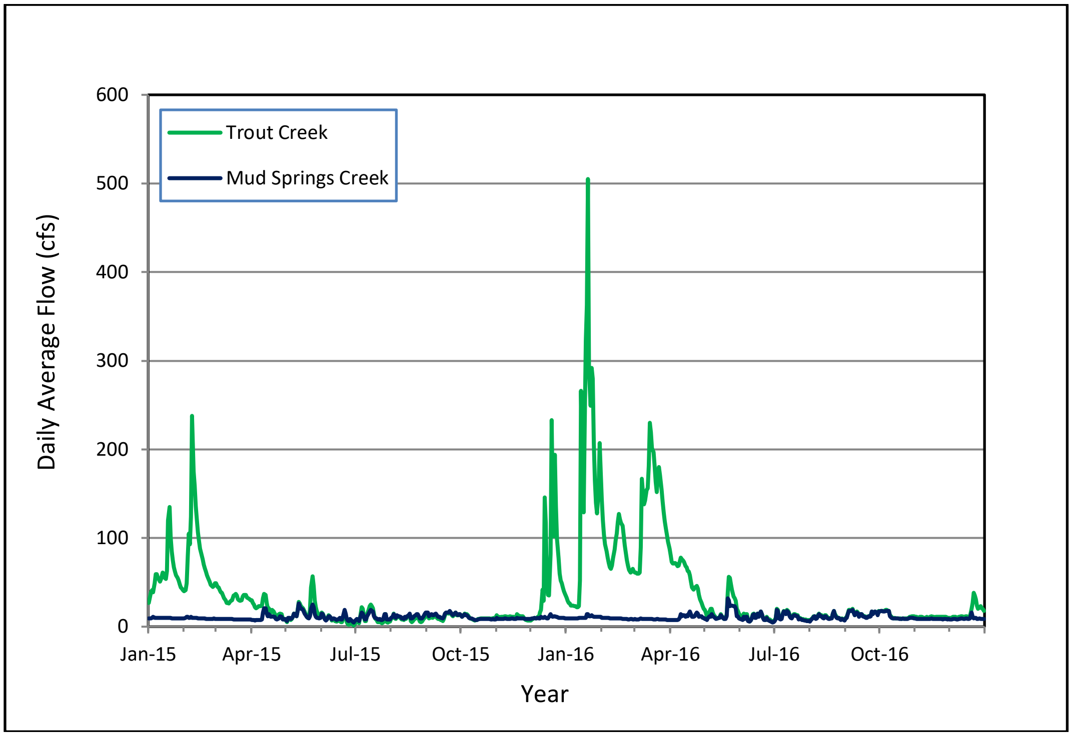

Figure 4-42. Comparison of flows in Mud Springs Creek (Gage 14095250) and Trout Creek (Gage 14095255) from January 2015 through December 2016. Source OWRD 2020k.

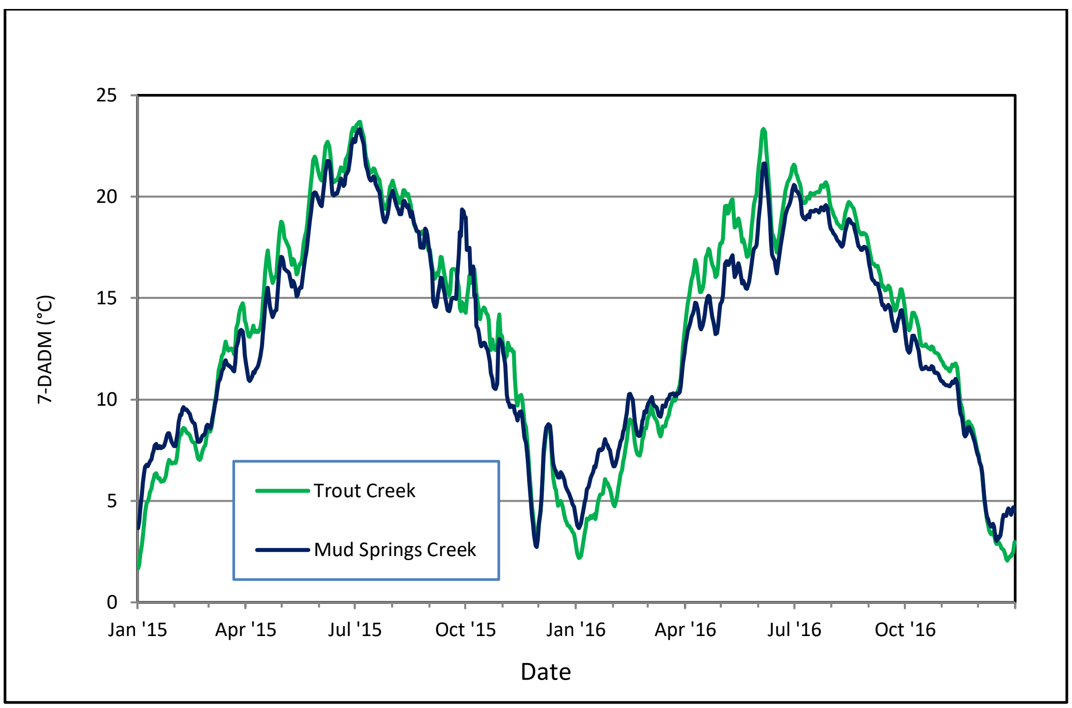

Figure 4-43. Comparison of 7-day average of daily maximum water temperature (7-DADM) for Trout Creek (at Gage 14095255) and Mud Springs Creek (at Gage 14095250) from January 2015 through December 2016. Source: Reclamation 2017d.

4.7.4 Water Quality

Trout Creek is listed as water quality limited for habitat modification, sedimentation and biological criteria (Table 4-9). Mud Springs Creek is listed as limited for pH. The 303(d) listings of Trout Creek for habitat modification and sedimentation are based on conditions documented by USFS habitat surveys in the upper basin, with the assumption these conditions persist for the entire length of the creek (Watershed Professionals Network 2002).

Table 4-9. Trout Creek and Mud Springs Creek reaches covered by the DBHCP that are identified in Oregon's 2012 Integrated Report as water quality limited.

Reach	Pollutant	Season	Criteria	Status	
				Category	Description
Trout Creek					
RM 0.0 - 13.6	Biological Criteria	Year round	Waters of the state must be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.	5	Water quality limited, 303(d) list, TMDL needed
RM 0.0 - 50.7	Habitat Modification	Undefined	The creation of tastes or odors or toxic or other conditions that are deleterious to fish or other aquatic life or affect the potability of drinking water or the palatability of fish or shellfish may not be allowed.	4C	Water quality limited, not a pollutant
RM 0.0 - 50.7	Sedimentation	Undefined	The formation of appreciable bottom or sludge deposits or the formation of any organic or inorganic deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry may not be allowed.	5	Water quality limited, 303(d) list, TMDL needed
RM 0.0 - 50.7	Temperature	Year round (Non-spawning)	Salmon and trout rearing and migration: 7-DADM ≤ 18.0°C	5	Water quality limited, 303(d) list, TMDL needed
Mud Springs Creek					
RM 0.0 - 25.6	pH	Fall/Winter/ Spring	pH 6.5 to 8.5	5	Water quality limited, 303(d) list, TMDL needed

Source: ODEQ 2017.

4.8 Crooked River Subbasin

4.8.1 Geography and Land Use

The Crooked River and its tributaries (Ochoco Creek, McKay Creek and Beaver Creek) drain an area of about 4,500 square miles, making it the largest subbasin within the Deschutes Basin. The Crooked River forms in eastern Crook County and western Harney County at elevations of 3,800 to 5,400 feet, and enters the Deschutes River at Lake Billy Chinook (Figure 4-44). The Crooked River and Ochoco Creek merge within the City of Prineville, the largest population center within the subbasin. McKay Creek flows into the Crooked River 0.5 mile downstream of Ochoco Creek, also within the City of Prineville. The lower 9 miles of the river pass through the Crooked River Gorge, which is up to 500 feet deep in places.

The headwaters of the Crooked River lie mostly on federal lands under the administrative control of the USFS (Ochoco National Forest) and BLM (Prineville District). The remainder of the subbasin is predominantly private land utilized for range and irrigated crop production. Within the covered lands, a 14.8-mile reach of the Crooked River between Bowman Dam and Dry Creek is designated *Recreational* under the Federal Wild and Scenic Rivers Act of 1968. Most of the North Fork Crooked River (upstream of the covered lands) is also designated *Wild, Scenic* or *Recreational* under the Wild and Scenic Rivers Act.

Covered activities in the Crooked River subbasin include Ochoco Reservoir on Ochoco Creek upstream of the City of Prineville. Prineville Reservoir on the Crooked River is also described in the chapter to provide a comprehensive understanding of basin hydrology, but it is a federal facility operated by Reclamation and is not covered by the DBHCP. The primary diversions covered by the DBHCP in the subbasin are the OID Crooked River Diversion (RM 57.0), the NUID Crooked River Pumps (RM 27.6) and the Ochoco Main Canal at Ochoco Dam on Ochoco Creek (RM 10.5). Water is also diverted at several smaller structures on Ochoco Creek and McKay Creek that are covered by the DBHCP, as well as numerous small diversions that are not associated with the DBHCP.

4.8.2 Hydrology

The hydrology of the Crooked River subbasin is distinct from the western portions of the upper Deschutes Basin for two reasons. First, the Crooked River subbasin receives substantially less precipitation than tributaries with headwaters in the Cascade Mountains to the west of the Deschutes River. Average annual precipitation in Prineville, near the lower end of the Crooked River subbasin, is only 9.9 inches (WRCC 2017). At Rager Ranger Station, which lies at elevation 4,000 feet near the eastern end of the subbasin, the average annual precipitation is only 17.0 inches. In contrast, average annual precipitation at Santiam Pass on the Cascade crest is 85.6 inches.

The second reason for the difference in hydrology is the absence of deep, highly-permeable geologic surface deposits of the type present in other portions of the Deschutes Basin. Much of the Crooked River subbasin is in close contact with the John Day Formation, which is older and much less permeable than the Newberry Volcanic Deposits and Quaternary Sediments that overlie it to the south and west (Lite and Gannett 2002). The result is limited interchange between surface and ground water in the upper Crooked River subbasin. Rather than recharging groundwater, most precipitation that falls in the upper subbasin becomes surface runoff that peaks rapidly and briefly during storm events and spring snowmelt. Other than discharge of about 20 cfs to the South Fork Crooked River, the Upper Crooked River and its tributaries receive little groundwater support and tend to drop dramatically after the end of snowmelt in early spring. Groundwater only becomes a significant source of streamflow downstream of Prineville Reservoir. Discharge of shallow groundwater fed largely by irrigation between Bowman Dam at RM 70.5 and Smith Rock at RM 25.5 contributes a net of about 27 cfs to the Crooked River on a seasonal basis (LaMarche 2008). Downstream of Smith Rock, particularly in the lower 10 miles above Lake Billy Chinook, the Crooked River passes through a canyon of sufficient depth to intersect the regional groundwater table and gain as much as 1,100 cfs (Gannet and Lite 2004).

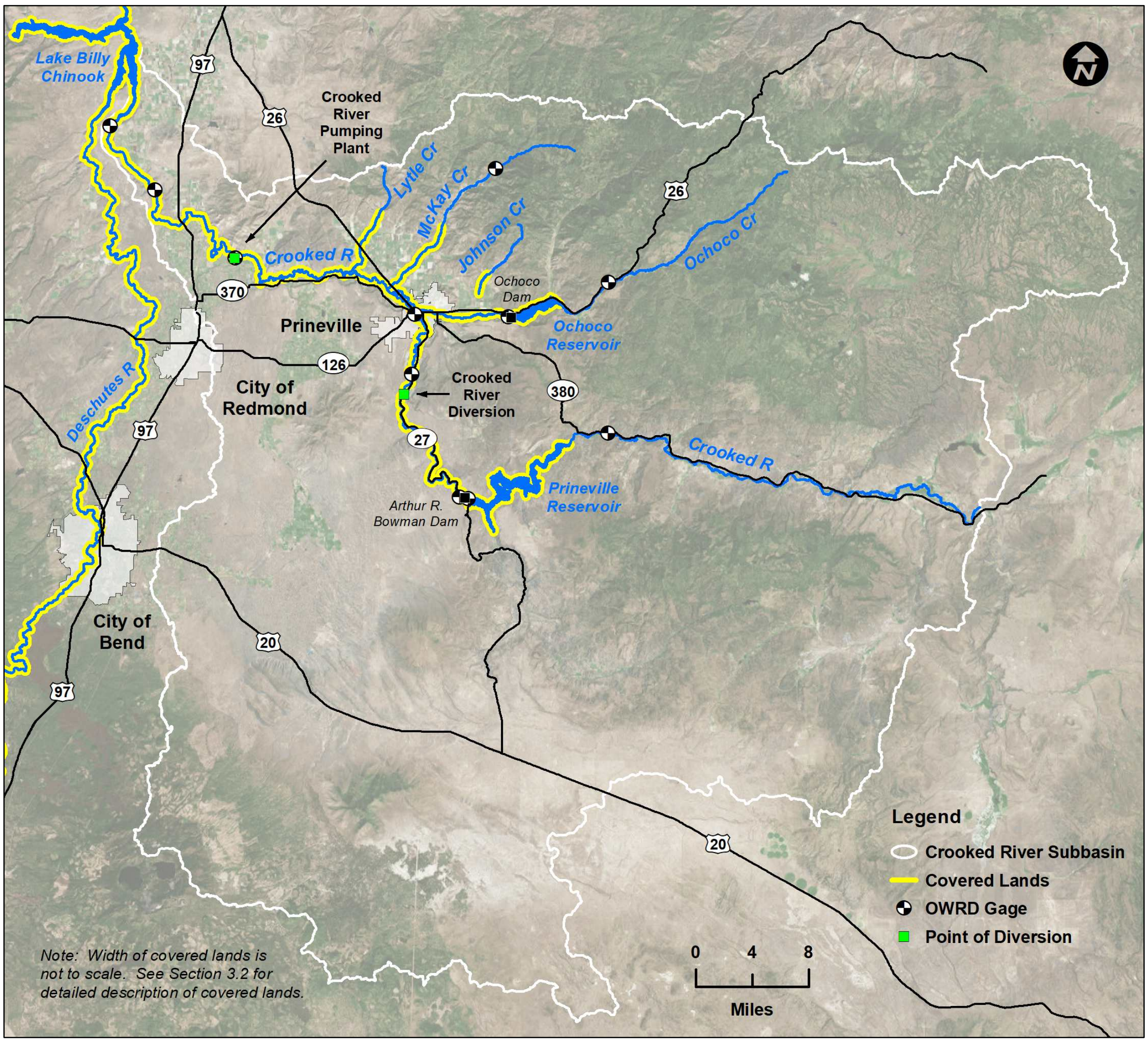

Figure 4-44. Map of the Crooked River Subbasin.

Current hydrologic conditions in the Crooked River and Ochoco Creek are illustrated by flow data for five locations with significance to ongoing irrigation activities. Upstream of Prineville Reservoir (Figure 4-45) daily average flow in the Crooked River is unregulated during the winter and reduced during the summer by a number of small diversions unrelated to the DBHCP. Flow above Prineville Reservoir typically peaks in spring during snowmelt, and falls close to zero by late summer. In many years, storm events and/or heavy snowpack can result in short-term runoff events upstream of the reservoir well in excess of 3,000 cfs. Downstream of Bowman Dam (Figure 4-46), the combination of irrigation storage and flood control eliminates flows over 3,000 cfs, reduces average winter flow, and increases average summer flow compared to unregulated conditions. At Terrebonne (Figure 4-47), which is downstream of all irrigation diversions, the cumulative effects of diversions and tributary inflow are apparent. Peak winter flow in the Crooked River at Terrebonne again exceeds 3,000 cfs in some years due to inflow from Ochoco Creek and McKay Creek, but summer flow is much less than below Bowman Dam due to multiple irrigation diversions. Further downstream at Opal Springs (Figure 4-48) groundwater discharge increases flow in the Crooked River by more than 1,000 cfs during all seasons.

Flow in Ochoco Creek below Ochoco Dam (Figure 4-49) shows a seasonal pattern similar to the Crooked River below Bowman Dam, though much smaller in magnitude. Ochoco Creek flow is high immediately below the dam during the irrigation season when water is released, and low during the winter when water is stored. In 13 of 23 years between 1994 and 2016, it was necessary to release additional water from Ochoco Reservoir during the storage season to maintain flood storage capacity. Between Ochoco Dam and the mouth of Ochoco Creek, summer flow is reduced by multiple irrigation diversions covered by the DBHCP.

Historically low flows in the Crooked River downstream of Bowman Dam have been ameliorated in recent years by two actions. The Crooked River Collaborative Water Security and Jobs Act of 2014 (Crooked River Act) made over 62,000 acre-feet of previously-uncontracted storage in Prineville Reservoir available for fish and wildlife use. This water will be released from storage at various times of year to increase instream flow downstream of Bowman Dam. In addition, summer flows at Terrebonne have been increased through an agreement between NUID and the Deschutes River Conservancy (DRC) that ensures NUID will not operate the Crooked River Pumps to divert water unless minimum flows of 43 to 181 cfs can be maintained at the Terrebonne Gage (Table 4-10). The result of this agreement is that Crooked River flow at Terrebonne will not drop appreciably below the historical median in non-dry years or below the historical 80 percent exceedance level in dry years during the driest months of July and August (Figure 4-50).

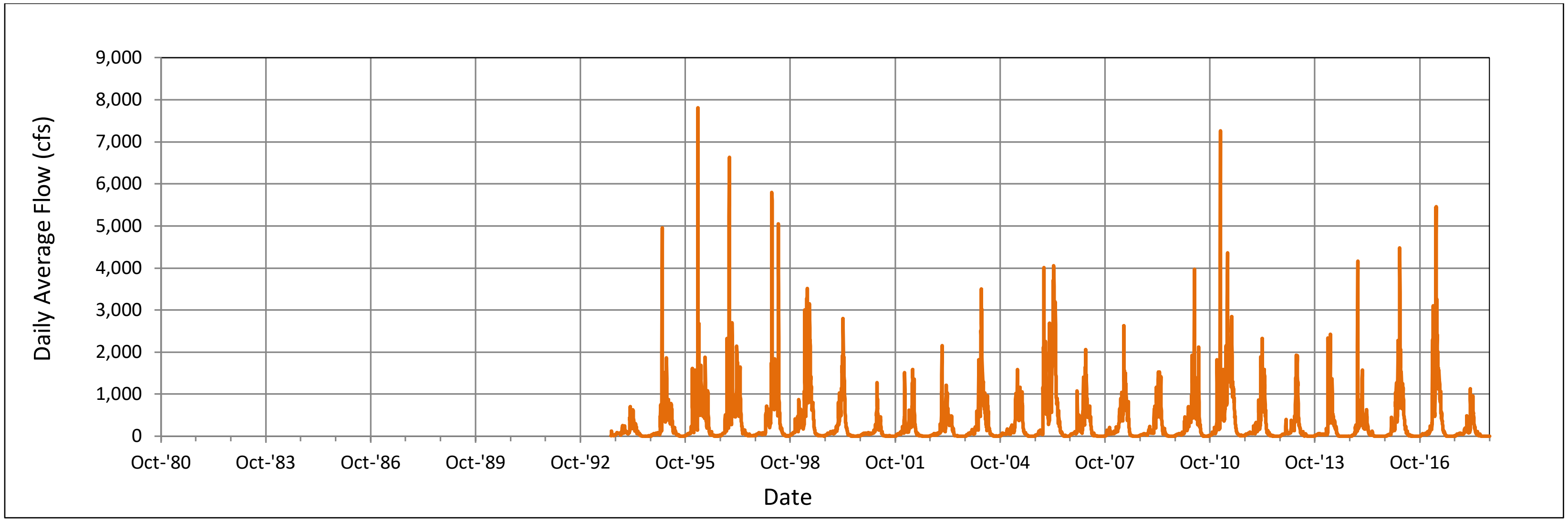

Figure 4-45. Reported flow in the Crooked River above Prineville Reservoir from 1994 through 2018. Source: OWRD 2020m. (Note: The reporting period for this location is shorter than for other covered waters due to lack of historical data prior to 1994.)

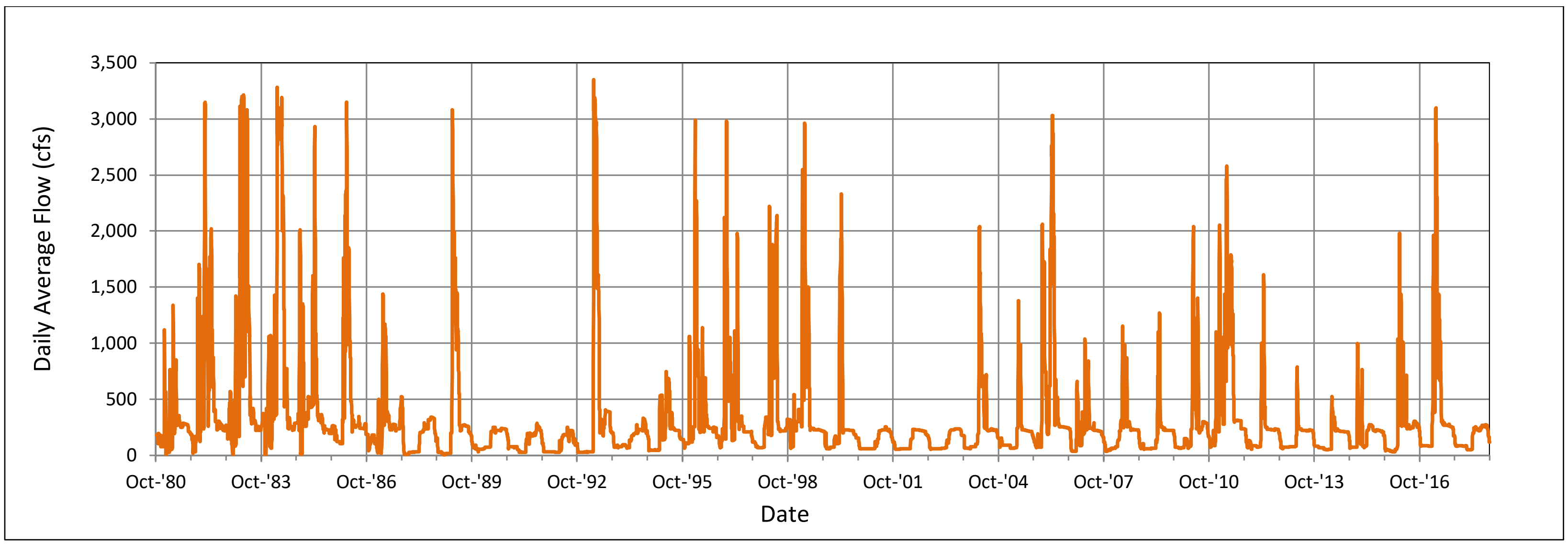

Figure 4-46. Reported flow in the Crooked River below Bowman Dam (RM 70.5) from 1981 through 2018. Source: OWRD 2020n.

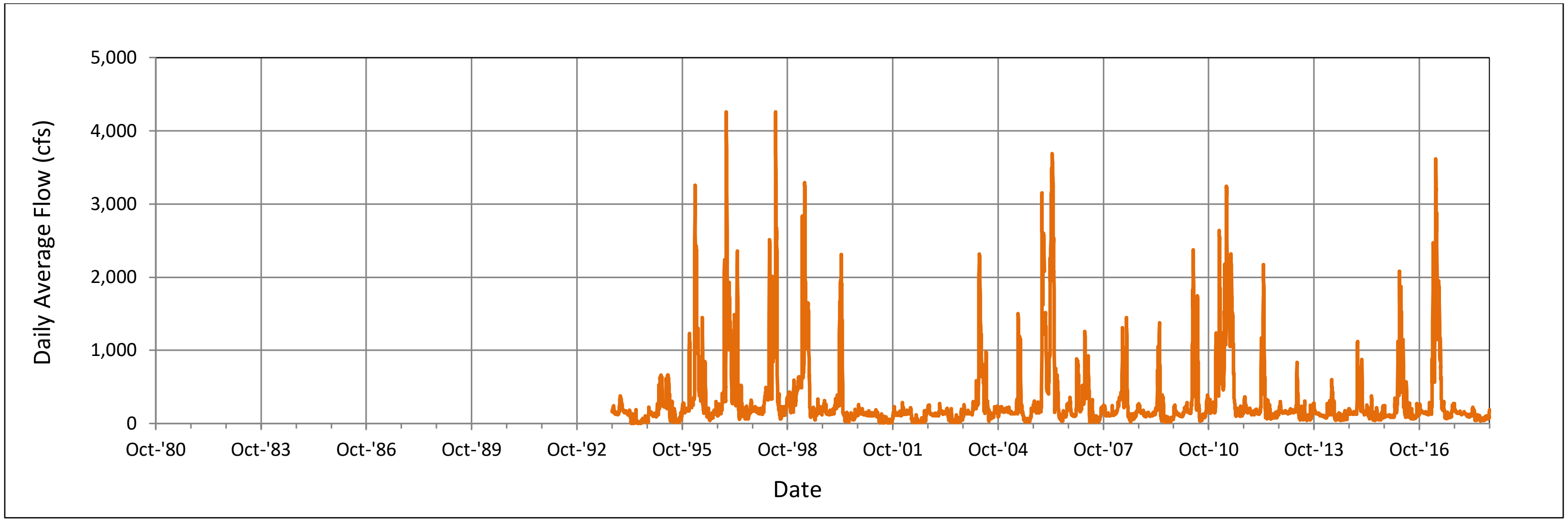

Figure 4-47. Reported flow in the Crooked River at Terrebonne (RM 27.0) from 1994 through 2018. Source: OWRD 2020o. (Note: The reporting period for this location is shorter than for other covered waters due to lack of historical data prior to 1994.)

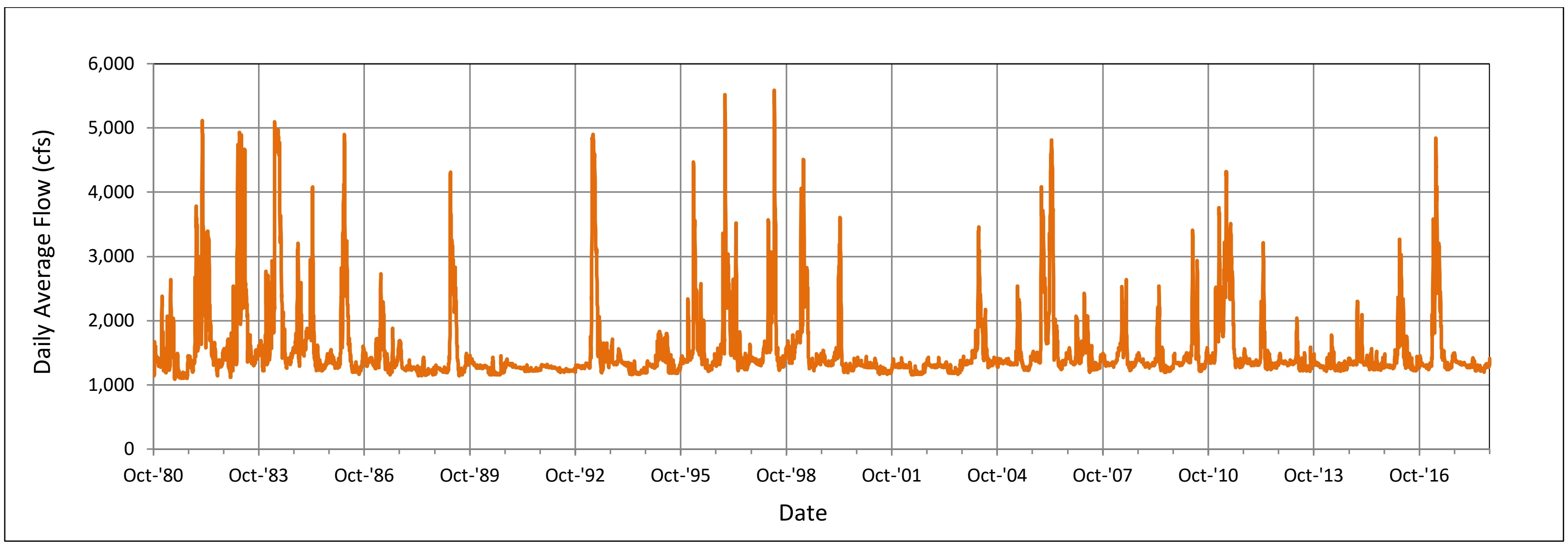

Figure 4-48. Reported flow in the Crooked River below Opal Springs (RM 6.7) from 1981 through 2018. Source: OWRD 2020p.

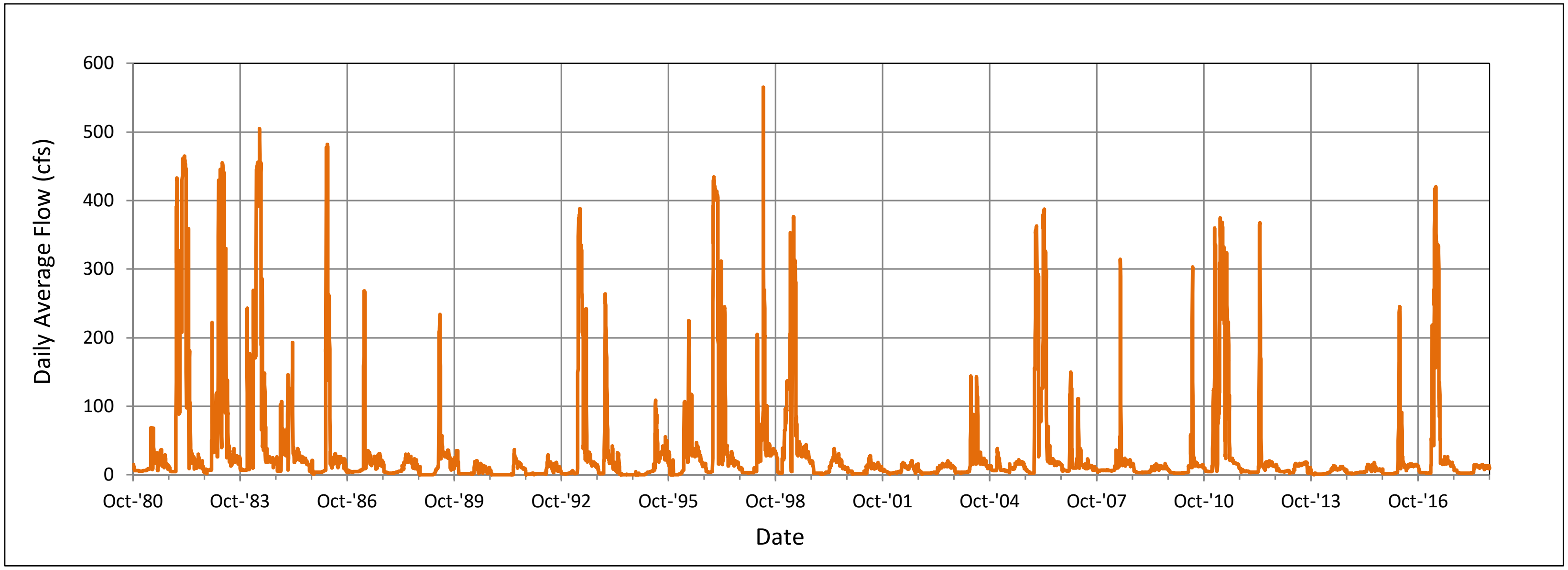

Figure 4-49. Reported flow in Ochoco Creek below Ochoco Dam (RM 11.2) from 1981 through 2018. Source: OWRD 2020q.

Table 4-10. Minimum flows to be maintained at Gage 14087300 on the Crooked River near Terrebonne when NUID is diverting water at its pumps.

Month	Minimum Daily Average Flow (cfs)	
	Dry Year *	Non-Dry Year
April	120	181
May	43	95
June	54	86
July	51	61
August	56	68
September	57	114
October	121	151

* For purposes of this measure, Dry Years and Non-Dry Years exist when OWRD makes a written declaration according to the following metrics:

1. Dry Year Declaration in March – Established only if the following conditions apply:
   a. The OWRD's or Bureau of Reclamation's predicted March month-end contents of Prineville Reservoir are less than or equal to the 50 percent exceedance level of the contents at March 31 based on all data from the prior 30 years, and
   b. Either:
      i. The Prineville Reservoir outflow has not exceeded 75 cfs within 30 days of the actual date of OWRD's Non-Dry Year/Dry Year declaration, or
      ii. The Prineville Reservoir outflow has exceeded 75 cfs within 30 days of the actual date of OWRD's Non-Dry Year/Dry Year declaration only to supply irrigation demands for downstream users.
2. Non-Dry Year Declaration – Established if any of the following conditions apply:
   a. The conditions necessary for a Dry Year Declaration do not apply, or
   b. When OWRD fails to make any written Dry Year Declaration.

OWRD maintains discretion to apply and interpret the Dry Year Declaration metric if there is an extenuating circumstance(s) with respect to March month-end contents of Prineville Reservoir or its outflows 30 days prior to a Dry or Non-Dry Year Declaration so as to target a Dry Year recurrence interval of 3 out of 10 years over a 30-year period. Further, upon request by NUID and the DRC, OWRD may revise the metrics if it is expected that the recurrence interval of a Dry Year Declaration over a 30-year period will change from 3 out of 10 years.

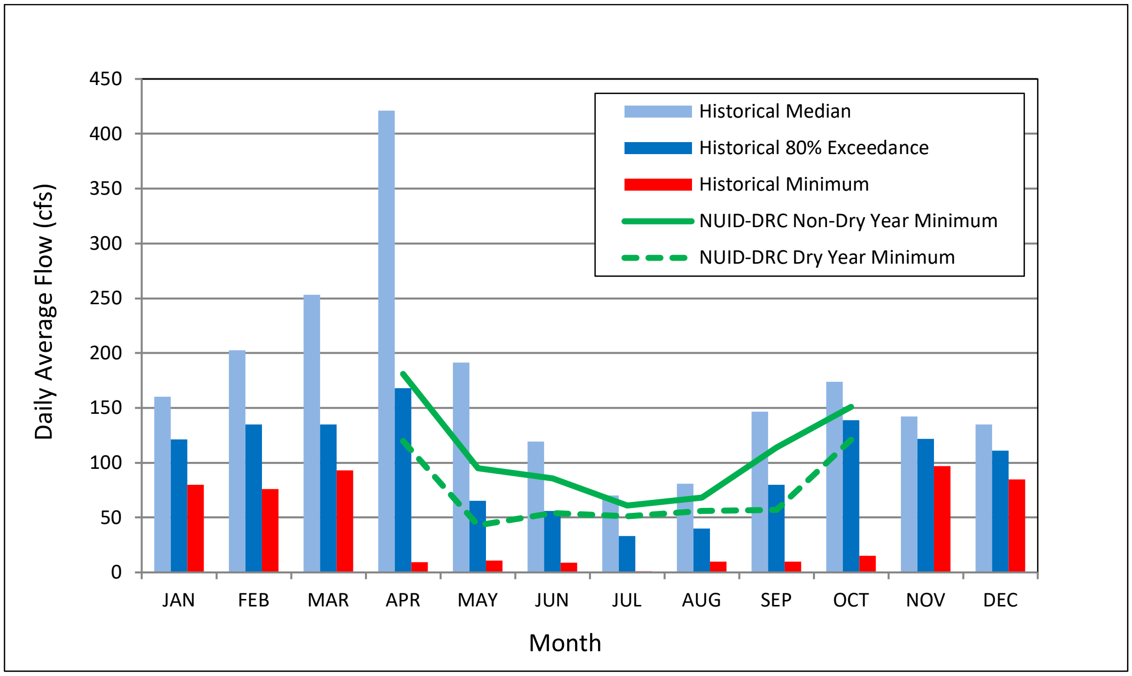

Figure 4-50. Comparison of historical (1994-2018) daily average flows in the Crooked River at Terrebonne (RM 27.0) to flows that will be provided under the original NUID-DRC Agreement.

4.8.3 Water Temperature

Water temperatures in the Crooked River and Ochoco Creek are strongly influenced by irrigation storage, release and diversion. Upstream of Prineville Reservoir (Figures 4-51) the 7-DADM in the Crooked River can reach 28°C in July and August due to low natural flow and high solar insolation. Ochoco Creek shows a similar pattern upstream of Ochoco Reservoir (Figure 4-57), with the 7-DADM reaching 22°C or more. Immediately below the reservoirs, however, summer water temperatures are typically 8 to 10 °C cooler (Figures 4-52 and 4-58). The cooling effect of Prineville Reservoir persists for roughly 13 miles from Bowman Dam to the Crooked River Diversion due to the high volume of water (in excess of 200 cfs) released throughout the irrigation season (Figure 4-45). Downstream of the Crooked River Diversion (Figures 4-53 to 4-56), low flow and the general absence of riparian shade produce a warming trend, and by the time water reaches Lone Pine Road (RM 29.6) it is nearly back to the temperature it reached upstream of Prineville Reservoir (i.e., prior to the cooling effect of the reservoir). In Ochoco Creek (Figures 4-58 and 4-59) the warming process occurs more quickly due to the small size and lower overall flow of the creek.

Water temperatures in McKay Creek vary between 18 and 22 °C for most of the summer upstream of Ochoco Irrigation District diversions (Figure 4-60) as well as downstream (Figure 4-61). Water is not stored or impounded on McKay Creek, but a number of diversions and returns occur between the National Forest Boundary (about RM 12) and Smith Inverted Weir (RM 0.6). Temperatures in lower Lytle Creek (RM 0.5) show a very similar pattern (Figure 4-62).

The Crooked River from Lake Billy Chinook to RM 51.0 is identified as water temperature limited under Section 303(d) of the Clean Water Act for exceeding the summer maximum 7-DADM of 17.8°C for salmon and trout rearing and migration (ODEQ 2017). Lower Ochoco Creek (RM 0.0 to 22.4) and lower Lytle Creek (RM 0.0 to 4.2) have similar listings. Lower McKay Creek (RM 0.0 to 19.5) is identified as water quality limited for exceeding the year round maximum 7-DADM of 18.0°C for salmon and trout rearing and migration. All reaches of the Crooked River, Ochoco Creek, McKay Creek and Lytle Creek covered by the DBHCP are designated for salmon and trout rearing and migration, although anadromous use of Lytle Creek is limited to the lower 0.5 mile.

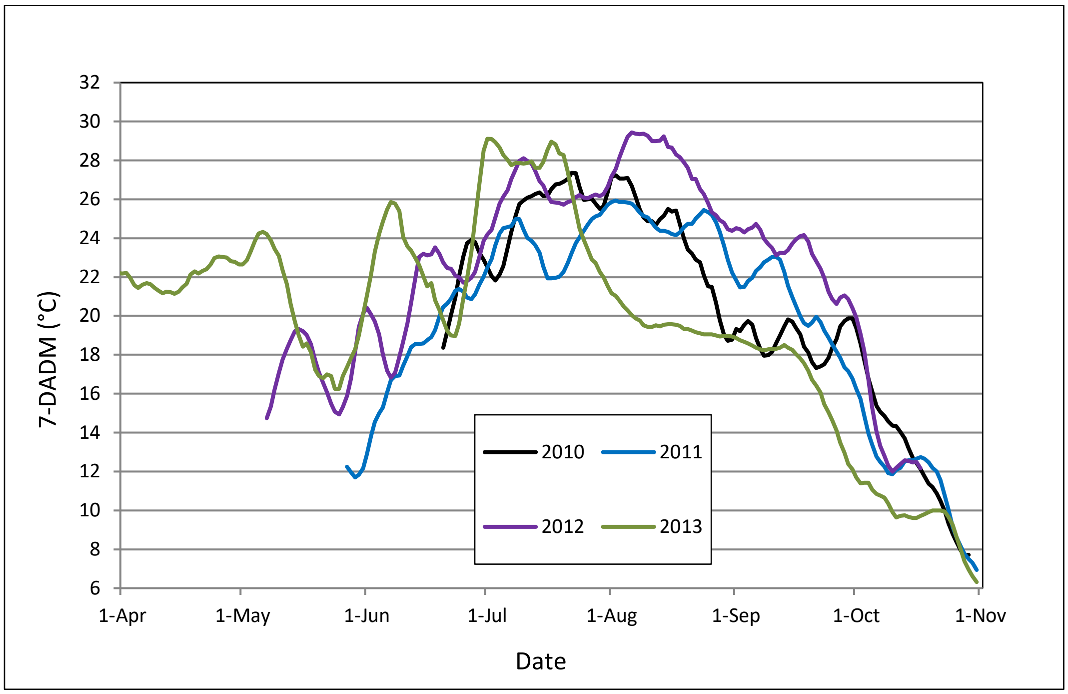

Figure 4-51. Seven-day averages of daily maximum water temperatures (7-DADM) in the Crooked River 2 miles upstream of Prineville Reservoir during the irrigation season. Source: CRWC 2014.

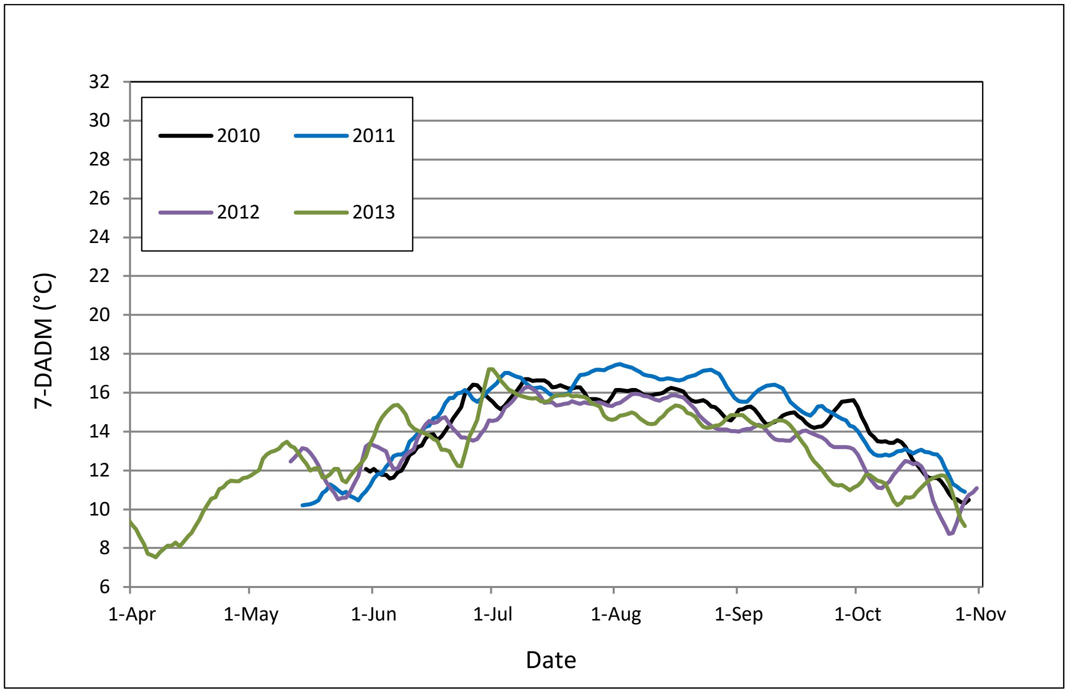

Figure 4-52. Seven-day averages of daily maximum water temperatures (7-DADM) in the Crooked River below the Crooked River Diversion (RM 56.8) during the irrigation season. Source: CRWC 2014.

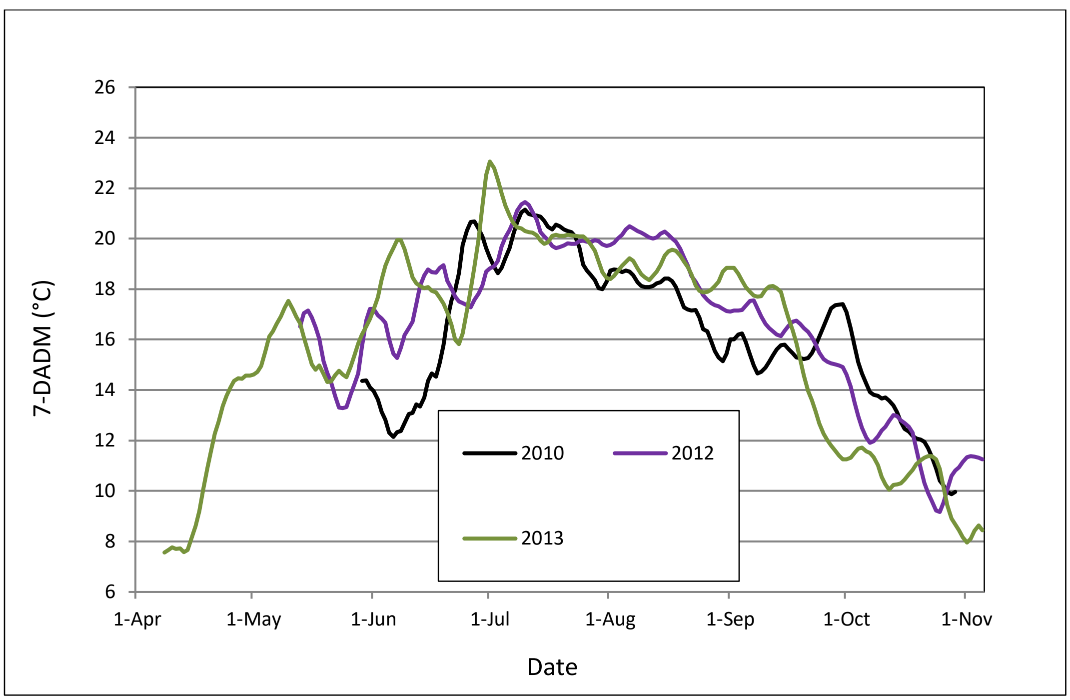

Figure 4-53. Seven-day averages of daily maximum water temperatures (7-DADM) in the Crooked River below the Peoples Diversion (RM 50.0) during the irrigation season. Source: CRWC 2014.

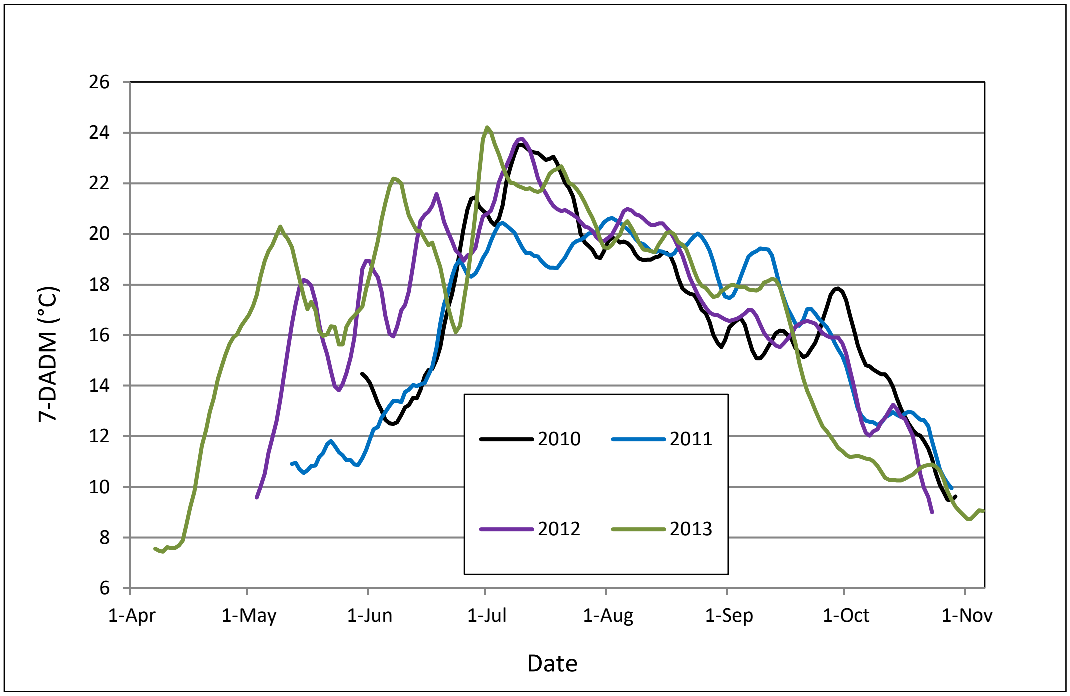

Figure 4-54. Seven-day averages of daily maximum water temperatures (7-DADM) in the Crooked River below the confluence with Ochoco Creek (RM 45.4) during the irrigation season. Source: CRWC 2014.

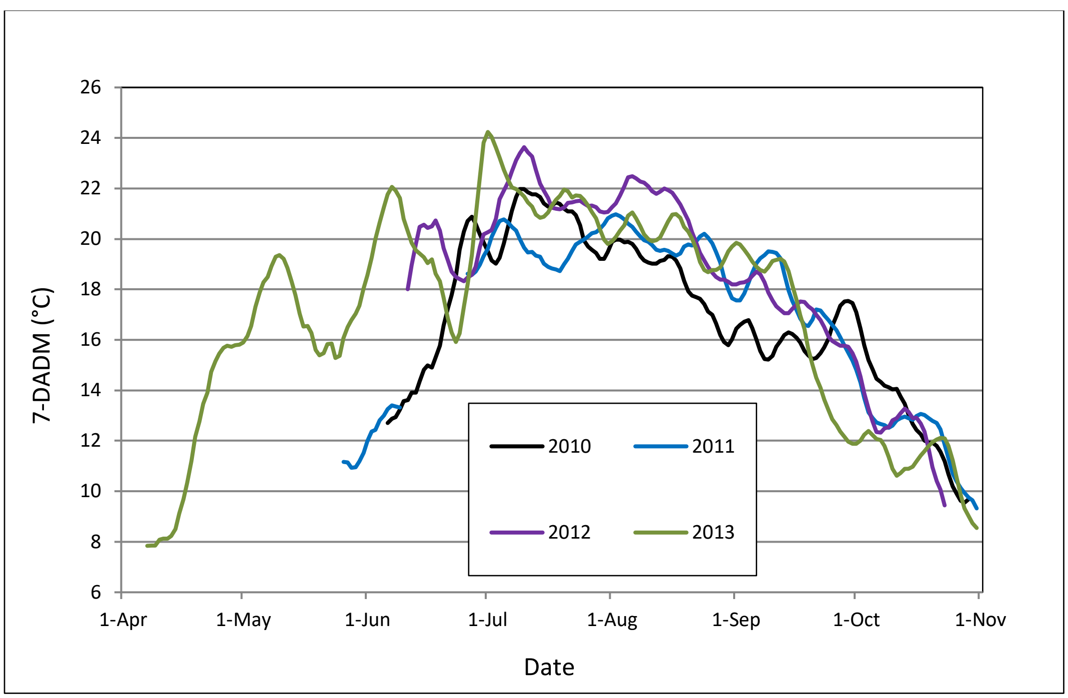

Figure 4-55. Seven-day averages of daily maximum water temperatures (7-DADM) in the Crooked River below the confluence with McKay Creek (RM 44.9) during the irrigation season. Source: CRWC 2014.

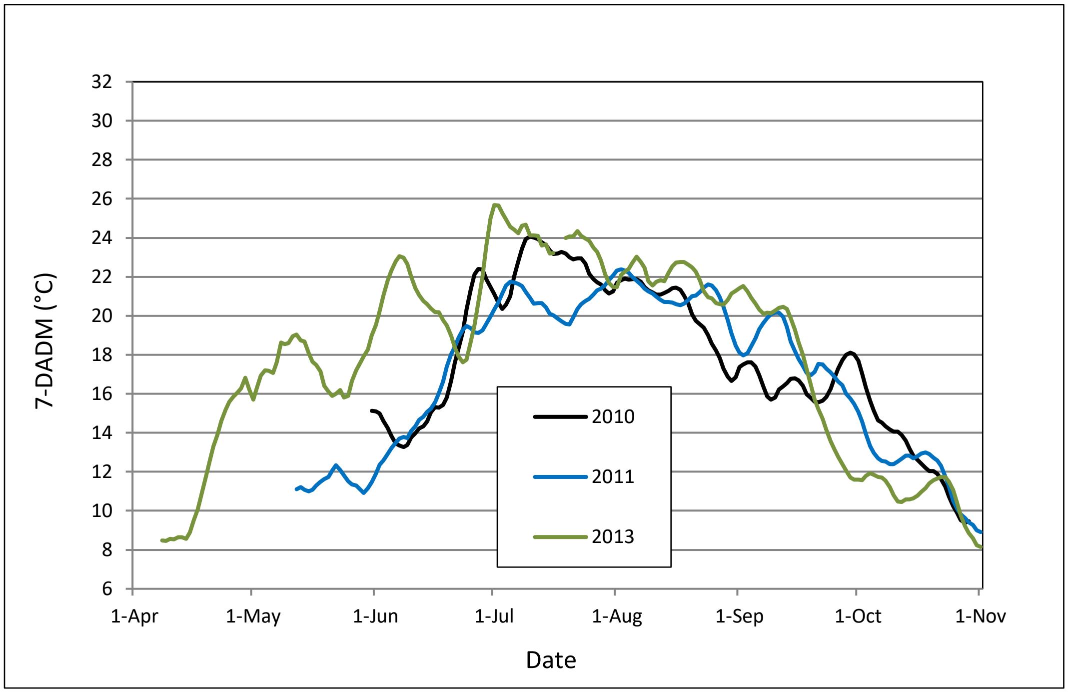

Figure 4-56. Seven-day averages of daily maximum water temperatures (7-DADM) in the Crooked River at Lone Pine Road (RM 29.6) during the irrigation season.
Source: CRWC 2014.

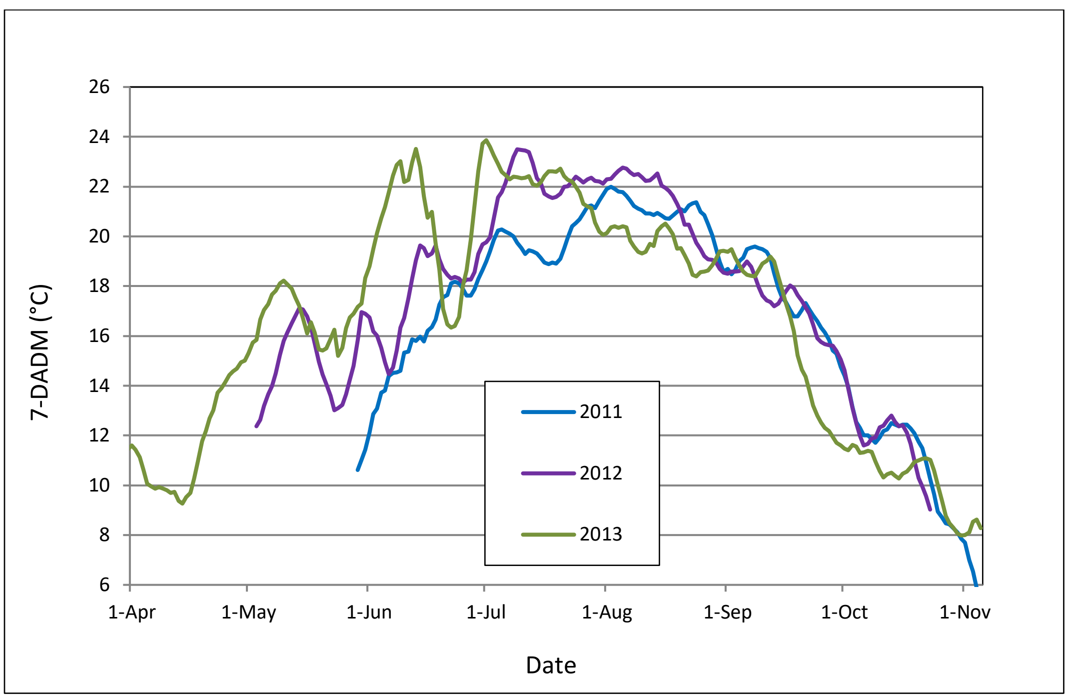

Figure 4-57. Seven-day averages of daily maximum water temperatures (7-DADM) in Ochoco Creek 2 miles upstream of Ochoco Reservoir during the irrigation season.
Source: CRWC 2014.

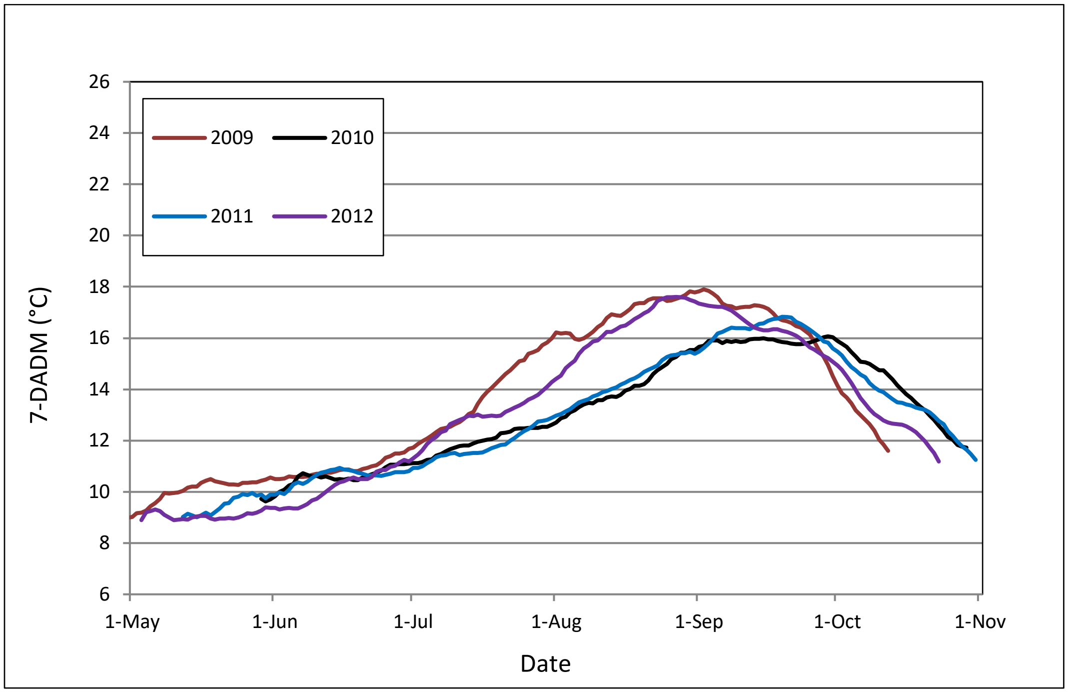

Figure 4-58. Seven-day averages of daily maximum water temperatures (7-DADM) in Ochoco Creek below Ochoco Dam (RM 11.0) during the irrigation season. Source: CRWC 2014.

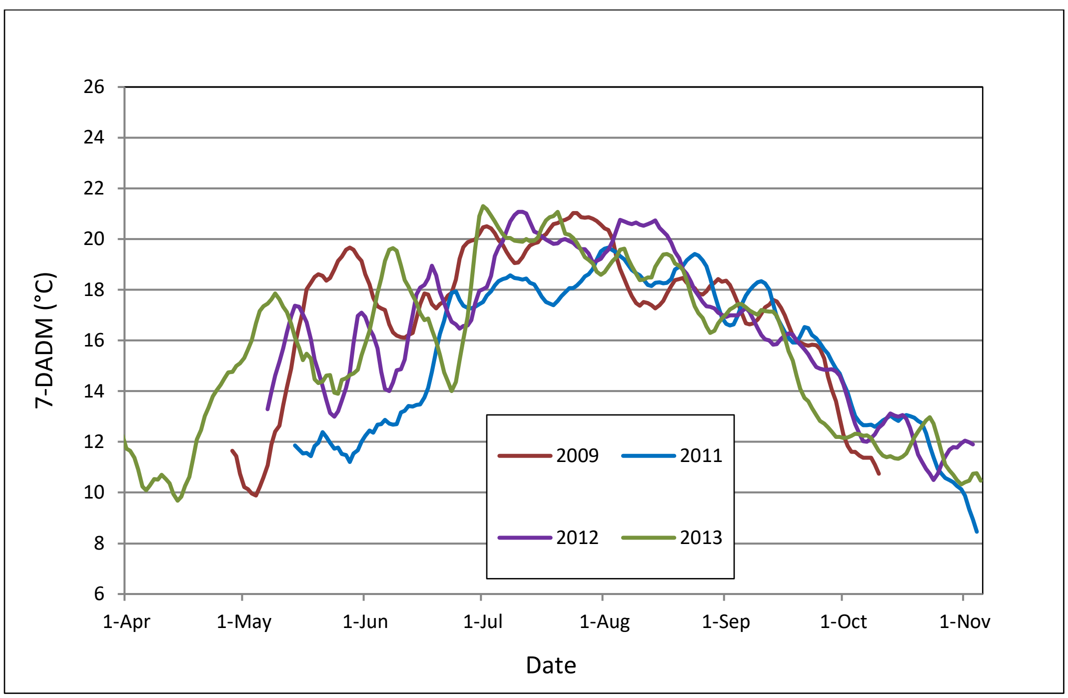

Figure 4-59. Seven-day averages of daily maximum water temperatures (7-DADM) in Ochoco Creek at US Route 26 (RM 0.7) during the irrigation season. Source: CRWC 2014.

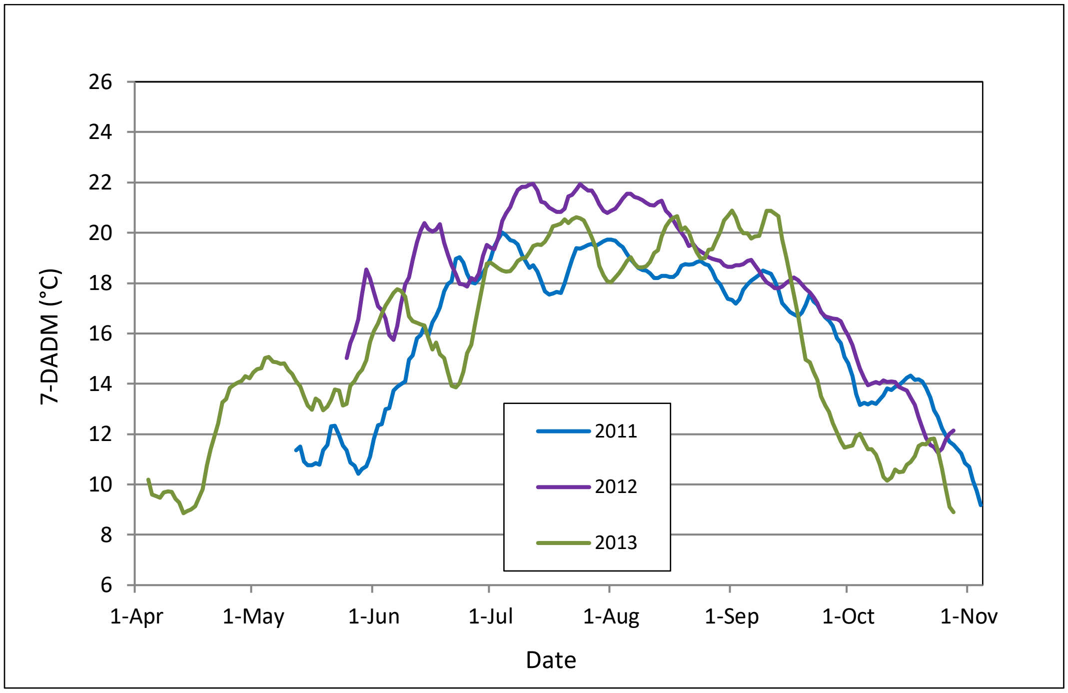

Figure 4-60. Seven-day averages of daily maximum water temperatures (7-DADM) in McKay Creek below Allen Creek (RM 8.3) during the irrigation season. Source: CRWC 2014.

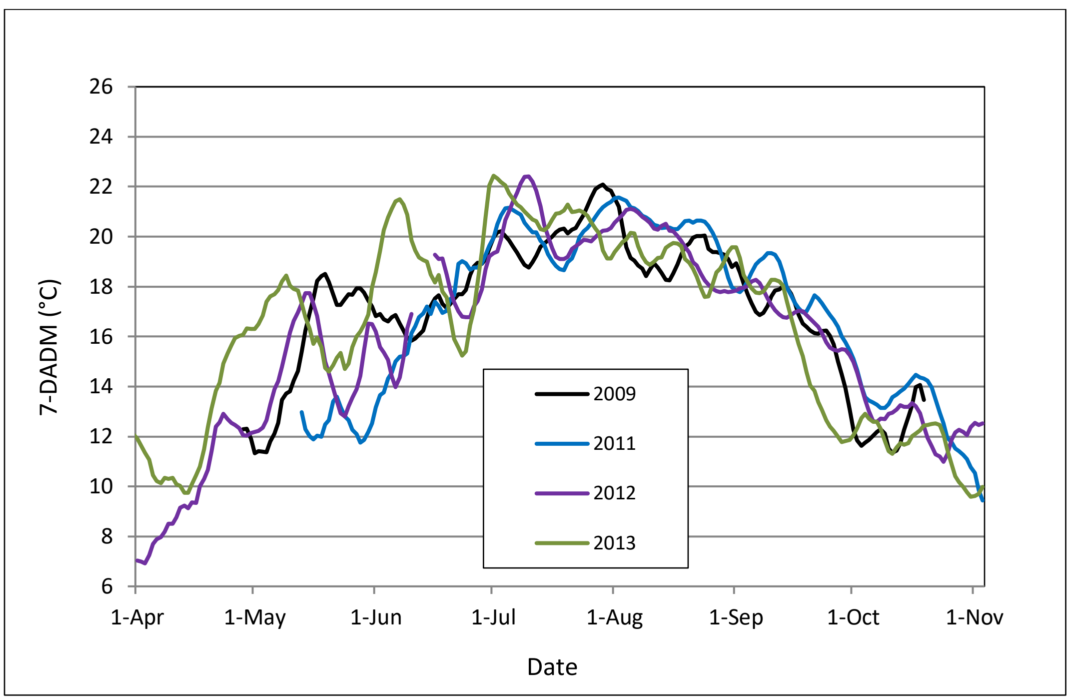

Figure 4-61. Seven-day averages of daily maximum water temperatures (7-DADM) in McKay Creek at US Route 26 (RM 0.4) during the irrigation season. Source: CRWC 2014.

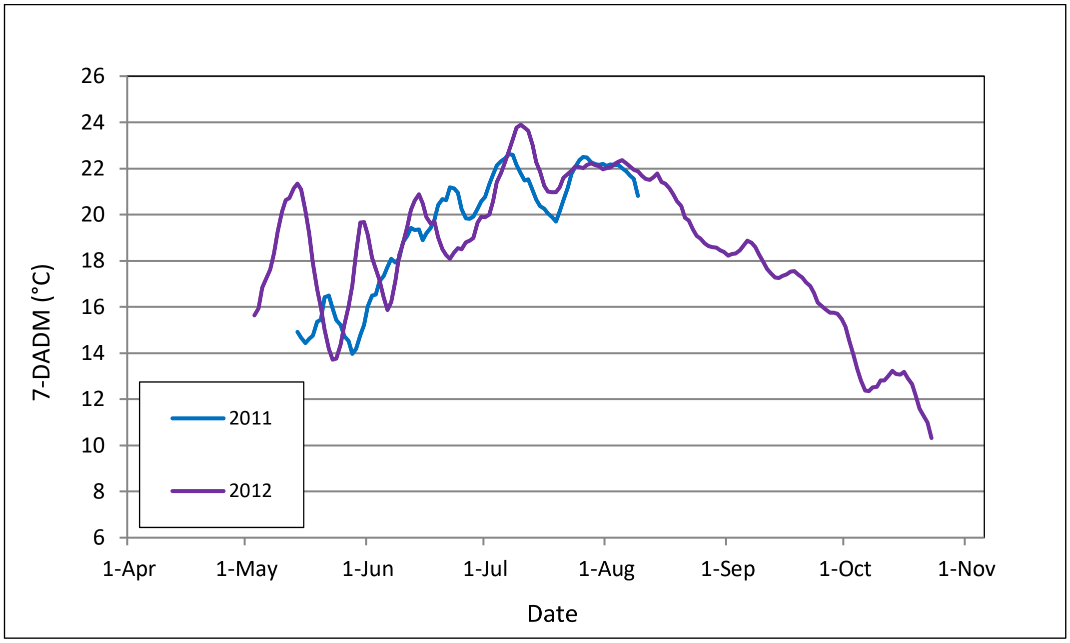

Figure 4-62. Seven-day averages of daily maximum water temperatures (7-DADM) in Lytle Creek at Campbell Ranch (RM 0.5) during the irrigation season. Source: CRWC 2014.

Four of the covered irrigation districts (COID, LPID, NUID and OID) operate irrigation returns to the Crooked River and its tributaries (see Section 3.5, *Covered Activities and Facilities*). Some of these convey very small amounts of water, operate infrequently and/or flow directly into the Crooked River arm of Lake Billy Chinook where they have negligible potential to influence surface water temperature (R2 and Biota Pacific 2013a). The remaining returns have the potential to influence temperatures in the receiving waters for one day or more during the irrigation season (Table 4-11).

Table 4-11. Irrigation return flows with the potential to influence water temperature in the Crooked River, Ochoco Creek, McKay Creek and Lytle Creek.

Location (RM)	Name	Description	Estimated Maximum Rate of Return (cfs)	Reported Maximum 7-DADM (°C)
Crooked River Returns				
49.4	Juniper Canyon Flood Control Channel	Local tailwater throughout the irrigation season	8.0	22.6
39.6	The Gap	Operational spill throughout the irrigation season	18.5	29.2
34.1	Dry Canyon Return	Local tailwater throughout the irrigation season	42.0	24.0
29.6	Lone Pine Return	Local tailwater throughout the irrigation season	2.0	28.1
27.5	NUID Main Canal at Crooked River Crossing	Operational spill for one day at start of season to flush canal, and during emergency canal draining	200	N/A
25.0	Lateral J-22 Spill	Operational spill less than once per year for emergency and maintenance canal draining	1.0	35.0*
19.6	Lateral 31 Drain	Operational spill throughout the irrigation season	1.0	35.0 *
18.4	Lateral 34 Drain	Operational spill throughout the irrigation season	1.0	35.0 *
11.9	NUID Main Canal at MP 37	Operational spill for one day at start of season to flush canal, and during emergency canal draining	100	N/A
Ochoco Creek Returns				
6.3	OID D-2 Drain	Local tailwater throughout the irrigation season	2.0	17.6
5.1	Crooked River Diversion Canal Spill	Operational spill throughout the irrigation season	75.0	16.5

Location (RM)	Name	Description	Estimated Maximum Rate of Return (cfs)	Reported Maximum 7-DADM (°C)
McKay Creek Returns				
5.8	Ochoco Main Canal Spill	Operational spill throughout the irrigation season	100.0	19.6
3.9	Dry Creek live Flow and Spill	Live flow plus operational spill	20.0	18.3
3.2	Crooked River Distribution Canal Spill at Reynolds	Operational spill throughout the irrigation season	54.0	21.0
1.3	OID D-8 Drain	Local tailwater throughout the irrigation season	10.0	21.8
1.0	Ryegrass Canal Spill	Operational spill throughout the irrigation season	45.0	22.0
Lytle Creek Returns				
5.7	Grimes Flat West Canal Spill	Operational spill throughout the irrigation season	unknown	N/A
5.0	Ochoco Main Canal Spill	Operational spill throughout the irrigation season	unknown	N/A
3.2	OID D-7 Drain	Local tailwater throughout the irrigation season	unknown	N/A
3.0	Crooked River Distribution Canal Spill	Operational spill throughout the irrigation season	unknown	N/A
2.3	OID 827 Drain	Local tailwater throughout the irrigation season	unknown	N/A
1.9	OID 825 Drain	Local tailwater throughout the irrigation season	unknown	N/A
1.5	OID 823 Drain	Local tailwater throughout the irrigation season	unknown	N/A
1.3	Ryegrass Canal Spill	Operational spill throughout the irrigation season	40.0	24.2

Note:

* Maximum temperature for these returns, which enter the Crooked River as falls within the canyon, are based on reported daily maximum air temperatures at Prineville, Oregon, based on the assumption the returns achieve ambient air temperature before reaching the river.

4.8.4 Water Quality

Portions of the covered lands within the Crooked River subbasin are listed under Section 303(d) of the Clean Water Act as water quality limited for temperature, flow modification, habitat modification, biological criteria, DO, pH, total dissolved gas (TDG), E. coli and chlorophyll a (Tables 4-12 and 4-13). Current water temperature conditions are described in Section 4.8.3, *Water Temperature*. Flow modification, habitat modification and biological criteria refer to the general health of the aquatic system and its ability to support fish and other aquatic life. Conditions that lead to Section 303(d) listing for these three criteria are generally related to combinations of flow (see Section 4.8.2, *Hydrology*), temperature, physical habitat, riparian and aquatic plant communities, and water quality. Water quality parameters of interest relative to covered fish species and potentially associated with the covered activities are DO, pH, turbidity, and total dissolved gasses (TDG). Reclamation (2013) recently compiled and summarized water quality data for the Crooked River basin in support of the DBHCP. Data from that report for DO, pH and turbidity are presented below. Elevated TDG in the Crooked River below Bowman Dam has been evaluated by a number of parties in recent years, as reported by R2 and Biota Pacific (2013b).

Dissolved Oxygen: Water being released from Prineville Reservoir during the irrigation seasons of 2001 through 2012 had DO concentrations of 10.1 mg/l or greater during all sampling events (Figure 4-63). Downstream of the reservoir, DO remained above the State cool-water criterion of 6.5 mg/l at all sample locations except for a single report of 5.9 mg/l in July 2002 at Lone Pine Road (Terrebonne). Most of the sampled locations had reported DO concentrations above the State cold-water rearing habitat criterion of 8.0 mg/l. It appears that DO concentrations in this reach of the Crooked River are largely, but not entirely, driven by water temperature. As indicated in Figures 4-53 through 4-56, the 7-DADM for the Crooked River between the Peoples' Diversion (RM 50.0) and the Lone Pine Road (RM 29.6) is between 20°C and 24°C for much of the summer. The elevation within this reach ranges from 2,750 to 2,900 feet. For this elevation range, 100 percent DO saturation would be 8.2 mg/l at 20°C and 7.6 mg/l at 24°C. Some of the reported DO concentrations below 8.0 mg/l during the summer could result from short-term temperature increases not reflected in the 7-DADM values, or from other factors such as increased biological oxygen demand.

In Ochoco Creek, no DO measurement during the irrigation season of 2010 through 2012 was below 8.5 mg/l (Figure 4-64). McKay Creek had higher DO concentrations within the area influenced by the covered activities (Figure 4-64; *McKay Creek at Highway 26*) than it did upstream of the covered lands (Figure 4-64; *McKay Creek below Allen Creek Confluence*). Within the covered lands, the DO concentration in McKay Creek was not reported to be less than 9.1 mg/l. All locations sampled on the Crooked River, Ochoco Creek and McKay Creek within and upstream of the covered lands showed a similar trend in DO; concentrations were high in the spring and/or fall, and low during mid- to late summer. This is likely due to natural fluctuations in surface water temperature between winter and summer.

Table 4-12. Crooked River Reaches covered by the DBHCP that are identified in Oregon's 2012 Integrated Report as water quality limited.

Reach	Pollutant	Season	Criteria	Status	
				Category	Description
Crooked River					
RM 0.0 - 51.0	E. coli	Summer	30-day log mean of 126 E. coli organisms per 100 ml; no single sample > 406 organisms per 100 ml	5	Water quality limited, 303(d) list, TMDL needed
RM 0.0 - 51.0	Flow Modification	Undefined	The creation of tastes or odors or toxic or other conditions that are deleterious to fish or other aquatic life or affect the potability of drinking water or the palatability of fish or shellfish may not be allowed.	4C	Water quality limited, not a pollutant
RM 0.0 - 51.0	pH	Fall / Winter / Spring	pH 6.5 to 8.5	5	Water quality limited, 303(d) list, TMDL needed
RM 0.0 - 51.0	pH	Summer	pH 6.5 to 8.5	5	Water quality limited, 303(d) list, TMDL needed
RM 51.0 - 70.0	pH	Summer	pH 6.5 to 8.5	5	Water quality limited, 303(d) list, TMDL needed
RM 0.0 - 51.0	Temperature	Summer	Rearing: 7-DADM ≤ 17.8°C	5	Water quality limited, 303(d) list, TMDL needed
RM 51.0 - 70.0	Total Dissolved Gas	Undefined	Not exceed 110% of saturation	5	Water quality limited, 303(d) list, TMDL needed
RM 0.0 - 51.0	Chlorophyll a	Summer	Reservoir, river, estuary, non-thermally stratified lake: 0.015 mg/l	5	Water quality limited, 303(d) list, TMDL needed
RM 0.0 - 124.4	Biological Criteria	Year round	Biocriteria: Waters of the state must be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.	5	Water quality limited, 303(d) list, TMDL needed
RM 0.0 - 124.4	Dissolved Oxygen	Year round (Non-spawning)	Cool water: Not less than 6.5 mg/l	5	Water quality limited, 303(d) list, TMDL needed

Source: ODEQ 2017.

Table 4-13. Ochoco, McKay and Lytle creek reaches covered by the DBHCP that are identified in Oregon's 2012 Integrated Report as water quality limited.

Reach	Pollutant	Season	Criteria	Status	
				Category	Description
Ochoco Creek					
RM 0.0 - 36.4	E. Coli	Summer	30-day log mean of 126 E. coli organisms per 100 ml; no single sample > 406 organisms per 100 ml	5	Water quality limited, 303(d) list, TMDL needed
RM 0.0 - 22.4	Temperature	Summer	Rearing: 7-DADM ≤ 17.8 C	5	Water quality limited, 303(d) list, TMDL needed
McKay Creek					
RM 0.0 - 14.7	E. Coli	Summer	30-day log mean of 126 E. coli organisms per 100 ml; no single sample > 406 organisms per 100 ml	5	Water quality limited, 303(d) list, TMDL needed
RM 0.0 - 19.5	pH	Summer	pH 6.5 to 8.5	5	Water quality limited, 303(d) list, TMDL needed
RM 0.0 - 19.5	Temperature	Year Round (Non-spawning)	Salmon and trout rearing and migration: 7-DADM ≤ 18.0°C	5	Water quality limited, 303(d) list, TMDL needed
Lytle Creek					
RM 0.0 - 4.2	Habitat Modification	Undefined	The creation of tastes or odors or toxic or other conditions that are deleterious to fish or other aquatic life or affect the potability of drinking water or the palatability of fish or shellfish may not be allowed.	4C	Water quality limited, not a pollutant
RM 0.0 - 4.2	Temperature	Summer	Rearing: 7-DADM ≤ 17.8°C	5	Water quality limited, 303(d) list, TMDL needed

Source: ODEQ 2017.

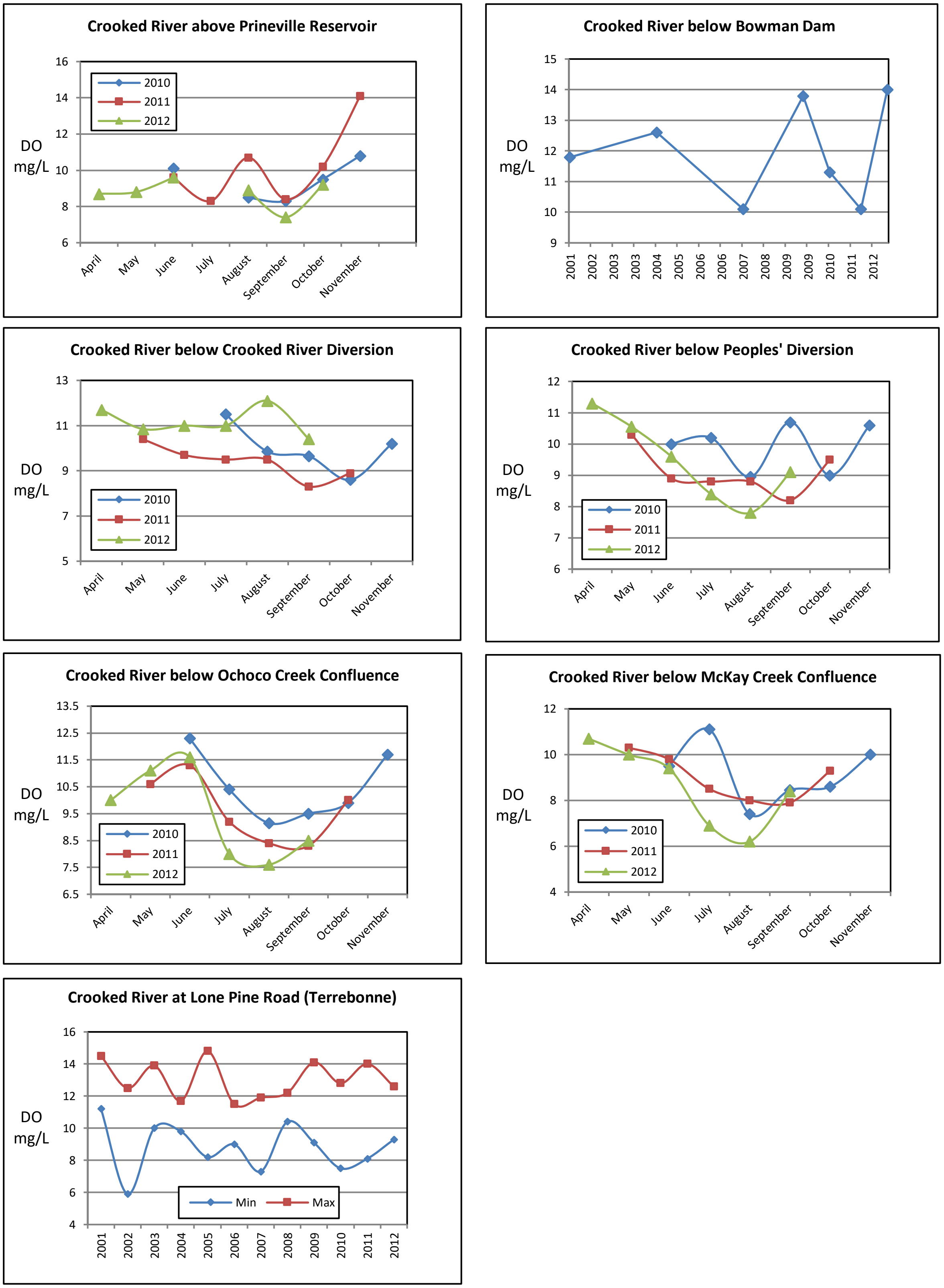

Figure 4-63. Reported concentrations of dissolved oxygen in the Crooked River from Bowman Dam (RM 70.5) to Lone Pine Road (RM 29.6) during the irrigation season. Source: Reclamation 2013.

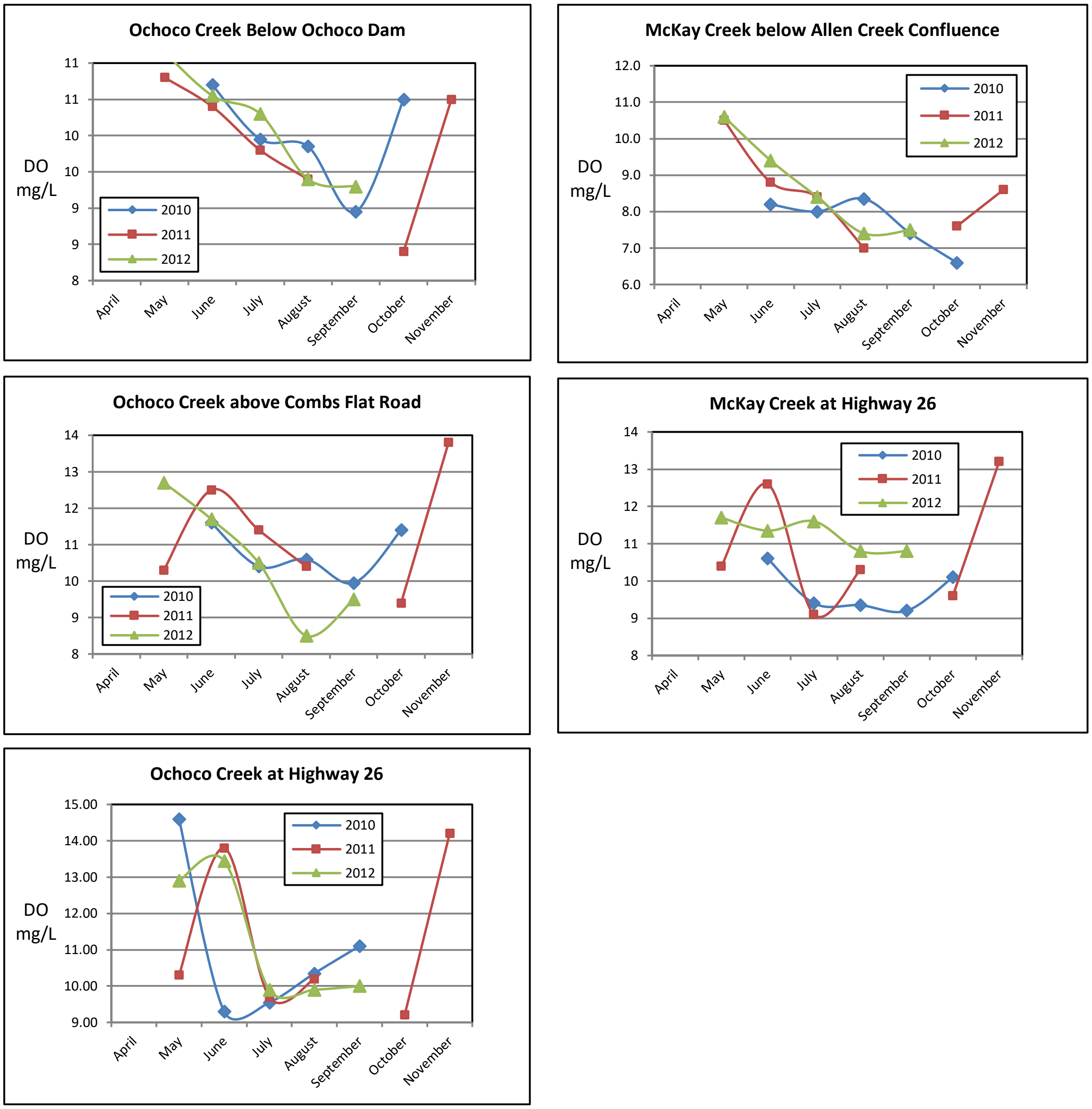

Figure 4-64. Reported concentrations of dissolved oxygen in Ochoco Creek and McKay Creek during the irrigation season. Source: Reclamation 2013.

pH: Waters in the Crooked River, Ochoco Creek and McKay Creek are slightly basic, generally ranging in pH from 7.7 to 9.0 (Figures 4-65 and 4-66). Upstream of Prineville Reservoir, pH levels in the Crooked River were above the State criterion of 8.5 throughout the irrigation season (Figure 4-65). Downstream of the reservoir, the seasonal pattern in pH was similar to that reported for DO; levels exceeding the State maximum of 8.5 occurred in the spring and fall while levels during the late summer were lower. Seasonal pH levels were less consistent in Ochoco Creek and McKay Creek (Figure 4-66).

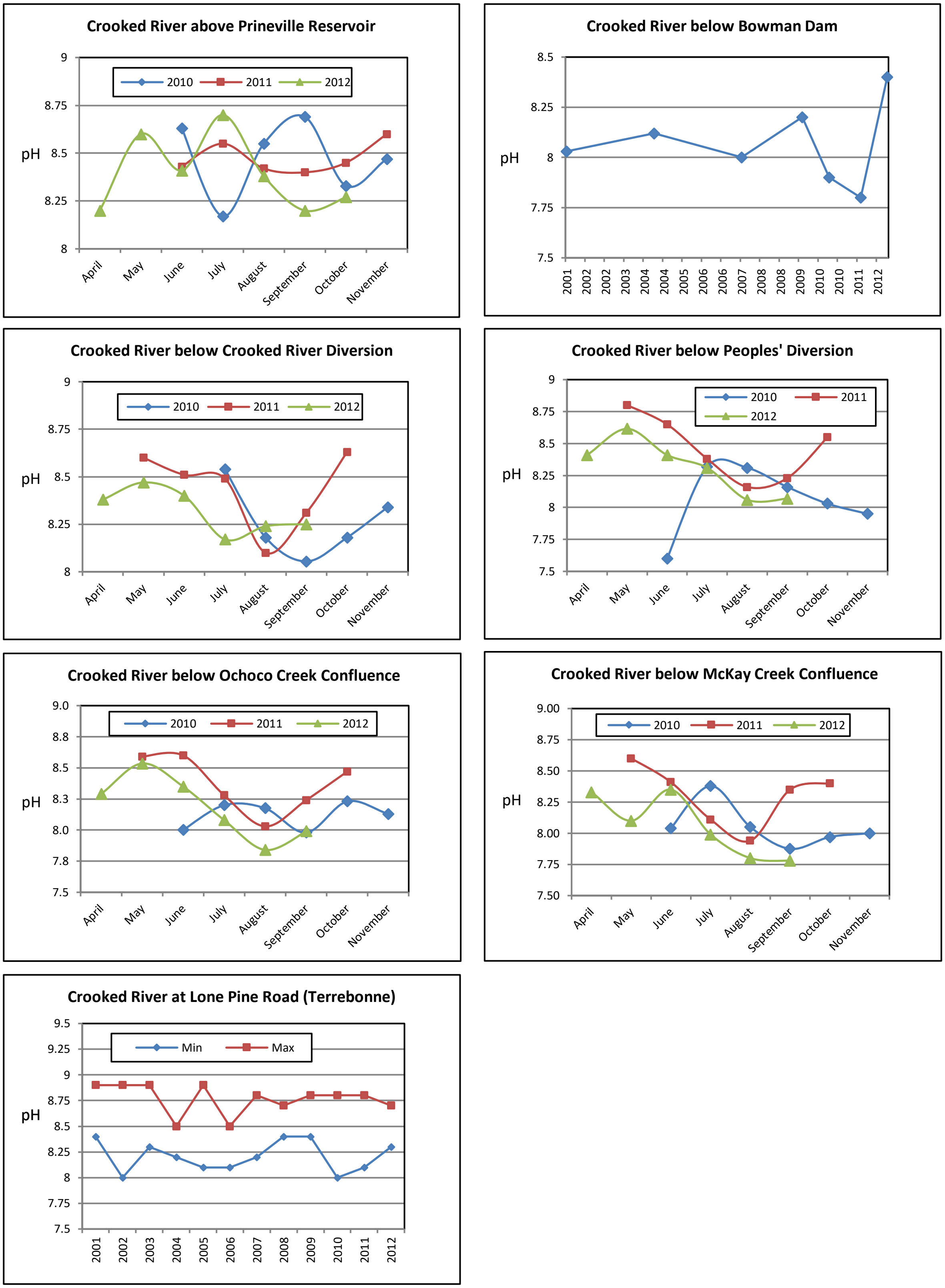

Figure 4-65. Reported pH levels in the Crooked River from Bowman Dam (RM 70.5) to Lone Pine Road (RM 29.6) during the irrigation season. Source: Reclamation 2013.

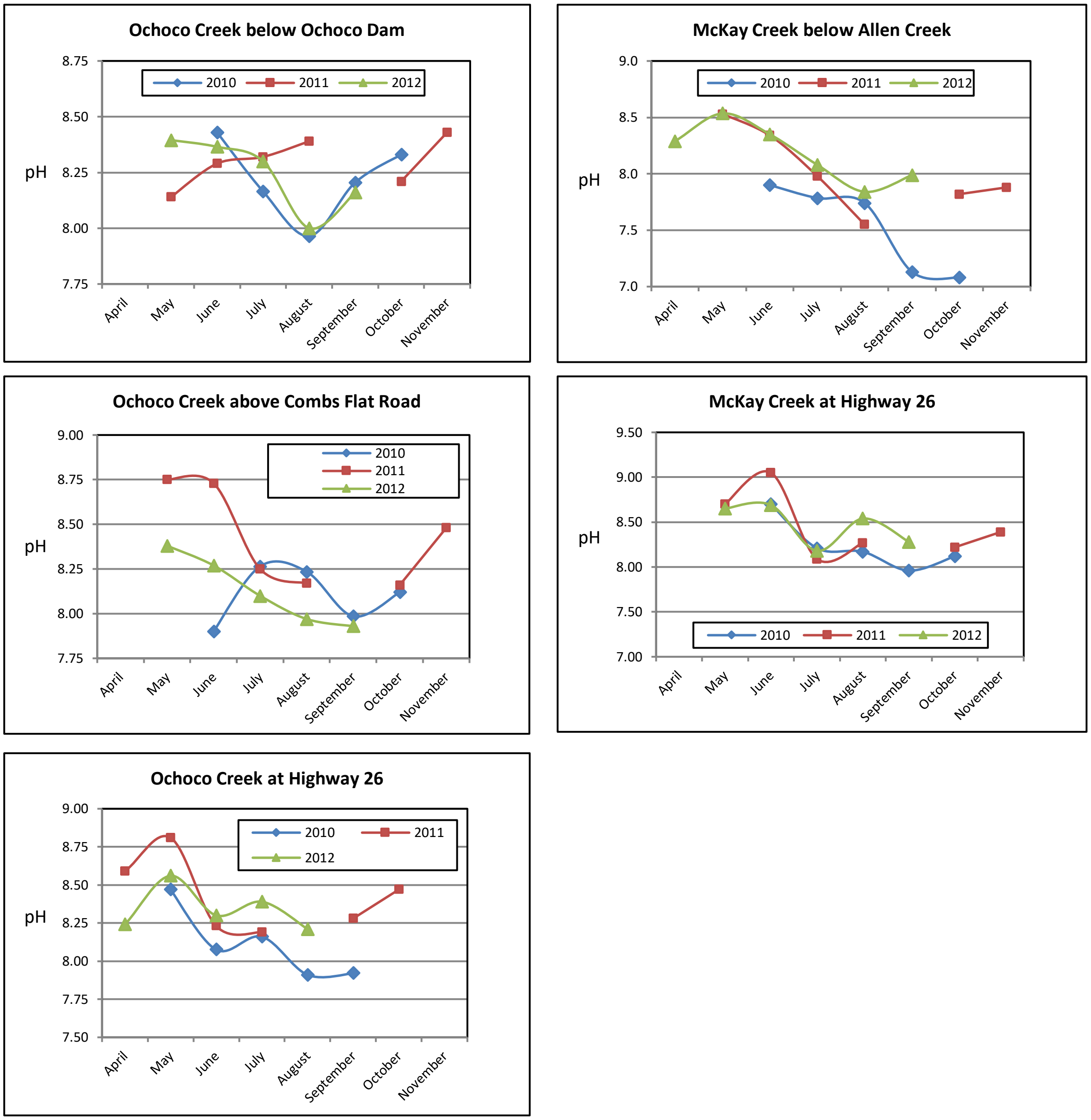

Figure 4-66. Reported pH levels in Ochoco Creek and McKay Creek during the irrigation season.
Source: Reclamation 2013.

Turbidity: Most turbidity levels for the Crooked River were between 4 and 12 NTU (Figure 4-67), but maximum levels of over 40 NTU were reported at Lone Pine Road (Terrebonne). Turbidity in the Crooked River was slightly higher on average within the covered lands than immediately upstream of Prineville Reservoir, but it showed no consistent change (increase or decrease) with downstream distance from the reservoir. Turbidity levels in Ochoco Creek and McKay Creek were also between 2 NTU and 10 NTU in most locations, with spikes in turbidity at various times (Figure 4-68).

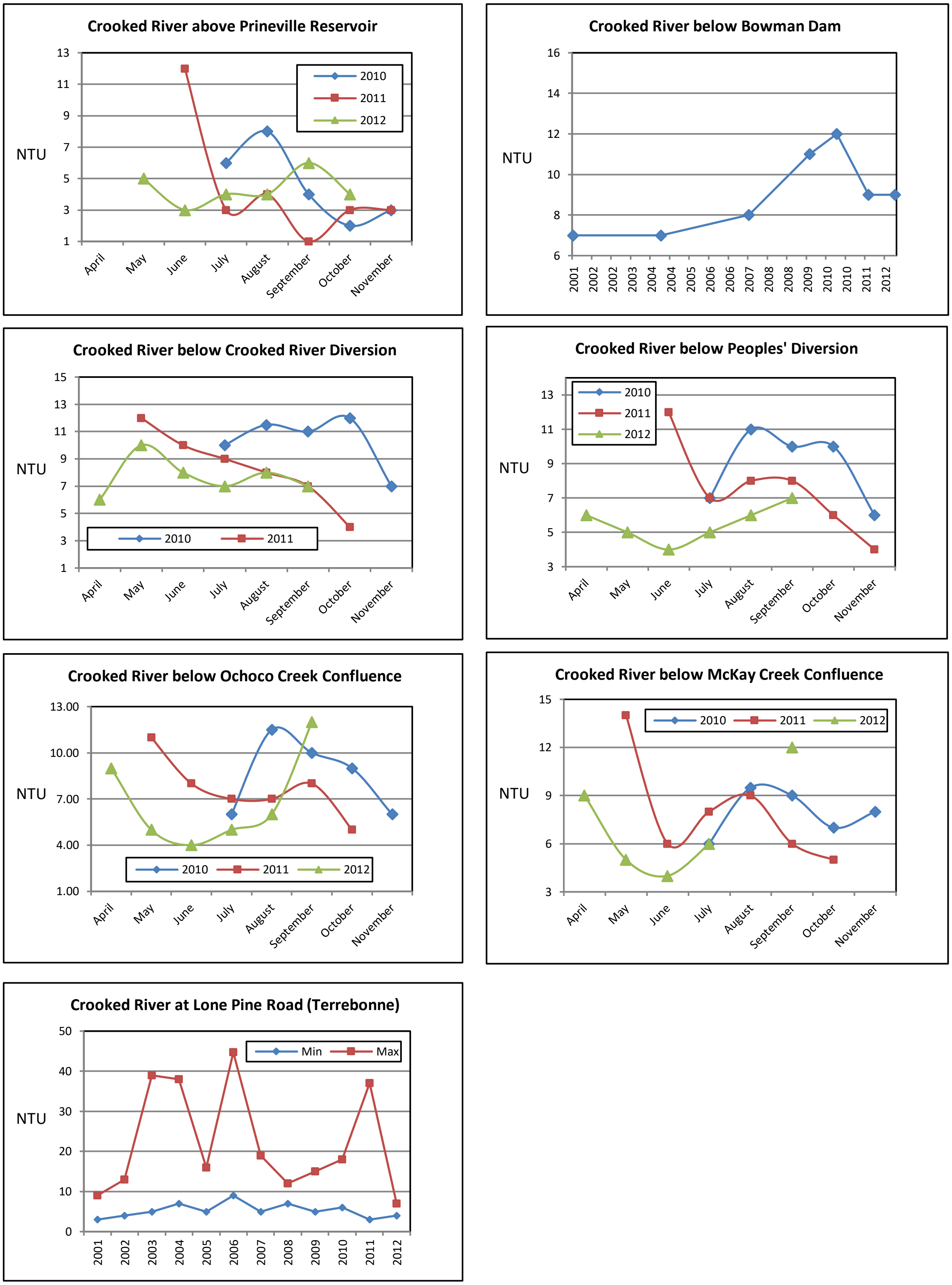

Figure 4-67. Reported turbidity levels in the Crooked River from Bowman Dam (RM 70.5) to Lone Pine Road (RM 29.6) during the irrigation season. Source: Reclamation 2013.

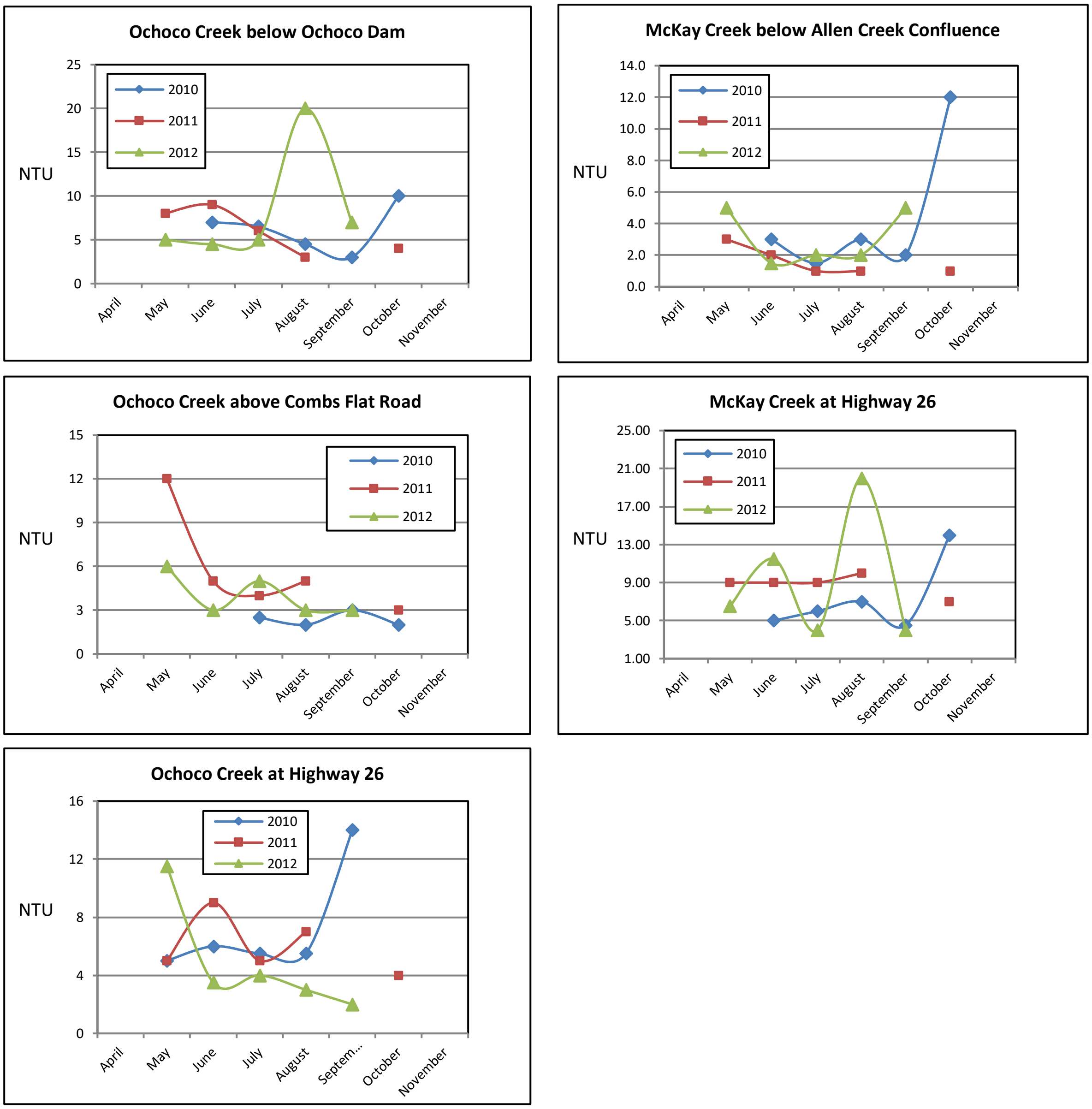

Figure 4-68. Reported turbidity levels in Ochoco Creek and McKay Creek during the irrigation season. Source: Reclamation 2013.

TDG: High concentrations of atmospheric gasses (primarily nitrogen and oxygen) in aquatic habitats are known to cause the formation of gas bubbles in the blood and tissue of fish and other aquatic organisms that can be harmful or fatal. Juvenile salmonids can tolerate TDG concentrations of 115 percent relative to atmospheric pressure for extended periods, and 120 percent for brief periods if they have access to deep water (Rulifson and Pine 1976; Johnson et al. 2005). To provide an additional margin of safety for shallow-water invertebrates that are important to aquatic food chains, the USEPA and DEQ regulate TDG as a toxic pollutant when concentrations exceed 110 percent of saturation. In hatchery-receiving waters and other waters less than 2 feet deep, the regulatory threshold is 105 percent of saturation.

Elevated TDG levels have been reported in the Crooked River. Air becomes entrained in water that is released from Prineville Reservoir through the outlet works or over the spillway and into the stilling basin, thereby increasing TDG concentration (Reclamation 2008, 2009). In April 1989, signs of gas bubble disease were observed in over 80 percent of the redband trout captured during electrofishing surveys below Bowman Dam (Reclamation 2008). In April of 2006, ODFW similarly observed signs of gas bubble disease in fish in the Crooked River (Reclamation 2008; Nesbit 2010).

Three independent studies have measured TDG levels downstream of Bowman Dam. Reclamation (2008) performed a study at six stations along 12 miles of the Crooked River throughout 2006 and 2007. They measured TDG levels during reservoir releases (all without use of the spillway) between 229 and 2,900 cfs. TDG level in the reservoir was 104 percent, while TDG levels just downstream of the stilling basin ranged from 106.4 percent at a release of 288 cfs to 122.5 percent at 2,600 cfs. Regression equations developed from the 2006 – 2007 data predict TDG concentrations below the dam reach the regulatory threshold of 110 percent at reservoir releases of 686 cfs or more (Table 4-14).

Reclamation found that TDG levels dissipated in the downstream direction during periods of high flow (greater than 789 cfs) and typically returned to 110 percent about 2 miles downstream from the stilling basin (Reclamation 2008). However, they also observed TDG levels increased again at monitoring stations further downstream in the Crooked River, even when saturation levels were initially low immediately below the dam. These in-river TDG increases were attributed to warming water temperatures and increased primary productivity associated with algae and other biological activity in the water column as the river flowed downstream.

Table 4-14. Predicted river flows where certain TDG levels are exceeded at the Bowman Dam tailrace based on various linear regression models.

	River Flow (cfs)		
TDG (%)	Reclamation (2008)	Nesbit (2010)	Sharp (2012)
110	686	530	520
115	1,579	893	964
120	2,471	1,255	1,418
125	3,364	1,617	1,873

Sources: Reclamation 2008, Nesbit 2010, Sharp 2012.

TDG monitoring was repeated at the same survey locations between April 2008 and April 2010 by Nesbit (2010). Although Nesbit collected data at lower maximum and lower minimum flows than Reclamation, the resulting regression equation still showed a strong positive correlation between flow and TDG concentration. The Nesbit (2010) data suggest TDG saturation levels below Bowman Dam exceed 110 percent at 530 cfs and exceed 115 percent at 893 cfs. Nesbit (2010) found elevated that TDG levels sometimes continued downstream 7.5 miles when flows were greater than 600 cfs, but unlike Reclamation, Nesbit did not differentiate between gases generated at the dam and gas level modifications due to in-river conditions.

More recently, Sharp (2012) collected TDG data in the Crooked River near Bowman Dam during October 2011 and again in April and May 2012. As summarized in Table 4-14, Sharp's TDG predictions are similar to Nesbit's, even though Sharp's tailrace sampling location was 200 feet downstream of both previous studies.

4.9 Climate Change

Future climate change is anticipated to alter watershed hydrology in varying ways throughout the Deschutes Basin. Climate models predict that average air temperatures in south central Oregon will increase by 1.3 to 4.0°C by 2050, and from 2.7 to 4.8°C by 2080 (Halofsky et al. 2019). Predicted changes in hydrology vary across the covered lands due to basin geography, precipitation patterns, and underlying geology (Luce et al. 2019). Generally, anticipated climate change effects include decreased snowpack, earlier snowmelt and runoff, lower summer streamflow, and more frequent high-magnitude storm and runoff events (Luce et al. 2019). Peak flows are predicted to be higher and summer low flows lower compared to existing conditions. Winter snowpack residence time is anticipated to decrease by 7 to 8 weeks in the Cascade Range (Luce et al. 2019). The greatest reduction in summer streamflows is anticipated for the eastern slope of the Cascade Range, which includes the western flank of the Upper Deschutes Basin. The timing of these changes is uncertain, but earlier snowmelt could result in summer streamflow losses of 40 to 60 percent by 2040 (Luce et al. 2019, Mote et al. 2019).

Under a climate change scenario that includes more total precipitation and a higher percentage of the precipitation falling as rain, peak runoff is expected to shift to earlier in the year (Halofsky et al. 2019). Earlier runoff could reduce irrigation water supply later in the season; however, the basin’s groundwater system and the storage capacities of the irrigation reservoirs would moderate the effects of decreased snowfall and runoff timing. Under such a scenario, the covered reservoirs are expected to be equally likely to fill to capacity. However, higher evapotranspiration rates are anticipated under climate change, and these would reduce available storage by an unknown amount.

Under a climate change scenario that includes significant variation in annual precipitation, there may be more years in which reservoirs do not fill and water users experience supply shortages. Groundwater-influenced systems may be less affected because of the longer residence time of water passing through subsurface geology. Precipitation and snowmelt infiltration followed by groundwater discharge to surface waters occurs over a longer period of time when compared to systems dominated by surface runoff. Consequently, groundwater-dominated systems like the upper Deschutes River are less influenced by annual fluctuations in precipitation. However, climate changes that include significant lengthening of the current climate cycles being experienced in the basin (i.e., extended droughts or wet periods) could eventually be reflected in the groundwater system as well.

Based on the historical record, basin-scale groundwater levels will continue to fluctuate in response to climate cycles that affect the overall recharge to the system. Under a climate change scenario that includes more total precipitation and a higher percentage of precipitation that falls as rain, peak runoff is expected to shift to earlier in the year and would likely not significantly impact the overall recharge to the groundwater system (Luce et al. 2019). In addition, the magnitude of water level changes will generally dampen with distance eastward across the basin and away from the primary recharge source (the Cascade Range) (Luce et al. 2019).

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FINAL

DESCHUTES BASIN
HABITAT CONSERVATION PLAN

Chapter 5 – Current Conditions of the Covered Species

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5 – CURRENT CONDITIONS OF THE COVERED SPECIES

5.1 Bull Trout

The bull trout is federally listed as threatened. USFWS has also listed critical habitat for bull trout, which includes some waters on the covered lands. The Deschutes Basin is considered a population stronghold for the species, and contains five known local populations, in the Metolius River Basin, Lake Billy Chinook Reservoir, Deschutes River above Lake Billy Chinook upstream to Big Falls, the lower Crooked River upstream to Opal Springs Dam, and lower Whychus Creek.

5.1.1 Life History

Bull trout express two distinct life-history strategies: resident and migrant (Rieman and McIntyre 1993). Resident fish rear, mature, and spawn without leaving their natal streams, whereas migratory bull trout emigrate from small streams to large rivers (fluvial), lakes (adfluvial), or the ocean (anadromous). A single bull trout population can express both resident and migratory life history strategies (Rieman and McIntyre 1993; Homel et al. 2008).

The predominant life history variant in the basin is an adfluvial form that migrates from stream habitats to a lake to maximize feeding opportunities and growth. Mature adfluvial bull trout reside in reservoirs for about 6 months between November and June. Most bull trout, even those not ready to spawn, begin migrating upstream in May or June and return to mainstem rivers or lakes in November or December. In addition to spawning, the spring migration may be necessary to avoid high summertime water temperatures, or insufficient water levels in lakes. Spawning occurs September through November, in cold, flowing groundwater-fed streams that are free of fine sediment. Cold water temperatures result in extremely long egg incubation periods, and fry (young salmonids that have absorbed their yolk sac) may take up to 225 days to emerge from the gravel.

Bull trout generally reach sexual maturity in 4 to 7 years and live up to 10 years (Johnston et al. 2007). After rearing for 1 to 4 years in small streams, migratory bull trout move to larger rivers or lakes, where they grow and mature. Migrant and resident life-history forms grow at similar rates during their first years of life in headwater streams. However, once migratory fish move into more productive waters of larger rivers and lakes, they grow more quickly than resident forms (Rieman and McIntyre 1993). Therefore, adult resident bull trout are smaller than adult migratory fish.

Migratory bull trout appear to use a broad variety of available habitat types throughout their life cycle (Batt 1996). Emigration timing and frequency of spawning are also highly variable. For example, migrant bull trout usually emigrate from their rearing streams at 2 to 3 years of age and about 6 to 8 inches long, but younger fish occasionally emigrate earlier (Elle et al. 1994).

Some adult bull trout may spawn annually while others alternate years; four or more year classes could compose a single spawning cohort, with each year class including up to three different juvenile life-history strategies (Batt 1996). As with other salmonids, the diversity of life-history strategies expressed within bull trout populations likely buffers against extinction by allowing fish to maximize growth and reproduction opportunities.

5.1.2 Habitat Requirements

Bull trout have perhaps the most narrowly-defined habitat requirements of any native salmonid species in the Pacific Northwest. They require cold water temperatures (below 12ºC [54ºF]) and complex stream habitat (e.g., deep pools, large wood debris), as well as connectivity between spawning and rearing areas, and downstream foraging, migration and overwintering habitats (USFWS 2015). As a result, bull trout survival may be negatively affected by activities that cause erosion, increase siltation, removal of stream cover, or change in water flow or temperature (Knowles and Gumtow 1996). For example, during incubation, eggs are particularly vulnerable to siltation and bedload movement, which are common forms of habitat degradation associated with agriculture, forestry, mining, and other anthropogenic activities.

Stream flow, channel form and stability, substrate conditions, cover, water temperature, and the presence of migration corridors are known to influence bull trout distribution and abundance (Post and Johnston 2002). However, water temperature is typically the limiting habitat factor for bull trout distribution. Optimum water temperatures for rearing are from 7 to 8 °C (45 to 46 °F) and temperatures above 15°C (59°F) limit bull trout distribution (Batt 1996). USFWS (2014a) has interpreted the upper threshold of suitable temperatures for the bull trout in the Deschutes Basin to be a 7-day maximum of the daily average temperature (7-DADM) of ≤ 16°C (61 °F). During the summer in the Deschutes Basin, temperatures in this narrow range are only found in the uppermost reaches of headwater streams, in spring-fed systems such as the Metolius River, or downstream of significant sources of groundwater discharge such as Opal Springs (Crooked River) and Alder Springs (Whychus Creek).

Bull trout have voracious appetites and take full advantage of all available food sources, including insects, amphibians, and other fishes. Large bull trout prefer eating fish such as sucker, sculpin, minnow, and other salmonids. Mountain whitefish are a preferred prey of adult bull trout in riverine habitats (Knowles and Gumtow 1996), but kokanee are likely the primary food item for adult adfluvial bull trout in the upper Deschutes Basin (Ratliff and Howell 1992).

5.1.3 Range and Distribution in the Deschutes Basin

5.1.3.1 Historical Range and Distribution

Historically, bull trout were distributed throughout the Deschutes Basin from its headwaters to the Columbia River (Buchanan et al. 1997; Figure 5-1). However, bull trout have been extirpated from several streams and lakes within the basin, including Crescent, Suttle and Blue Lakes, Link and Lake Creeks, and the Upper Deschutes River upstream of Big Falls (Buchanan et al. 1997; Marx, pers. comm. 2000; USFWS 2004).

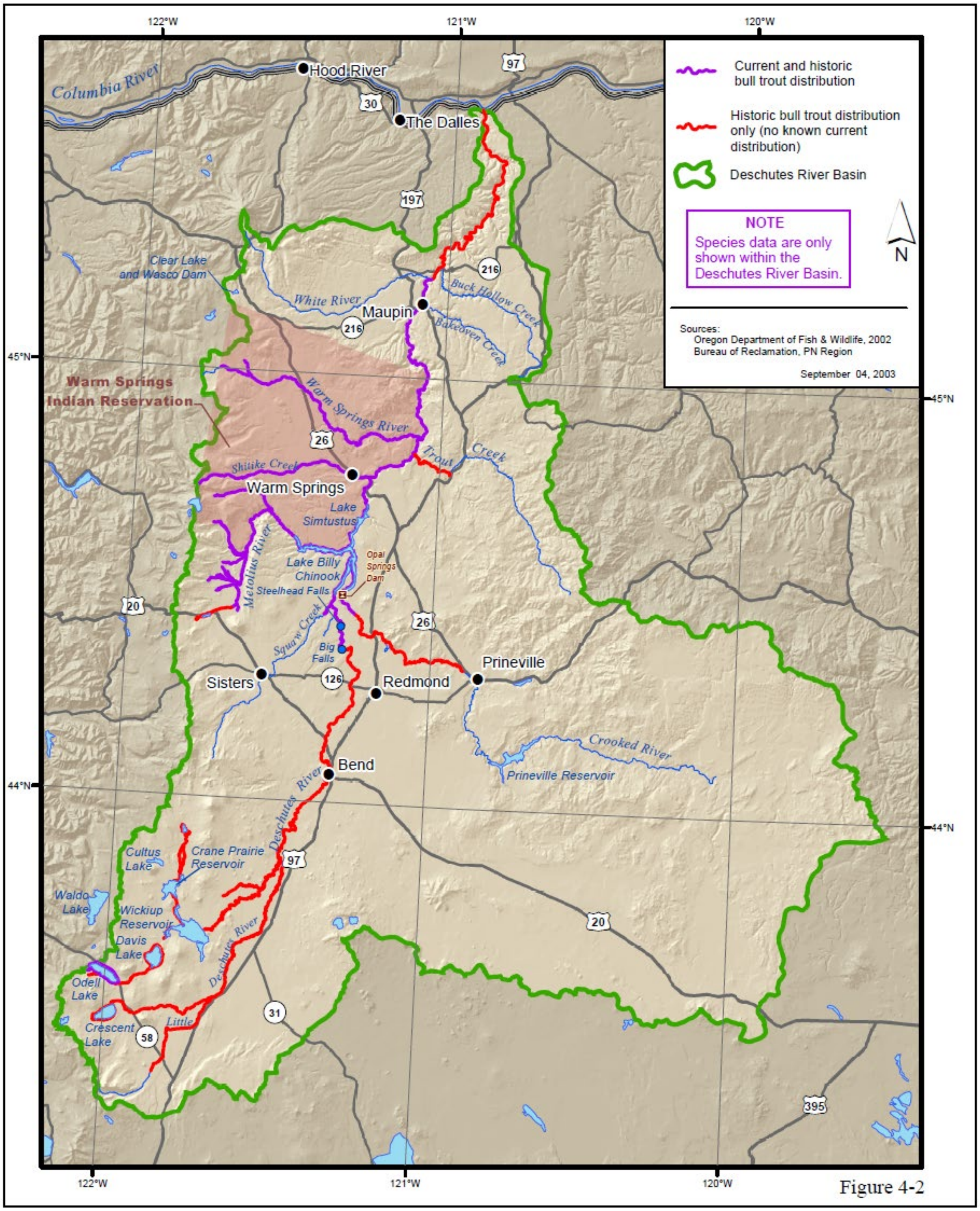

Figure 5-1. Current and historical distributions of bull trout in the Deschutes Basin. Source: Figure 4-2 in Reclamation (2003).

5.1.3.2 Current Range and Distribution

Current distribution in the upper Deschutes Basin is limited to the Metolius River Basin, Lake Billy Chinook Reservoir, the Deschutes River from Lake Billy Chinook to Big Falls, the lower Crooked River upstream to Opal Springs Dam, and lower Whychus Creek. Though limited in number, bull trout currently also reside in the lower mainstem Deschutes River above Sherars Falls, as well as in Shitike Creek and the Warm Springs River (USFWS 2002; CTWSRO 2011). Migratory life-history forms from this subpopulation are known to forage in the main stem Deschutes River between the confluence with the White River and the Pelton Regulating Dam (Reclamation 2003). Recent studies by the Confederated Tribes of the Warms Springs Reservation of Oregon also suggest fluvial populations of bull trout may inhabit the Lower Deschutes River all the way to the confluence with the Columbia River (Graham et al. 2011). Odell Lake supports a population of resident, adfluvial bull trout that is isolated from the rest of the Deschutes Basin and is located upstream of the covered lands (see discussion below). Although bull trout can be found in all three major tributaries upstream of Round Butte Dam, the majority of upper Deschutes Basin bull trout appear to originate from the Metolius River subbasin, since this is the only area where there is evidence of reproduction (Ratliff et al. 1996; Thiesfeld et al. 1996). For example, extensive surveys of the Deschutes River arm of Lake Billy Chinook have not captured significant numbers of juveniles, nor have researchers observed the stratified age structure indicative of a reproductive population of bull trout, as is seen in surveys near the mouth of the Metolius River (Thiesfeld et al. 1996). Until recently, Metolius River-origin bull trout populations were isolated from those found in the lower Deschutes Basin due to construction of Round Butte Dam in 1964, and the subsequent abandonment of passage facilities in 1968.

Stray subadult and adult bull trout from the Metolius watershed were occasionally caught in the Crooked River as far upstream as the City of Prineville through the early 1980s. However, the 1982 enlargement of the Deschutes Valley Water District’s Opal Springs Diversion Dam on the lower Crooked River (RM 6.9; 0.6 mile upstream of Lake Billy Chinook) created an upstream barrier to bull trout and other migratory fish (NPCC 2004). Adult and subadult bull trout from the Metolius population continue to inhabit the lower reaches of the Crooked River upstream to Opal Springs Diversion Dam (Goodman et al. 2005), and a fish ladder completed at the dam in 2019 now gives bull trout volitional access to habitat upstream of the dam.

Bull trout populations in the Deschutes River upstream of RM 132 were historically reproductively isolated from downstream populations by Big Falls. Further segregation of Upper Deschutes River bull trout populations occurred upon completion of Crane Prairie Dam in 1922, Crescent Lake Dam in 1928, and Wickiup Dam in 1949, which blocked access to Upper Deschutes River basin spawning areas. During the 1950s, remnant bull trout populations in the Deschutes River above Big Falls were eliminated by increased water temperatures, altered streamflow, inundated juvenile rearing areas and adult spawning areas, barriers to spawning habitat (both artificial and natural), competition with non-native fish species, and overharvest.

The last bull trout observations in Crane Prairie Reservoir, Wickiup Reservoir, and Crescent Lake occurred in 1955, 1957, and 1959 respectively. The last bull trout observed in the Deschutes River above the City of Bend occurred in 1954. Ratliff and Howell (1992) listed two bull trout populations, Upper Deschutes River and Crescent Lake, as “probably extinct.” There may have been separate populations in Fall River and Tumalo Creek, but spawning was not documented in these systems and bull trout are no longer found there. Of the historical adfluvial populations, only the Odell Lake population continues to produce bull trout. Although abundance of bull trout in Odell Lake remains unknown, angler observations of bull trout incidentally caught in the kokanee fishery have been increasing since the harvest of bull trout was prohibited in 1990.

The Odell Creek/Odell Lake complex (part of the Cascade Highlands assessment unit; Critical Habitat Unit Number 7) also supports the only known resident, non-reservoir, adfluvial bull trout population in Oregon (Ratliff and Howell 1992; Buchanan et al. 1997). The Odell Lake population was isolated from other bull trout populations in the Upper Deschutes River by a lava flow that dammed Odell Creek about 5,000 to 6,000 years ago. Because of its geographic isolation from other Deschutes Basin bull trout populations, the Odell Lake subbasin has been defined as a separate bull trout recovery unit core area. This core area lies within the Upper Deschutes River subbasin, but it occurs upstream of the covered lands. Activities covered by the DBHCP do not affect bull trout in this area.

Primary spawning areas are found in the Metolius River subbasin, including Jefferson, Candle, Canyon, Roaring, Spring, and Jack creeks and the Whitewater River. Spawning can also occur in the mainstem Metolius River (Marx 2003). To a lesser extent, spawning occurs in the Warm Springs River and Shitike Creek in the Lower Deschutes Basin. Spawning distribution within each tributary can be extensive, with as many as 20.1 redds per kilometer (32.3 redds per mile) in the Whitewater River and 38.1 redds per kilometer (61.3 redds per mile) in Shitike Creek (Goodman et al. 2005).

5.1.4 Populations in the Deschutes Basin

The Deschutes Basin is a core area identified within USFWS's Coastal Recovery Unit (RU), and is considered a current bull trout population stronghold (USFWS 2015). Within the Lower Deschutes River Core Area, there are five existing local populations:

- Warm Springs River
- Shitike Creek
- Whitewater River
- Jefferson Creek – Candle Creek Complex
- Jack Creek – Canyon Creek – Heising Spring Complex

These populations exhibit diverse life history strategies: resident, fluvial, and adfluvial (USFWS 2010a). The Metolius River system, which includes the Whitewater River, Jefferson Creek, and Jack Creek, supports the largest bull trout population in Oregon. Bull trout currently inhabit most riverine habitats of the Metolius drainage (USFWS 2002). The Metolius subbasin supports a migratory bull trout population that uses the Metolius River and Lake Billy Chinook as seasonal foraging habitat and as a migratory corridor (Buchanan et al. 1997). Between 1987 and 2004, the number of redds steadily increased from 27 to 1,045 (Ratliff et al. 1996; Wise 2003). However, in 2008, redd counts declined to a low of about 382 then began to rebound in 2010 with a total of 634 redds counted. Based on the redd counts, spawning number can be estimated at 2.3 adult fish per redd. A peak observation of 1,750 bull trout spawned in the Metolius subbasin in 2001 (Wise 2003), and the 5-year average from 2005-2009 was 1,554. The Warm Springs River and Shitike Creek bull trout populations are generally much smaller than the Metolius population, but they both support spawning and rearing (Brun and Dodson 2001).

5.1.5 Habitat in the Deschutes Basin

Bull trout habitats within the Deschutes Basin include high Cascade headwater streams, glacially fed streams, spring systems, lakes, and mainstem rivers. Adult adfluvial bull trout generally spend about half of every year in a natural or man-made lake (generally November-May). Adfluvial bull trout in the covered lands would use Lake Billy Chinook for these purposes. These fish most likely forage in shallow areas in the reservoir where most of their prey exists. Depending on water conditions, bull trout will occupy deep areas of the reservoir where water temperatures are cool (7 to 12 °C [45-54°F]) and move to the surface when surface water temperatures drop to or below 12°C (54°F). At other times of the year, these fish may move upstream to forage in the lowermost portions of the Crooked River, Upper Deschutes River, or Whychus Creek.

5.1.6 Legal Status and Management

5.1.6.1 Federal and State Status

USFWS issued a final rule on June 10, 1998 that listed Columbia River populations of bull trout as threatened (FR 63; 31647). In the final listing rule, USFWS identified three subpopulations of bull trout in the Deschutes Basin: (1) Odell Lake, (2) Metolius River-Lake Billy Chinook complex, and (3) Lower Deschutes River. The Metolius River-Lake Billy Chinook complex and the Lower Deschutes River subpopulations are the only populations with access to the covered lands. Small numbers of the Metolius subpopulation migrate into the lower reaches of the Crooked River, Whychus Creek, and the mainstem Deschutes River upstream to Big Falls (Ratliff et al. 1996). The lower Deschutes River subpopulation has migratory access along the mainstem Deschutes River from its confluence with the Columbia River to spawning and rearing habitats in Warm Springs River and Shitike Creek. These Westside tributaries are outside of the covered lands (Figure 5-1).

In September 2005, USFWS published a final rule for bull trout critical habitat in the Columbia River Basin [70 FR 185; 56212]. The final rule included bull trout critical habitat for the Deschutes River (Critical Habitat Unit Number 6) in the middle and lower basin. In July 2009, the US District Court for the District of Oregon (*Alliance for the Wild Rockies v. USFWS*) ordered USFWS to re-analyze the critical habitat designation for bull trout in the Klamath River and Columbia River population groups. USFWS published a revised final rule on September 30, 2010 (USFWS 2010, FR 75(200) 63898).

USFWS prepared a Bull Trout Recovery Plan (USFWS 2015) that discusses bull trout status and recovery needs for core areas in the Deschutes Basin. Core areas have both suitable habitat and existing bull trout populations, while core habitat has suitable habitat for the species but no existing populations. The Lower Deschutes River typically refers to the river reaches downstream of the Pelton-Round Butte Hydroelectric Project; however, for recovery planning purposes, the Lower Deschutes River Core Area includes the Deschutes River and its tributaries as far upstream as Big Falls at RM 132, which encompasses the Metolius River-Lake Billy Chinook complex and the lower Deschutes River subpopulations. The Upper Deschutes Core Habitat area includes the Deschutes River and its tributaries upstream of Big Falls where bull trout currently do not exist.

5.1.6.2 Identified Threats to the Species

According to the 2008 USFWS status review, the factors that threaten bull trout include historical habitat loss and fragmentation, interaction with nonnative species, blockage of migratory corridors and passage impairments, high water temperatures, and poor water quality (USFWS 2008; USFWS 2015). The primary land and water management activities that depress bull trout populations and degrade habitat in the Deschutes critical habitat unit include operation and maintenance of dams, irrigation diversions, road crossings, and the introduction of non-native species (USFWS 2002). The Final Bull Trout Recovery Plan found that impassable dams and diversion structures isolate and fragment bull trout populations and adversely impact water temperature and quality. Nonnative fish species, including lake and brook trout, threaten bull trout through hybridization, competition, and possible predation (USFWS 2002). The severity of predicted snowpack loss (Mote et al. 2005; Pederson et al. 2013), drought and wildfire (Littell et al. 2009), and spring and summer climates (Littell et al. 2010) are also potential threats to bull trout populations.

5.1.6.3 Recovery Measures and Management

The Lower Deschutes River Core Area Implementation Plan for Bull Trout addresses research, monitoring, and evaluation actions being pursued within the recovery unit to identify relevant information for the purpose of addressing management of primary threats to bull trout (USFWS et al. 2015). The Service identifies these threats as: (1) habitat—upland/riparian land management, instream impacts, and water quality; (2) demographic—connectivity impairment, fisheries management, small population size, and forage fish availability; and (3) nonnatives.

For the Lower Deschutes River Core Area of the Coastal Recovery Unit, USFWS outlines there are no necessary actions to address habitat, demographic, or nonnative threats. However, USFWS recommends continued demographic efforts in monitoring bull trout populations, angling impacts in the spring fishery of Lake Billy Chinook, and spawner and juvenile densities in the Warm Springs River. USFWS also recommends the continuation of assessing and monitoring the distribution of bull trout and nonnative brook trout.

The implementation plan makes several recommendations for recovery, including continued ongoing work on: (1) upstream and downstream passage work at the Pelton-Round Butte hydro project; (2) implementation and maintenance of fish screens at water diversions and irrigation ditches; (3) implementation of land management plans and BMPs (USFWS et al. 2015). In addition to these continued efforts, the plan recommends "adaptively managing" bull trout and kokanee harvest in Lake Billy Chinook. Further, to address nonnative populations of brook trout, the plan recommends management actions in Warm Springs River, Shitike Creek, and Canyon Creek. All listed recovery actions are currently, or will be, carried out by concerted efforts of Oregon Department of Fish and Wildlife (ODFW), US Forest Service (USFS), USFWS, the Confederated Tribes of Warm Springs, and the Deschutes Basin Technical Working Group.

The fish collection facility jointly completed by Portland General Electric Company (PGE) and the Confederated Tribes of Warm Springs in 2009, provides downstream fish passage for salmonids through the Lower Deschutes River Core Area. Stream habitat restoration projects are also underway in nearby watersheds (e.g., Metolius River, Crooked River, Trout Creek, Whychus Creek, Shitike Creek).

In 2003, ODFW prepared a fish management plan for the Deschutes, Crooked, and Metolius river basins (Marx 2003), including specific planning efforts for bull trout, in accordance with the State Native Fish Conservation Policy (NFCP). This plan guides the development of localized plans for species management in the individual river basins and presents an approach to conserving aquatic resources and establishing management priorities, many of which were adopted by the federal recovery plan.

5.1.7 Critical Habitat

About 100 miles of river and creek covered by the DBHCP (roughly 22 percent of the total covered lands) are designated as *Bull Trout Critical Habitat Unit 6 – Lower Deschutes River Basin* (USFWS 2010a). The vast majority of this critical habitat (88 miles) consists of Lake Billy Chinook and the Lower Deschutes River downstream of the Warm Springs Reservation. Specific areas of designated bull trout critical habitat on the covered lands include the following:

- The mainstem Deschutes River from the Columbia River to about RM 68, with some exclusions (Figures 5-2 and 5-3)
- Trout Creek from the Deschutes River to about RM 2 (Figure 5-3)
- Lake Billy Chinook (Figure 5-4)
- The mainstem Deschutes River from Lake Billy Chinook to Big Falls (Figure 5-4)
- The Crooked River from its confluence with Lake Billy Chinook to Highway 97 (Figure 5-4)
- Whychus Creek from the Deschutes River to about RM 6 (Figure 5-4)

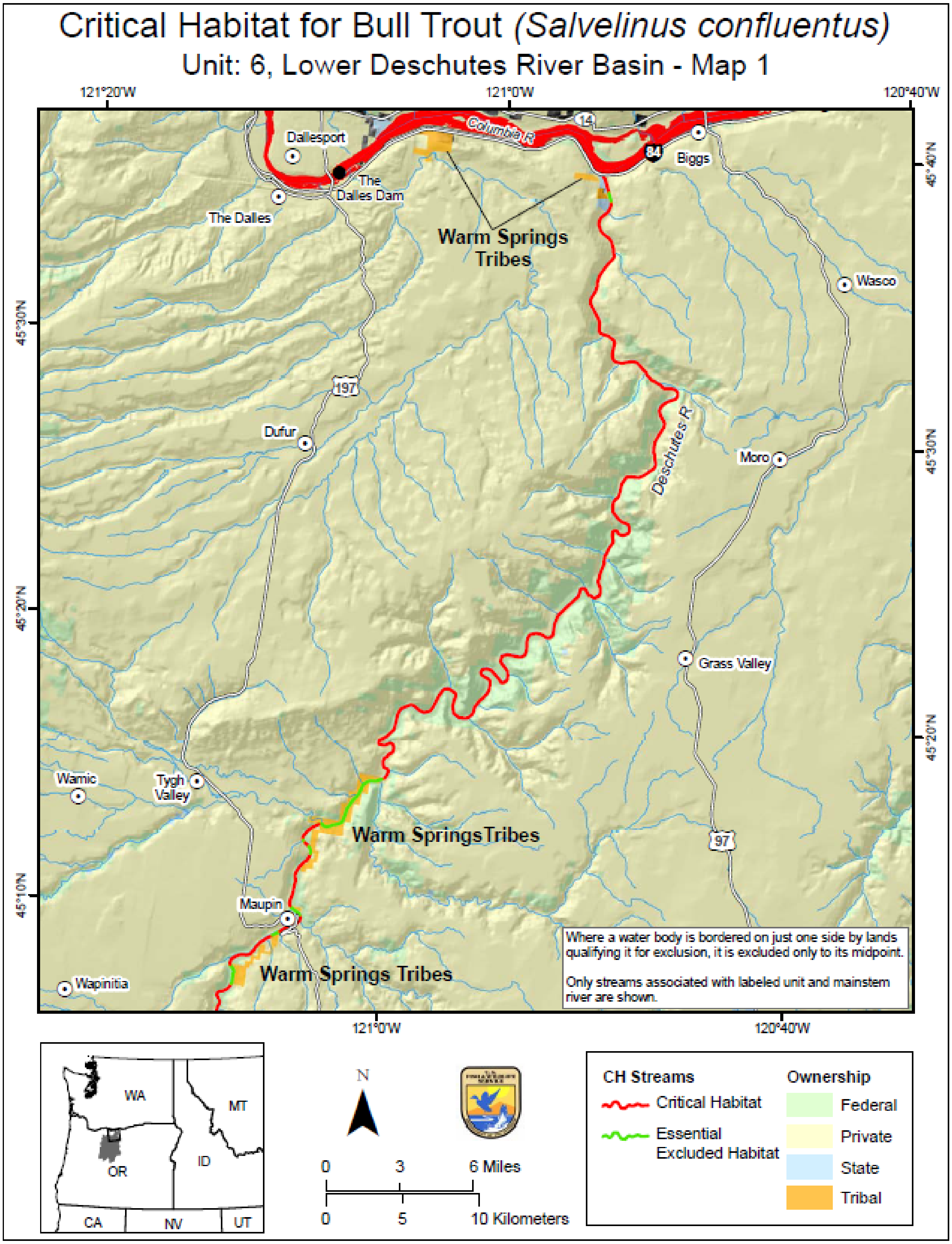

Figure 5-2. Bull Trout Critical Habitat Unit 6, Lower Deschutes River – Map 1. Source: USFWS 2017a.

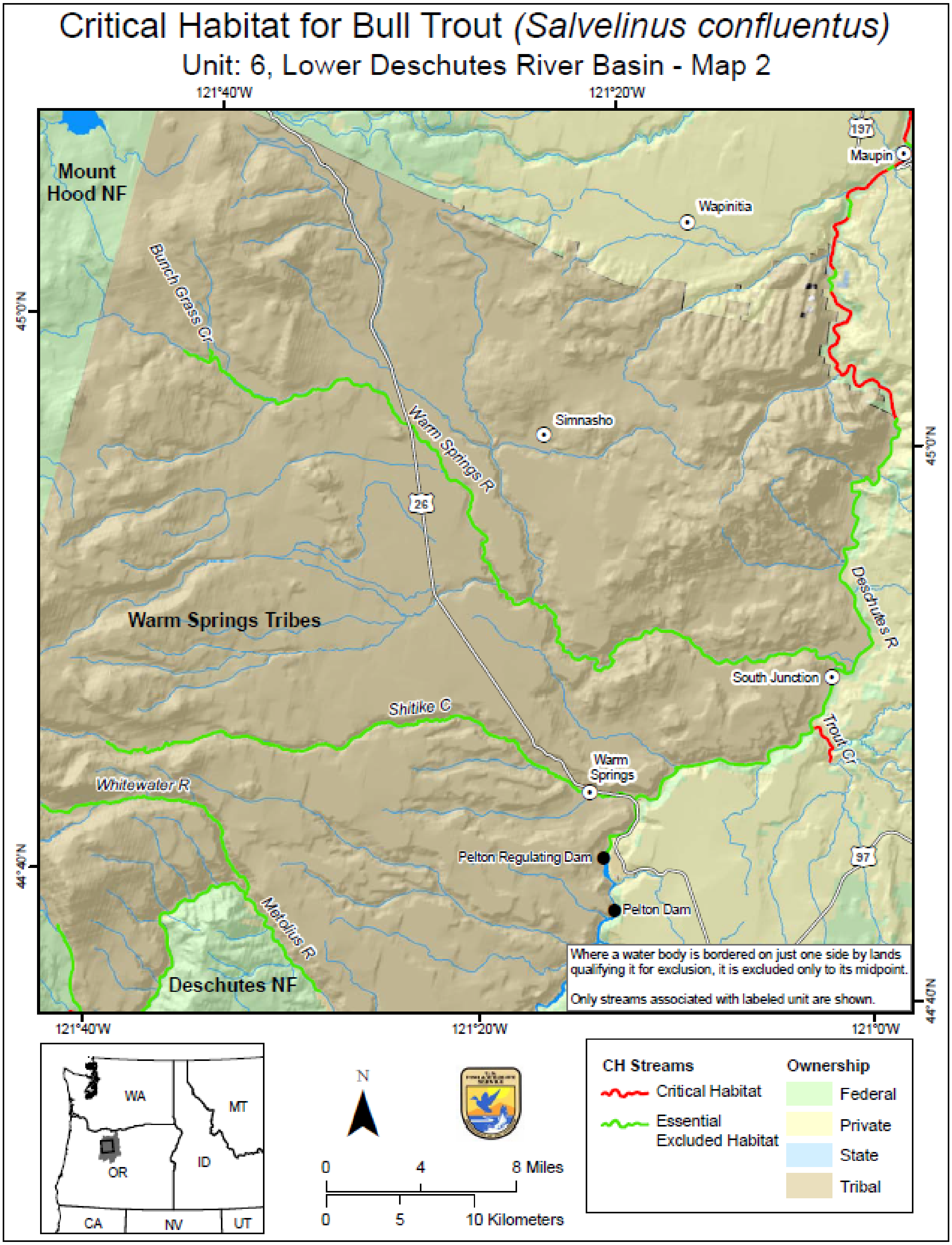

Figure 5-3. Bull Trout Critical Habitat Unit 6, Lower Deschutes River – Map 2. Source: USFWS 2017a.

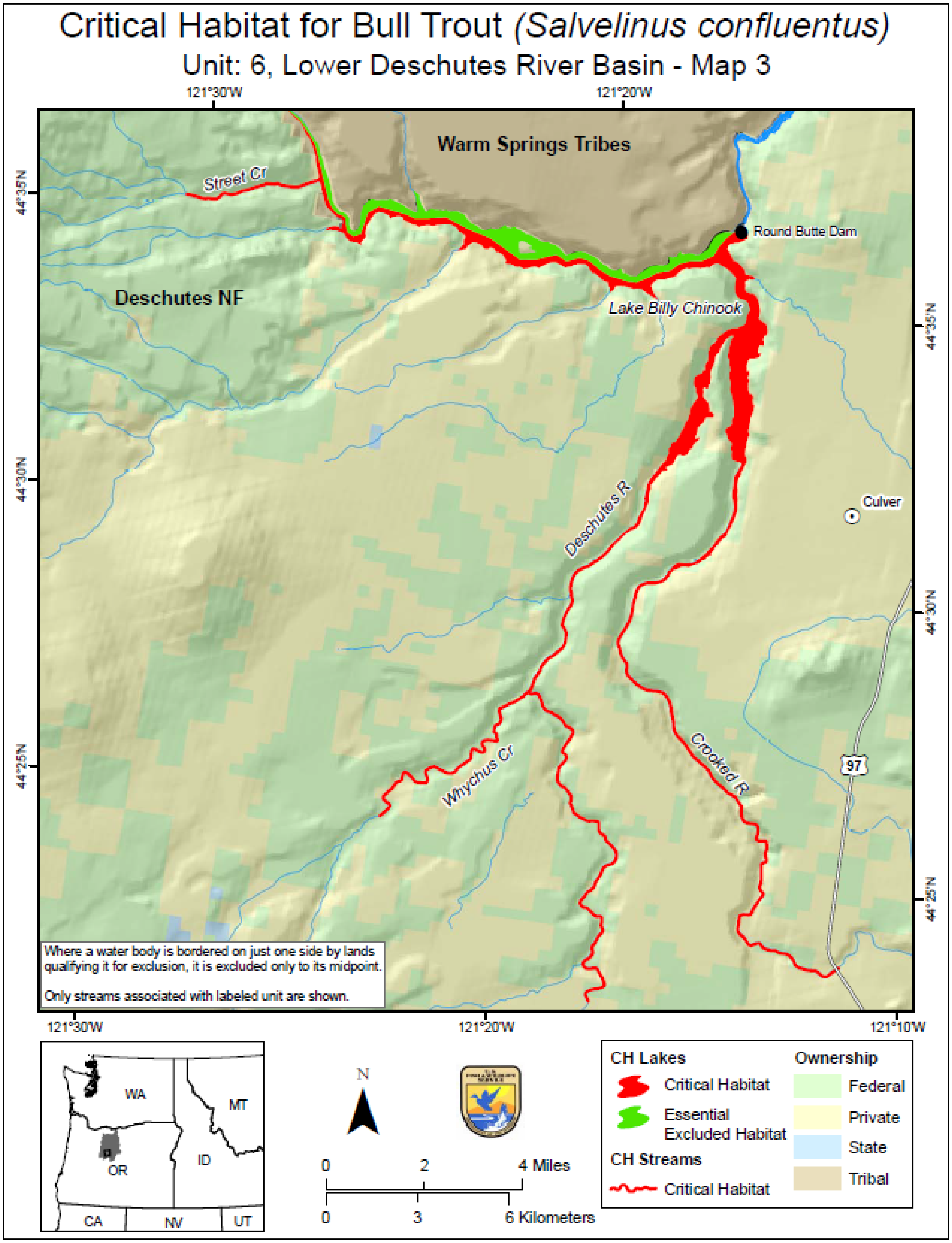

Figure 5-4. Bull Trout Critical Habitat Unit 6, Lower Deschutes River – Map 3. Source: USFWS 2017a.

5.2 Steelhead Trout

The covered lands contain summer steelhead within the Middle Columbia River (MCR) Steelhead Distinct Population Segment (DPS). This DPS, with the exception of fish upstream of the Pelton Round Butte Project at RM 100 on the Deschutes River, is listed as threatened under the Endangered Species Act (ESA). Upstream of Pelton Round Butte, where a reintroduction program is underway, steelhead are classified as nonessential experimental under section 10(j) of the ESA. Passage has recently been restored at Pelton Round Butte to allow migratory fish to access the Upper Deschutes River and its tributaries, and reintroduction is being supplemented with hatchery stock from the Round Butte Hatchery.

5.2.1 Life History

The steelhead is an anadromous variant of the rainbow trout (*Oncorhynchus mykiss*). Partial migration, when one portion of an animal population migrates while the other portion remains sedentary, has been well documented in salmonids (Jonsson and Jonsson 1993, Hendry et al. 2004; Figure 5-5). Examples of this type of migratory behavior include fluvial and adfluvial life-histories where trout migrate from mainstem riverine habitats and lakes to spawn in tributaries. A related term, “partial anadromy,” refers to a similar behavioral strategy whereby fish from the same reproductively-mixed population adopt divergent anadromous (ocean-going) and resident freshwater life-history strategies (Hendry et al. 2004; Figure 5-5). Most Pacific salmonid species, including rainbow trout, are partially anadromous, and this type of life-history diversity is believed to buffer against extinction (Hilborn et al. 2003; Greene et al. 2010).

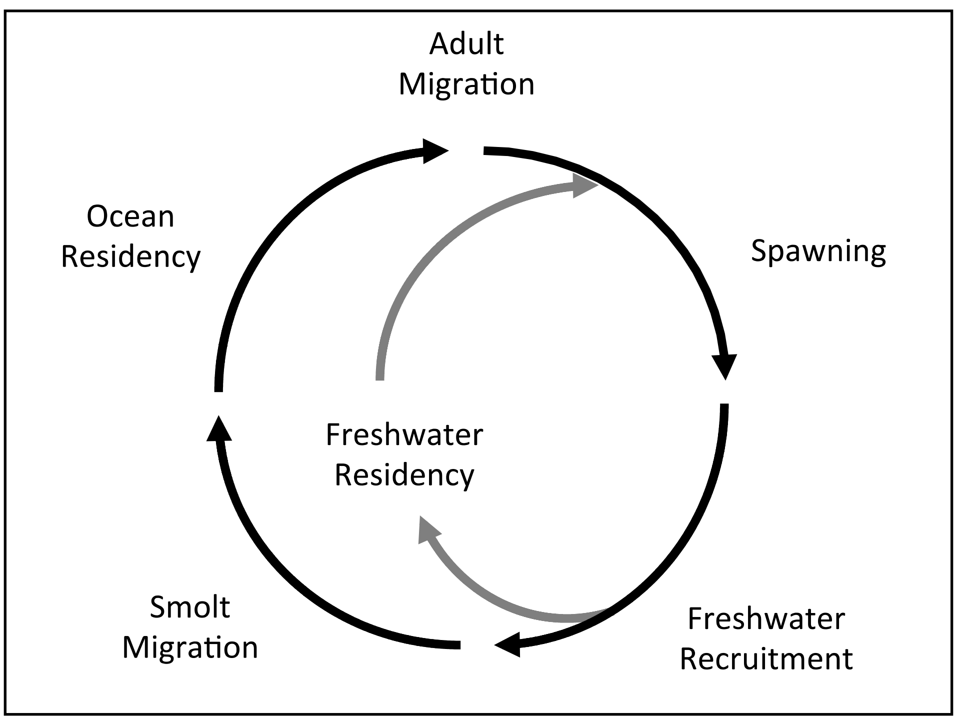

Figure 5-5. Life-cycle diagram for partially anadromous rainbow trout.

The term "steelhead," which has been conventionally used to identify anadromous rainbow trout, represents one of several life-history variants within *O. mykiss* populations. Stream residency is also common for this species, with resident individuals remaining in freshwater throughout their life-cycle, often moving between suitable habitats (Gowan et al. 1994), but never venturing to the ocean. In watersheds with ocean access, researchers have found that in addition to interbreeding (McMillan et al. 2007), resident rainbow trout and steelhead produce progeny of the alternate life-history form (Pascual et al. 2001; Thrower and Joyce 2004; Korman et al. 2010; Courter et al. 2013).

O. mykiss are iteroparous, which means they can spawn multiple times, although few steelhead survive the migration to and from the ocean a second time (about 1-5% in most interior basins). Rates of iteroparity are higher for resident rainbow trout, where as many as 40-60 percent of spawners may have spawned at least twice before death. Adult steelhead typically range in age from 2 to 6 years old.

A tremendous amount of life-history diversity also occurs amongst anadromous individuals within *O. mykiss* populations. For example, there are two adult steelhead migration strategies in the Pacific Northwest: summer and winter. Summer steelhead are found in Columbia River tributaries east of the Cascade Mountains. Adult summer steelhead enter freshwater between June and August, traveling upstream to suitable overwintering habitats where they remain until spawning in March through May. Summer steelhead are often described as "freshwater maturing" because their gonads are not yet fully mature when they re-enter their natal watersheds and the maturation process is completed during the winter holding period. This life-history strategy is common in *O. mykiss* populations in the interior Columbia Basin because early freshwater entry provides more time to travel long distances and overcome migration obstacles that may only be passable under transient flow conditions. Winter steelhead, on the other hand, enter freshwater much closer to their spawning date (March-May). This is predominantly a coastal steelhead life-history strategy, but occurs as far inland as the Hood River, White Salmon River, and Fifteenmile Creek in the Columbia Basin.

Deschutes River steelhead are the summer-run variety (as are all steelhead upstream from The Dalles Dam). They tend to pass Bonneville Dam in the Lower Columbia River prior to August 25 and are relatively small compared to steelhead that pass Bonneville Dam in September and October. Due to the notable differences in run timing and body size, summer run steelhead destined for tributaries in the middle Columbia River region are often referred to as A-run, and those destined for the Upper Columbia and Snake River regions are referred to as B-run.

In general, Deschutes steelhead enter freshwater 9 to 10 months prior to spawning and migrate up the Deschutes River from June through October. Deschutes River wild steelhead spawn from about the middle of March to the end of May (Zimmerman and Reeves 2000). Spawning in the eastside tributaries to the Deschutes River, such as Trout Creek, has evolved to an earlier time (January through mid-April) than westside tributaries or the mainstem Deschutes River because stream flow tends to decrease earlier in the more arid eastside watersheds (Olsen et al. 1992). Similar to other steelhead populations in the Columbia Basin, the number of repeat spawners in the Deschutes River is very low (less than 5 percent) (Busby et al 1996; Cramer and Beamesderfer 2006). Native summer steelhead in the Deschutes River typically deposit from 3,100 to 10,500 eggs per female, with a mean of 5,350 eggs (NPCC 2004). The number of eggs a female produces is directly related to their size.

In the Deschutes River, steelhead eggs hatch within 35 to 50 days, depending on water temperature (about 50 days at 10°C). The newly hatched steelhead (alevins) remain in the gravel for 2 to 3 weeks until the yolk sac is absorbed. Steelhead fry (young salmonids that have absorbed the yolk sac) usually emerge from redds in the middle to late summer. About 20 to 30 percent of the fertilized eggs survive to emerge as fry, and only about 3 percent of fry are expected to survive to smoltification (the process of physically changing to survive in saltwater). Juvenile steelhead (parr) rear in freshwater for 1 to 4 years prior to emigration, depending on water temperature and growth rates.

Downstream migration and smoltification typically occurs from April to mid-June when parr reach a size of 6 to 8 inches. Growth patterns determined by examining scale samples indicate up to eight different *O. mykiss* life history forms in the lower Deschutes River (Olsen et al. 1992). Pribyl (2002) noted that most juvenile steelhead emigrate after 2 years in freshwater. The majority of Deschutes River steelhead typically emigrate at age 2 and spend 1 to 2 years in saltwater, before returning to spawn. Although there are a variety of life history patterns, most returning Deschutes steelhead spawners are expected to be 4-year old fish (NMFS 2012).

5.2.2 Habitat Requirements

Because steelhead enter spawning areas weeks or months before they spawn, they are vulnerable to disturbance and predation. Instream or overhead cover is required to reduce disturbance and predation of spawning steelhead. Cover can be in the form of overhanging vegetation, undercut banks, submerged vegetation, submerged objects such as logs and rocks, floating debris, deep water, turbulence, and turbidity (Giger 1973).

Female steelhead deposit their eggs in cool, clear streams in shallow pool tailouts and in the transition areas between riffles and other slower velocity habitat types with suitable gravel size, depth, and current velocity. Prior to spawning, female steelhead dig a shallow depression in the substrate called a redd. After eggs are deposited and fertilized, the steelhead fill these redds back in.

Intermittent streams can be used for spawning if flows are maintained long enough to allow emergent fry to disperse downstream before dry conditions occur during late summer or fall. Spawning habitat requirements typically include water depths of 9 inches to 5 feet, water velocities from 1 to 3 feet per second (fps), and a largely sediment-free gravel or cobble substrate sized from 0.5 to 4 inches in diameter. Steelhead often prefer areas with uniform water velocity. They avoid fine sediments because the incubating eggs require a steady supply of cool (8 to 11 ^{o}C), oxygenated water, and fine sediments restrict hyporheic flow. Steelhead also avoid excessively large, course substrates, which are difficult to move.

To survive high winter and spring water velocities, and to avoid predation, emergent steelhead fry inhabit the interstitial spaces within the stream substrate. Fry also move into shallow and slow-moving margins of stream channels. Where shallow water habitat is limited, the edges of the river with overhanging vegetation are thought to be important for rearing. As juvenile steelhead grow, they move to areas with deeper water, a wide range of velocities, and large substrate, sometimes emigrating from tributaries to the main stem for a period of time prior to smolting (ODFW and CTWSRO 1990).

Summer rearing takes place primarily in the fast parts of pools, although juveniles can also be abundant in glides and riffles. Winter rearing occurs more uniformly, at low densities across a wide range of fast and slow habitat types. Productive steelhead habitat is characterized by rough streambed elements, primarily in the form of large and small pieces of wood or large boulders that help scour pools and generate complex stream habitat. As their swimming ability improves, steelhead parr and subadults move into feeding lanes behind boulders in riffles, or in heads of pools. These areas maximize opportunity to feed on drifting aquatic insects, while minimizing swimming effort. Habitat areas with cover such as large woody debris, undercut banks, or boulders are also preferred steelhead rearing areas. Therefore, a stream's capacity to support a robust steelhead population is determined by the quantity of these habitat types.

The diet of steelhead varies considerably according to life history stage and fish size, as well as the food items that are available. Juvenile steelhead feed primarily on benthic macroinvertebrates associated with the stream substrate such as immature aquatic insects (e.g., mayfly and stonefly nymphs; caddisfly, dipteran, and beetle larvae), amphipods, snails, aquatic worms, fish eggs, and occasionally small fish. Diets of juveniles can fluctuate seasonally, depending on food availability. At times, the diet may include terrestrial insects and emerging adult aquatic insects drifting in the current.

5.2.3 Range and Distribution in the Deschutes Basin

5.2.3.1 Historical and Current Range and Distribution

The Deschutes Basin summer steelhead population is part of the Cascade Eastern Slope Tributaries (CEST) Major Population Group (MPG). The CEST MPG is the most robust MPG within the Middle Columbia River Steelhead DPS. The waters covered by the DBHCP include 102 miles of mainstem Deschutes River and tributary (Trout Creek) downstream of Pelton Reregulating Dam and about 358 miles of rivers and creeks upstream of the reregulating dam. Steelhead currently have access to all 102 miles of covered waters downstream of the reregulating dam. Historically the species also had access to 158 miles (44 percent) of the covered rivers and creeks upstream of the reregulating dam, including the 20 miles of mainstem Deschutes River currently occupied by the dams and reservoirs of the Pelton Round Butte Project. The historical range also extended several miles upstream of the covered lands in the upper Crooked River and Ochoco Creek subbasins (Figure 5-6).[1] Apparently, steelhead did not make historical use of tributaries in the Metolius River Basin (Nehlsen 1995). The portions of the covered lands upstream of the reregulating dam and downstream of Bowman Dam, Ochoco Dam and Big Falls (about 143 miles total) are the focus of the ongoing steelhead reintroduction program.

Steelhead passage into the upper Deschutes Basin became problematic after construction of Pelton Dam in 1958 because the dam did not have effective downstream passage facilities. Round Butte Dam was constructed in 1964 seven miles upstream of Pelton Dam, exacerbating poor fish passage conditions. By 1968, efforts to pass anadromous fish at the Pelton Round Butte Project were terminated, resulting in exclusion of steelhead upstream of RM 100. Although steelhead were extirpated upstream of the hydropower project, the resident *O. mykiss* life-history type (rainbow trout) persisted in large numbers.

Under the terms of the Order Approving Settlement and Issuing New License (FERC June 21, 2005), provisions were made at Pelton Round Butte Project to allow migratory fish to once again move between the Upper and Lower Deschutes River. Round Butte Hatchery steelhead were reintroduced into the Whychus Creek and Crooked River subbasins beginning in 2007.

[1] The current and historical distributions reflected in Figure 5-6 are based on the distribution of steelhead prior to the 2007/2008 reintroduction efforts in the Whychus Creek watershed and Crooked River subbasin. The effects of the reintroduction efforts on the current distribution of the species are not depicted in Figure 5-6.

Approximately 220,000 juvenile steelhead were released into the Whychus Creek watershed in May 2007 and an additional 290,000 and 230,000 juvenile steelhead were released into the Whychus Creek watershed and the Crooked River subbasin, respectively, in May 2008. Additional annual fry and smolt releases have occurred since 2008 (Table 5-1), and are anticipated to continue in accordance with the Pelton Round Butte Project license as described in the Deschutes Reintroduction and Conservation Plan (ODFW and CTWSRO 2008).

Table 5-1. Cumulative numbers of hatchery-origin steelhead fry and smolts released annually in habitats upstream of the Pelton Round Butte Project, to support reintroduction in the upper Deschutes Basin.

Year	Fry Released[1]	Smolts Released[1]
2008[a]	525,000	0
2009[a]	832,288	0
2010[a]	611,787	13,380
2011[a]	705,866	13,723
2012[a]	609,253	12,149
2013[a]	617,308	7,084
2014[a]	703,900	10,287
2015[b]	698,103	56,597
2016[c]	613,471	45,939
2017[d]	516,659	48,832
2018[e]	529,000	45,001
Total	6,962,635	252,992

Sources: [a] ODFW unpublished data, [b] PGE & CTWSRO 2016, [c] PGE & CTWSRO 2017, [d] PGE & CTWSRO 2018, [e] PGE & CTWSRO 2019

Notes:

1 Release areas include the Crooked River, Ochoco Creek, McKay Creek, Upper Deschutes River, and Whychus Creek.

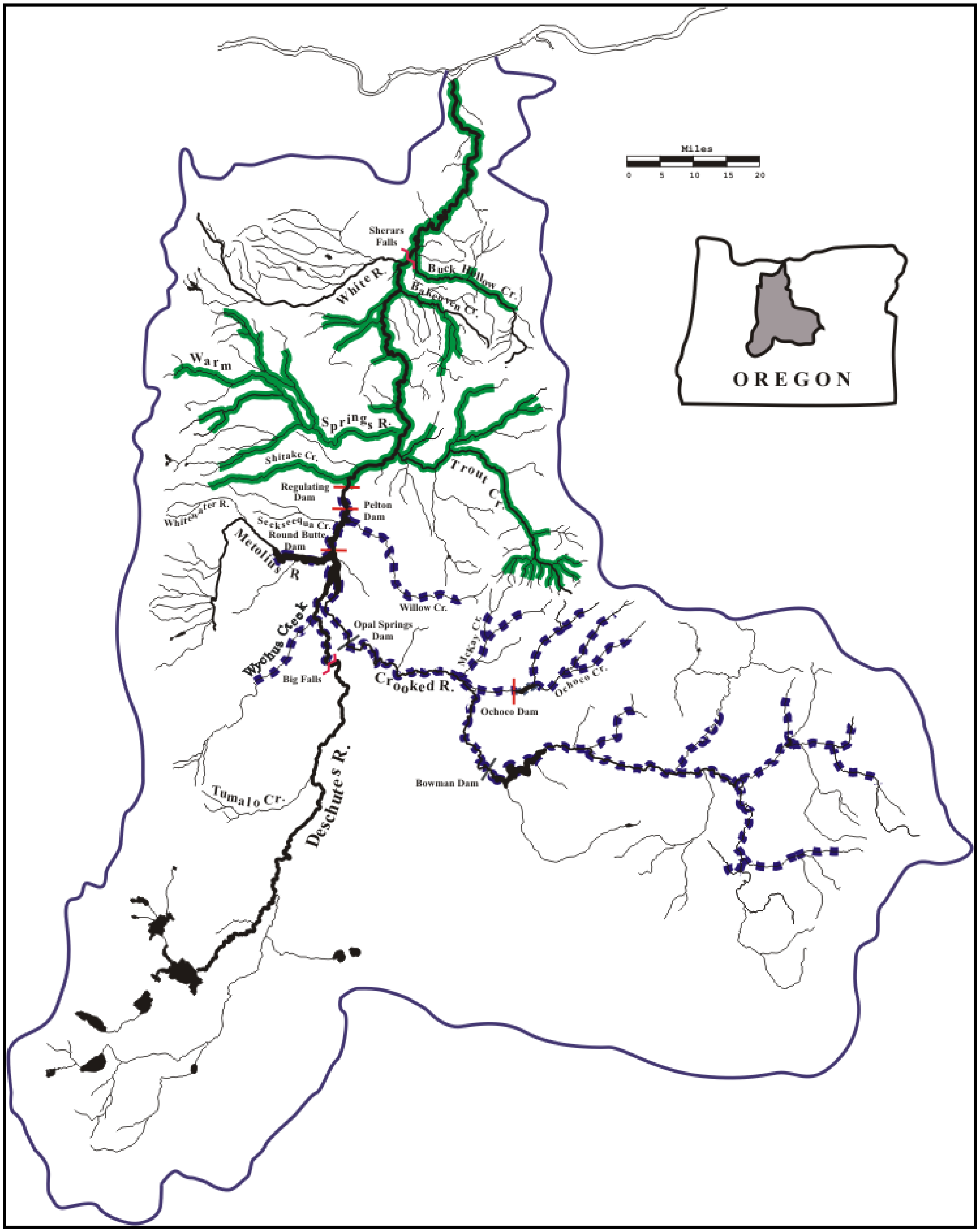

Figure 5-6. Current (solid shade) and historical (dashed shade) distributions of summer steelhead in the Deschutes Basin (prior to reintroduction efforts). Sources: Nehlsen (1995), Lichatowich (1998); adapted from Cramer and Beamesderfer (2006).

5.2.4 Populations in the Deschutes Basin

The covered lands encompass the established mainstem Deschutes River steelhead population from the mouth of the Columbia River to Pelton Regulating Dam, as well as reintroduced populations within 143 miles of mainstem Deschutes River and tributaries upstream of the reregulating dam. The data presented in this section for populations downstream of Pelton Round Butte Project reflect steelhead abundances for all waters associated with the Lower Deschutes River, including both independent steelhead populations (Eastside Tributaries and Westside Tributaries) that the Technical Recovery Team identified in this area (NMFS 2011), since it is difficult to segregate data for these two populations

Adult abundance and escapement. Estimates of summer steelhead escapement have been made for fish passing upstream of Sherars Falls (RM 43) since the 1977-78 run year (Table 5-2). Estimates of natural-origin adult summer steelhead passing Sherars Falls have ranged from a low of 482 to a high of 9,624 fish, and averaged about 5,000 fish annually (NPCC 2004). The most recent 5-year period of record shows the estimated escapement declining significantly from the previous decade, with a range of 5,358 to 1,196 fish. However, actual natural-origin steelhead escapement may be lower, since estimates for some years include stray hatchery-origin fish that were indistinguishable from natural-origin fish (French and Pribyl 2003).

The National Marine Fisheries Service (NMFS) established an interim abundance target of 6,300 fish for the two wild Deschutes Basin steelhead populations below the Pelton Round Butte Project, while the ODFW goal for the Deschutes calls for a spawning escapement of 6,575 natural-origin steelhead upstream of Sherars Falls. The ODFW escapement level was designed to sustain maximum natural production potential during years of good juvenile and adult survival conditions (ODFW 1997). Natural-origin adult steelhead returning to the Deschutes Basin have exceeded these escapement targets only periodically during the period of record (Table 5-2).

Escapement numbers for current and future steelhead spawners would be substantially greater if Deschutes River hatchery and out-of-basin stray hatchery fish were included. The total escapement estimates for all wild and hatchery steelhead passing above Sherars Falls (RM 43) ranged from 4,328 to 40,533 (Table 5-2). Although Deschutes and stray hatchery steelhead are removed from the system at the Pelton and Warm Springs fish traps, ODFW biologists have observed that hatchery-origin steelhead comprise 40 to 50 percent of steelhead during surveys in several eastside Deschutes River tributaries (NPCC 2004).

The first juvenile steelhead from the newly-formed above-barrier population were passed downstream of the Pelton Round Butte Project in the spring of 2010 when 7,612 smolts were collected and transported to the lower Deschutes River. Since then, modest numbers of steelhead smolts continue to be passed into the lower river annually (Table 5-3). The Reintroduction Plan called for adults produced from these outmigrating smolts to be transported upstream past the Pelton Round Butte Project when they return in the summer and fall after 1-2 years in the ocean. Although the first adult steelhead were transported above the hydro project in 2011 (Table 5-3), ODFW did not immediately authorize the transport of all adult fish. Managers first called for testing whether the fish passage facility was working as intended. A NMFS guidance measure outlined a minimum of 50 percent collection of tagged outmigrating Middle Columbia River steelhead or spring Chinook salmon from one tributary arm (Metolius, Deschutes, or Crooked River) of Lake Billy Chinook before adopting a full scale trap and haul program (NMFS 2012).

Table 5-2. Estimated number of steelhead migrating upstream of Sherars Falls (RM 43) by run year.

Run Year	Wild	Round Butte Hatchery	Stray Hatchery	Total Hatchery
1977-78	6,600	6,100	900	7,000
1978-79	2,800	3,200	300	3,500
1979-80	4,200	5,400	600	6,000
1980-81	4,100	5,500	500 a/	6,000
1981-82	6,900	3,800	1,200 a/	5,000
1982-83	6,567	3,524	1,249 a/	4,773
1983-84	8,228 b/	7,250	7,684 a/	15,443
1984-85	7,721 b/	7,563	3,824 a/	11,770
1985-86	9,624 b/	7,382	5,056 c/	12,106
1986-87	6,207 b/	9,064	9,803 c/	18,358
1987-88	5,367 b/	9,209	8,367	17,623
1988-89	3,546	3,849	2,909	6,336
1989-90	4,278	2,758	3,659	6,504
1990-91	3,653	1,990	2,852	4,786
1991-92	4,826	3,778	8,409	11,859
1992-93	904	2,539	4,261	6,008
1993-94	1,487	1,159	4,293	5,476
1994-95	482	1,781	4,391	6,126
1995-96	1,662	2,708	11,855	12,828
1996-97	3,458	5,932	23,618	28,416
1997-98	1,820	5,042	17,703	22,511
1998-99	3,800	3,527	11,110	15,120
1999-00	4,790	2,628	13,785	15,219
2000-01	8,985	4,380	15,072	19,310
2001-02	8,749	9,373	25,263	31,784
2002-03	9,363	8,880	15,203	23,004
2003-04	5,524	5,265	6,543	11,551
2004-05	3,161	4,354	4,972	9,356
2005-06	3,432	5,868	4,838	10,497
2006-07	3,986	6,589	19,189	25,945
2007-08	3,482	6,120	7,929	15,641
2008-09	4,048	5,497	9,498	16,038

Run Year	Wild	Round Butte Hatchery	Stray Hatchery	Total Hatchery
2009-10	4,236	9,557	15,768	25,587
2010-11	7,257	4,799	5,101	9,900
2011-12	5,450	4,063	5,363	10,324
2012-13	3,749	4,903	4,336	10,496
2013-14	5,450	2,523	2,884	5,469
2014-15	5,358	3,154	2,002	5,046
2015-16	2,457	4,293	1,926	5,954
2016-17	1,196	3,224	553	3,980
2017-18	1,487	2,348	1,039	3,364
2018-19	1,605	2,140	457	2,723

Source: Rod French, ODFW pers. comm. 2000.
Notes:
a May include some AD CWT marked steelhead that originated from Warm Springs National Fish Hatchery, although few of these ever returned to that facility.
b May include some unmarked hatchery steelhead out planted as fry into the Warm Springs River from Warm Springs NFH.
c May include adults from a release of 13,000 smolts from Round Butte Hatchery that were accidentally marked with the same fin clip as steelhead released from other Columbia basin hatcheries.

Table 5-3. Cumulative numbers of steelhead smolts passed downstream via the Selective Water Withdrawal fish collection facility at Round Butte Dam and returning adult steelhead passed upstream of the Pelton Round Butte Project.

Year	**Smolt Passage** downstream at Round Butte Dam[a]	**Adult Passage** upstream of Pelton Round Butte Project[b]
2010	7,733	0
2011	10,606	31
2012	7,806	128
2013	2,705	96
2014	2,113	81
2015	3,702	56
2016	4,003	36
2017	10,525	22
2018	8,841	28
Total	58,034	478

Sources: [a] PGE & CTWSRO 2019, [b] PGE Fish Counts

Modeled capacity estimates. Modeling for subbasin planning predicts the number of wild Deschutes summer steelhead spawners could range consistently from 6,000 to 7,000 fish with a moderate level of habitat restoration (NPCC 2004). Restoration of fish passage at the Pelton Round Butte Project and access to historical habitat in the Middle Deschutes and Lower Crooked River systems could add an additional 4,000 to 5,000 summer steelhead to the subbasin. Model estimates of habitat capacity for summer steelhead in the three NMFS-designated population areas could produce up to 13,800 adult steelhead returning annually to the subbasin. This estimate included potential adult returns numbering up to 3,100, 5,200, and 5,500 for the Deschutes River Westside population, Deschutes River Eastside population, and Deschutes River population upstream of the Pelton Round Butte Project, respectively (NPCC 2004).

Specific information on habitat carrying capacity for juvenile wild summer steelhead is not available for the lower Deschutes River subbasin. Based on present habitat, an average fecundity of 5,350 eggs per female, and an assumed egg-to-smolt survival of 0.75 percent, the maximum juvenile steelhead production capacity of the lower Deschutes River subbasin is estimated to be 147,659 smolts, with an adult spawning population of 6,575 fish (ODFW 1997). Both estimates of juvenile and adult production capacity are based on the assumption that current habitat will sustain past escapement levels. The estimated adult return from a spawner escapement of 6,575 is about 9,000 fish, assuming a 6 percent wild smolt-to-adult survival rate (ODFW 1997). The estimated return of 9,000 adults to the mouth of the Deschutes River would, theoretically, produce some level of harvestable wild summer steelhead.

Portland General Electric explored the potential for summer steelhead production in waters upstream of the Pelton Round Butte Project as part of the Federal Energy Regulatory Commission (FERC) relicensing process. During these investigations, a model was developed to evaluate the relative importance of different mortality and habitat factors that could affect reintroduced anadromous fish. The model estimated a juvenile parr capacity of 40,000 and 160,000 in the accessible habitat upstream of the hydroelectric project. Based on assumed stock-recruitment relationships and expected survival rates, the estimated equilibrium spawner numbers of steelhead ranged from 500 to 4,000 spawners per year (Cramer and Beamesderfer 2006).

Using a mesohabitat-based habitat carrying capacity model and existing habitat parameters, Ackerman et al. (2007) refined the Cramer and Beamesderfer (2006) estimate of potential parr production above the Pelton Round Butte Project to approximately 82,000 parr, or about 1,000 to 2,000 adult spawners. Currently, there are natural and artificial barriers and seasonal flow considerations for certain stream reaches, which create partial or complete blockages to upstream migration by steelhead released above the Pelton Round Butte Project. Under existing conditions, over three quarters of the estimated parr production potential is in river reaches that are currently inaccessible to fish (either from natural or artificial barriers) (Spateholts 2008).

Population productivity. In addition to the abundance and capacity discussed above, population productivity (i.e., population growth rate) is an important metric for evaluating steelhead population status. Productivity is a measure of the recruitment of subsequent adult returns as a factor of the original number of spawners (adults/spawners). Productivity levels reflect cumulative survival across all life stages, which can be influenced by improvements in the quality and quantity of available habitats. The summer steelhead population has the capability to respond to favorable management and environmental factors, though some have surmised that the effects of thousands of stray steelhead spawning with the indigenous stock may have a negative impact on the population's productivity (NPCC 2004). However, there is no quantifiable evidence for hatchery fish impacts on natural-origin fish production (Lister 2014). In fact, based on data from fish counting stations in the Middle Columbia River Region, steelhead production has been steadily increasing in the Deschutes Basin and in other nearby watersheds since the historic lows of the early and mid-1990s.

The subbasin planning model estimated the current productivity of the Deschutes River Westside steelhead population to be 6.4 adults per spawner. With moderate habitat restoration, this productivity could increase the returning adult/spawner ratio to 9:1. The current productivity of the Deschutes River Eastside Population was estimated to be 1.6:1, with a potential to increase to 2.9 adults per spawner, as a function of moderate habitat restoration. The potential productivity of the Deschutes population upstream of the Pelton Round Butte Project could be 5.7 adults per spawner, if spawners were present. With restored fish passage and moderate habitat restoration, population productivity could reach 8.2 returning adults per spawner (NPCC 2004).

5.2.5 Habitat in the Deschutes Basin

The primary limiting factor for steelhead production on the covered lands is juvenile rearing habitat (Ackerman et al. 2007; Courter et al. 2014). Direct estimates of habitat carrying capacity for summer steelhead in the Upper Deschutes River (above the Pelton Round Butte Project) are not available, but juvenile (parr) production capacity has been estimated using the Unit Characteristic Method (UCM) based on existing habitat parameters (Ackerman et al. 2007). Model predictions of parr capacity have ranged between 82,000 and 142,500 fish (Spateholts 2008; Courter et al. 2014). Currently, natural and artificial barriers and seasonal flow conditions for certain stream reaches partially or completely block the upstream migration of steelhead released above the Pelton Round Butte Project. Under existing conditions, over three quarters of the estimated parr production potential is in river reaches that are inaccessible to anadromous fish (either from natural or artificial barriers) (Spateholts 2008). However, redband trout (the resident *O. mykiss* life history type) is widely dispersed and extends into the headwaters of the Deschutes Basin.

ODFW recently collected aquatic habitat data throughout the upper Deschutes Basin as part of the Aquatic Inventory Project. Using these data, Spateholts (2008) estimated fish production potential for steelhead trout in all accessible reaches upstream of Lake Billy Chinook. All of these reaches are on lands covered by the DBHCP. Courter et al. (2014) later compiled habitat attributes (ODFW's Aquatic Inventories Project (AIP)) in the upper Deschutes Basin to estimate carrying capacity (Table 5-4) and combined a habitat model with a hydraulic model to evaluate how habitat conditions change in response to stream flow. The specific streams studied included the Upper Deschutes River, Crooked River and Whychus Creek. In summary, juvenile rearing capacity increased with increasing summer flow conditions and reduced water temperatures. The most pronounced capacity increases occurred in higher elevation stream reaches due to the smaller volume of water and therefore proportionally greater impacts of flow changes on habitat availability. Interestingly, in the Deschutes River, increases in flow reduced the predicted capacity at the higher end of the simulated flow range; this is due to the suboptimal depth conditions predicted in riffle habitats when stream flows were high.

Table 5-4. Mesohabitat unit counts from habitat surveys conducted by the Aquatic Inventory Project and steelhead parr carrying capacity estimates for stream reaches upstream of the Pelton Round Butte Project.

Stream	Reach	Length (miles)	Number of Mesohabitat Units by Type						Parr Capacity
			Pool	Riffle	Glide	Cascade	Rapid	Backwater	
Deschutes	Big Falls to Steelhead Falls	4.5	14	26	-	-	16	-	**40,000**
	Steelhead Falls to Lake Billy Chinook	7.7	41	24	10	7	24	-	**6,700**
Whychus	TSID Diversion to City of Sisters	2.0	18	20	-	-	6	2	**2,000**
	Within City of Sisters	2.0	47	44	-	-	1	3	**16,500**
	City of Sisters to Alder Springs	18.6	263	340	3	1	79	25	**2,200**
	Alder Springs to Mouth	1.6	24	24	-	4	4	1	**2,400**
Crooked	Bowman Dam to Crooked River Diversion	14.1	24	77	25	-	3	18	**19,500**
	Crooked River Diversion to US Route 26	8.5	93	56	19	1	-	38	**2,800**
	US Route 26 to NUID Pumps	20.4	230	55	36	-	12	64	**3,100**
	NUID Pumps to US Route 97	9.2	24	24	15	7	14	5	**41,300**
Ochoco	Ochoco Dam to Mouth	11.2	177	160	78	-	4	-	**4,500**
McKay	Jones Dam to Mouth	5.8	83	79	49	-	-	-	**1,500**

Source: Courter et al. 2014.

5.2.6 Legal Status and Management

5.2.6.1 Federal and State Status

NMFS originally listed the Middle Columbia River (MCR) steelhead Evolutionarily Significant Unit (ESU) as threatened in March 1999 (Federal Register [FR] 64:4517). Although critical habitat for this ESU was designated in February 2000 (FR 65:7764), the designation was withdrawn by NMFS in May 2002 (FR 67, FR 6215). Subsequently, a final critical habitat designation was published in September 2005, with an effective date of January 2006 (FR 70:52360). NMFS reaffirmed the threatened status for this ESU in January 2006, and designated the ESU as a Distinct Population Segment (DPS). According to NMFS (2000) and Busby et al. (1996), current population sizes in this DPS are substantially lower than historical levels. The latest status reviews in 2015 concluded that while the Middle Columbia Steelhead DPS has seen notable increases in abundance in some population groups, the DPS still has numerous depressed stocks and threats to its continued existence that have not been adequately addressed. NMFS believes it will take at least 10 to 20 years to see the benefits of recent habitat improvements and management changes aimed at increasing abundance and productivity of the DPS.

The Interior Columbia Basin Technical Recovery Team (NMFS 2011) identified three independent wild summer steelhead populations in the Deschutes Basin:

(1) The Deschutes River Eastside Tributaries population;

(2) The Deschutes River Westside Tributaries population; and

(3) The Crooked River population (extirpated)

The Technical Recovery Team separated the Eastside and Westside populations on the basis of marked habitat and subsequent life-history differences. Eastside tributaries drain drier, lower-elevation areas than the Westside tributaries; consequently, flow patterns and water temperatures are quite different between the two areas. Steelhead in the two regions are temporally segregated, with Eastside tributary fish spawning between January and April, and Westside tributary fish spawning between April and May (Olsen et al. 1992).

The Eastside Tributaries population includes fish spawning and rearing in the mainstem Deschutes River from its mouth to the confluence of Trout Creek (RM 0 – RM 87), and the tributaries entering the Deschutes from the east (primarily Buck Hollow, Bakeoven, and Trout creeks). The Westside Tributaries population includes mainstem spawners from the mouth of Trout Creek upstream to Big Falls (RM 87 – RM 132), and in tributaries entering the Deschutes from the west (primarily Warm Springs River, Shitike Creek, and Whychus Creek).

Hatchery fish from Round Butte Hatchery (completed in 1973), are included in the ESA-Threatened designation for the DPS. The Round Butte hatchery is the only hatchery releasing summer steelhead in the Deschutes River subbasin. As mitigation for effects of the Pelton Round Butte Project (FERC Project No. 2030), the project operators are required to return 1,800 Deschutes summer steelhead adults annually to the Pelton Fish Trap from hatchery smolt releases.

Because the 2006 final ESA listing determination for MCR steelhead included the Round Butte Hatchery stock as part of the DPS (71 Fed. Reg. 834, January 5, 2006), steelhead from Round Butte Hatchery out-planted above Round Butte Dam would have been regarded as an ESA-listed threatened species. Therefore, in 2013 NMFS ratified a decision to designate steelhead populations upstream of the Pelton Round Butte Project as "Nonessential Experimental," which allows for incidental take of steelhead released above Round Butte Dam as long as the take is incidental to otherwise lawful activities (78 Fed. Reg. 2893, January 15, 2013). In addition to allowing take, there is also no section 7(a)(2) consultation requirement for federal actions that may adversely affect steelhead in the upper Deschutes Basin and no critical habitat has been designated.

Under the ESA section 10(j), NMFS is given the authority to designate a population as experimental if it furthers the conservation of the species and the experimental population is geographically separate from the rest of the listed species. When Congress amended the ESA in 1982, it added this provision to reduce opposition to release of listed species outside their current range. In their designation, NMFS determined that the MCR steelhead reintroduced above the Pelton Round Butte Project would be completely separated geographically while upstream of the dams, thereby meeting the requirements for a Nonessential Experimental status designation, but once these fish are moved below the dams they intermingle with other MCR steelhead in the lower Deschutes Basin, making it impossible to differentiate the fish. Therefore, NMFS chose to consider all MCR steelhead above Round Butte Dam as Nonessential Experimental, while all MCR steelhead below the dam would receive the same protections afforded fish listed as threatened under the ESA, regardless of their natal origins. The Nonessential Experimental designation for steelhead above the Pelton Round Butte Project will end in January 2025 if MCR steelhead remain listed, at which time steelhead in the Upper Deschutes basin would receive the same protections under the ESA as other populations in the middle Columbia region.

5.2.6.2 Identified Threats to the Species

The Conservation and Recovery Plan for Oregon steelhead populations in the Middle Columbia River Steelhead DPS (ODFW Steelhead Recovery Plan; Carmichael 2010) identified limiting factors and threats to the recovery of summer steelhead populations. Limiting factors were defined as physical, biological, or chemical conditions of the environment that influence viable salmonid population (VSP) parameters of steelhead. These VSP parameters include abundance, productivity, spatial structure, and diversity. Threats are human actions (such as harvest, hatchery operation and land management), or natural events (such as flood and drought) that cause or contribute to limiting factors. Major limiting factors for the three summer steelhead populations in the Deschutes Basin are degraded floodplain and channel structure, degraded riparian communities, water quality (temperature, chemical contaminants and nutrients), altered hydrology, altered sediment routing, blocked and impaired fish passage, and limited spawning habitat (Table 5-5). Threats to the viability of these three populations are identified in Tables 5-6 through 5-8. Key threats are hatchery practices, hydropower operations, land use practices and irrigation systems (Carmichael 2010).

NMFS (2000) believes one of the most significant sources of risk to steelhead in the Middle Columbia River DPS is the recent and dramatic increase in the percentage of hatchery fish escapement in the Deschutes Basin. In recent years, the percentage of hatchery steelhead strays in the Deschutes River has exceeded 70 percent, and many of these fish are believed to be long-distance strays from outside the DPS, based on differential marking (Reclamation 2003). Coincident with this increase in strays is a corresponding decline in the abundance of native wild steelhead in the Deschutes River. NMFS (2000) stated that the increasing trend in hatchery fish poses a risk to native wild steelhead due to negative effects of genetic and ecological interactions. The downriver transportation of juvenile hatchery steelhead from upriver locations in the Columbia and Snake River basins may contribute to increasing numbers of strays in the Deschutes River (NPCC 2004).

The mainstem Columbia River hydropower system is considered a primary threat to the viability of Middle Columbia river summer steelhead populations (NMFS 2011). In addition, the Pelton Round Butte Project has been identified as a key concern for Westside Deschutes and Crooked River populations. Hydropower development has affected the Deschutes Basin through delayed upstream passage (adults), direct and indirect mortality on downstream migrants (juveniles), alteration of the hydrograph (mainstem and estuary flow regime), depletion of historically available nutrients, and degraded rearing and food resources for both presmolts and smolts in the Columbia (Carmichael 2010).

Land use has been identified as having the most key concerns of any threat category affecting Middle Columbia summer steelhead populations (NMFS 2011). Specific threats related to land use include agriculture, grazing, forestry and road maintenance activities that result in impaired upstream and downstream movement of juvenile and adult steelhead, impaired physical habitat quality, impaired water quality due to elevated water temperatures and agricultural chemicals, and reduced water quantity and/or modified hydrologic processes. For the Crooked River, operation of irrigation systems is included as a land use activity that negatively impacts summer steelhead by altering seasonal hydrographs and increasing summer water temperatures.

Table 5-5. Habitat-limiting factors summary for Middle Columbia River summer steelhead populations on the DBHCP covered lands.

Population / Spawning Area	Major Limiting Factors	Sites Affected*	Viable Salmonid Population (VSP) Characteristics Impacted	Potential Causes/Threats	Life Stages Affected
			DESCHUTES EASTSIDE POPULATION		
Deschutes River Eastside Population	Degraded floodplain and channel structure (complexity, deep pools, diversity); degraded riparian communities; water quality (temp, chemical contaminants and nutrients); altered hydrology (higher peak, lower low flows); altered sediment routing	Major and minor spawning areas	Productivity, abundance, spatial structure and diversity	Livestock grazing, roads, residences, agricultural practices that simplify habitat, irrigation withdrawals, dams and other barriers	All life stages
Lower Trout Cr. Major Spawning Area	Degraded floodplain and channel structure; degraded riparian communities; altered hydrology; degraded water quality (temp); altered sediment routing; blocked and impaired fish passage	Trout Cr. H (especially below Willowdale), T (RM 0 – 50.7), F, CS, R, S, PB (Mud Springs Cr.); Mud Springs Cr. IP (culvert in Section 15 and just above Gateway)	Productivity, abundance, spatial structure and diversity	Agricultural practices, channel simplification following flood, roads, irrigation storage reservoirs and diversions, livestock grazing	All life stages
			DESCHUTES WESTSIDE POPULATION		
Deschutes River Westside Population	Degraded riparian communities; degraded floodplain and channel structure (complexity, side-channel habitat, diversity); water quality (temp); altered hydrology (low flow); altered sediment routing; blocked and impaired fish passage	Major and minor spawning areas	Abundance, productivity, spatial structure and diversity	Primarily livestock grazing, roads, residential development and agricultural practices that simplify habitat, irrigation withdrawals, forest practices, dams and other barriers	All life stages
			CROOKED RIVER POPULATION		
Crooked River Population	Degraded riparian communities; degraded floodplain and channel structure (complexity, side-channel habitat, diversity); water quality (temp); altered hydrology (low flow); altered sediment routing; blocked and impaired fish passage	Major and minor spawning areas	Abundance, productivity, spatial Structure and diversity	Primarily livestock grazing, residential development and agricultural practices that simplify habitat, irrigation withdrawals, unauthorized OHV use, dams and other barriers, reservoir release flows	All life stages

Population / Spawning Area	Major Limiting Factors	Sites Affected*	Viable Salmonid Population (VSP) Characteristics Impacted	Potential Causes/Threats	Life Stages Affected
Crooked Confluence Minor Spawning Area (reintroduction)	Limited spawning habitat, passage	Crooked R. (RM 6 – RM 7) BP	Productivity, abundance, spatial structure and diversity	Barrier at Opal Springs Dam	Spawning
Lone Pine Minor Spawning Area (reintroduction)	Limited spawning habitat	Crooked R. (RM 7 – RM 20)	Productivity, abundance, spatial structure and diversity	N/A	Spawning
McKay Major Spawning Area (reintroduction)	Degraded channel structure; water quality (temp), altered hydrology, degraded riparian communities, altered sediment routing, passage	McKay Cr. (RM 0 – RM 14) including Allen Cr. F, CS, R, H, S, T, BP; McKay Cr. (RM 14 – RM 19) including Little McKay Cr. CS, R, S, WQ	Productivity, abundance, spatial structure and diversity	Past channelization, livestock grazing and agricultural practices, irrigation withdrawals, unauthorized OHV use, permanent and seasonal barriers, removal of riparian vegetation, loss of large woody debris	All life stages
Lower Ochoco Major Spawning Area (reintroduction)	Degraded channel structure and reduced complexity, altered hydrology, degraded riparian communities, altered sediment routing	Ochoco Cr. (RM 0 – RM 10) F, CS, R, H, S, IP	Productivity, abundance, spatial structure and diversity	Urban development in reach through Prineville, flow management in releases from Ochoco Dam. Livestock grazing and agricultural practices in upper reach below Ochoco Dam	All life stages
Lower Crooked Major Spawning Area (reintroduction)	Degraded floodplain and channel structure; degraded riparian communities; altered hydrology; degraded water quality (temp, pollutants); altered sediment routing	Crooked R. (RM 20 – RM 56) F, CS, R ,H, WQ, T, S; Crooked R. (RM 56 – RM 70) H, WQ, S, BP	Productivity, abundance, spatial structure and diversity	Livestock grazing and agricultural practices, past channelization, flow management or releases from Bowman Dam, irrigation withdrawals	All life stages

Source: Tables 8-16, 8-18, and 8-19 in Carmichael 2010.
Notes:
* Abbreviations for limiting factors: degraded floodplain connectivity and function (F), degraded channel structure and complexity (CS); degraded riparian communities (R); altered hydrology (H); degraded water quality (WQ), temperature (T); altered sediment routing (S); man-made block to migration (BP); impaired fish passage (IP).

Table 5-6. Key and secondary threats to viability of the Deschutes River Eastside summer steelhead population.

DESCHUTES RIVER – EASTSIDE TRIBUTARIES
Key Threats <u>Current Hatchery Practices</u> • *Limiting factor(s) primarily affected:* Straying of hatchery steelhead into spawning grounds. • *Life stage(s) primarily affected:* Spawners. • *Specific threat(s):* Management designed to produce returns of hatchery summer steelhead to the Deschutes and many other upstream Columbia River tributaries results in significant proportions of stray hatchery steelhead spawning naturally in this population. The principal concern relates to a continuing detrimental impact of stray hatchery fish in natural spawning areas on the genetic traits and productivity of naturally produced steelhead. <u>Current Land Use Practices</u> • *Limiting factor(s) primarily affected:* Reduced water quantity and/or modified hydrograph; impaired physical habitat quality; elevated water temperatures. • *Life stage(s) primarily affected:* fry, summer parr, winter parr. • *Specific threat(s):* Current land use practices (agriculture, grazing, forest practices, road maintenance, etc.) that impact steelhead growth and survival, or modify natural hydrographs during critical periods in tributary streams. Improvement of some habitat conditions is expected to occur in the future, based on current land use practices that are much improved over historical practices.
Secondary Threats <u>Current Mainstem Columbia Hydropower System</u> • Direct mortality of pre-smolts and smolts at dams; delayed upstream migration of returning adults over dams; cumulative impact of system on mainstem and estuary habitat for pre-smolts and smolts. <u>Land Use Practices</u> • Cumulative impact of past and present activities on estuarine habitat for pre-smolts and smolts; predation by birds on pre-smolts and smolts in estuary because of creation of dredge spoil islands; increased fine sediment from past and present agricultural and forestry practices reduces survival of eggs and alevins in tributary streams. <u>Harvest</u> • Mortality of returning adults in tributary streams from catch-and-release fishery. <u>Introduced Species</u> • Predation by non-native piscivorous fish on pre-smolts and smolts in mainstem Columbia.

Source: Table 8-3 in Carmichael 2010.

Table 5-7. Key and secondary threats to viability of the Deschutes River Westside summer steelhead population.

DESCHUTES RIVER – WESTSIDE TRIBUTARIES

Key Threats

Current Hatchery Practices

- *Limiting factor(s) primarily affected*: Stray hatchery steelhead spawn with wild population.
- *Life stage(s) primarily affected*: Spawners.
- *Specific threat(s)*: Management designed to produce returns of hatchery summer steelhead to the Deschutes and many other upstream Columbia River tributaries results in significant proportions of stray hatchery steelhead spawning naturally in this population. Straying of these hatchery fish into natural spawning areas threatens the genetic traits and productivity of naturally produced steelhead.

Current Hydropower

- *Limiting factor(s) primarily affected:* Impaired downstream migration through Lake Billy Chinook; blocked migration above Pelton Dam.
- *Life stage(s) primarily affected:* Smolts and returning adults.
- *Specific threat(s):* Fish passage currently blocked at Pelton Dam on the Deschutes, eliminating access by steelhead to a significant portion of the historical distribution of this population.

Current Land Use Practices

- *Limiting factor(s) primarily affected:* Impaired physical habitat quality.
- *Life stage(s) primarily affected:* fry, summer parr, winter parr.
- *Specific threat(s):* Current land use practices (agriculture, grazing, forestry, road maintenance) that negatively impact steelhead growth and survival in tributary streams. Improvement of some habitat conditions is expected to occur in the future, based on current land use practices that are much improved over historical practices.

Secondary Threats

Current Mainstem Columbia Hydropower System

- Direct mortality of pre-smolts and smolts at dams; delayed upstream migration of returning adults over dams; cumulative impact of system on mainstem and estuary habitat for pre-smolts and smolts.

Land Use Practices

- Cumulative impact of past and present activities on estuarine habitat for pre-smolts and smolts; predation by birds on pre-smolts and smolts in estuary because of creation of dredge spoil islands; elevated water temperatures and increased fine sediment from past and present agricultural and forestry practices reduce survival of eggs and alevins in tributary streams; reduced water quantity and/or modified hydrograph impacts growth and survival of fry and summer parr in tributaries.

Harvest

- Mortality of returning adults in tributary streams from catch-and-release fishery.

Introduced Species

- Predation by non-native piscivorous fish on pre-smolts and smolts in mainstem Columbia.

Source: Table 8-4 in Carmichael 2010.

Table 5-8. Key and secondary threats to viability of the Deschutes River – Crooked River steelhead population.

DESCHUTES RIVER – CROOKED RIVER (extirpated population)
Key Threats Current Hydropower • *Limiting factor(s) primarily affected:* Impaired downstream migration; blocked upstream migration, hydrograph, water quantity. • *Life stage(s) primarily affected:* smolts and returning adults. • *Specific threat(s):* Fish passage is currently blocked at Pelton Dam on the mainstem Deschutes, thereby entirely eliminating access by steelhead to the historical distribution of this population. Current Land Use Practices / Irrigation System • *Limiting factor(s) primarily affected*: Fish migration; impaired physical habitat quality; elevated water temperatures; reduced water quantity and/or modified hydrograph, population traits. • *Life stage(s) primarily affected:* fry, summer parr, winter parr, adults. • *Specific threat(s):* Current land use practices (agriculture, grazing, forestry, road maintenance, etc.) that impact steelhead growth and survival in tributaries; irrigation diversions. These conditions would impair the likelihood of re-establishing a self-sustaining population of steelhead in the future. Improvement of some habitat conditions is expected to occur in the future, based on current land use practices that are much improved over historical practices. Maintenance of an irrigation water storage system in the Crooked River alters the seasonal hydrograph (lower summer flows, higher autumn flows) and increases summer water temperatures. These conditions would impair the likelihood of re-establishing a self-sustaining population of steelhead in the future.
Secondary Threats Current Mainstem Columbia Hydropower System • Direct mortality of pre-smolts and smolts at The Dalles and Bonneville dams; delayed upstream migration of returning adults over dams; cumulative impact of system on mainstem and estuary habitat for pre-smolts and smolts. Land Use Practices • Cumulative impact of past and present activities on estuarine habitat for pre-smolts and smolts; predation by birds on pre-smolts and smolts in estuary because of creation of dredge spoil islands; increased fine sediment from past and present agricultural and forestry practices reduce survival of eggs and alevins in tributary streams. Introduced Species • Predation by non-native piscivorous fish on pre-smolts and smolts in mainstem Columbia.

Source: Table 8-5 in Carmichael 2010.

5.2.6.3 Recovery Planning and Management

The ODFW Steelhead Recovery Plan (Carmichael 2010) contains a series of recommended strategies and voluntary actions for achieving recovery of Oregon populations of the DPS. Eight management strategies were developed specifically to address identified threats to the tributary populations, including the three populations on the covered lands. These strategies are as follows:

Strategy 1. *Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.*

Strategy 2. *Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.*

Strategy 3. *Maintain and restore floodplain connectivity and function.*

Strategy 4. *Restore degraded and maintain properly functioning channel structure and complexity.*

Strategy 5. *Restore riparian condition and LWD recruitment and maintain properly functioning conditions.*

Strategy 6. *Restore natural hydrograph to provide sufficient flow during critical periods.*

Strategy 7. *Improve degraded water quality and maintain unimpaired water quality.*

Strategy 8. *Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.*

5.2.7 Critical Habitat

The Federal Critical Habitat Assessment Review Team (Bambrick et al. 2005) rated the conservation value of all watersheds supporting populations of Middle Columbia River steelhead. The team identified the primary constituent elements (PCEs) of critical habitat for steelhead (i.e., the physical and biological elements that support one or more life stages and are considered essential to the conservation of the species) (Table 5-9). NMFS subsequently designated critical habitat for Middle Columbia River steelhead on September 2, 2005 (FR 70:52808). The areas included in the designation encompassed all major tributaries within each Major Population Group downstream of passage barriers, as well as the mainstem Columbia River (Figure 5-7). Within the Deschutes Basin, critical habitat designations included Buck Hollow, Cottonwood, Deep, Eagle, Badger, Beaver, Mill, and Shitike creeks, as well as the Warm Spring River for the Lower Deschutes subbasin (Figure 5-8). The entire Trout Creek subbasin was also designated as critical habitat and included Brocher, Ward, Antelope, Tub Spring, Little Trout, Clover, Amity, Board Hollow, Big Log, Cartwright, Auger, Opal, and mainstem Trout creeks (Figure 5-9). Of these, lower Trout Creek is the only area of designated critical habitat for summer steelhead within the DBHCP covered lands.

Table 5-9. Types of sites and essential physical and biological features designated as PCEs for steelhead, and the life stage each PCE supports.

Site	Essential Physical and Biological Features	ESU/DPS Life Stage
Freshwater Spawning	Water quality, water quantity, and substrate	Spawning, incubation, and larval development
Freshwater Rearing	Water quantity and floodplain connectivity	Juvenile growth and mobility
	Water quality and forage [a]	Juvenile development
	Natural cover [b]	Juvenile mobility and survival
Freshwater Migration	Free of artificial obstructions, water quality and quantity, and natural cover [a]	Juvenile and adult mobility and survival
Estuarine Areas	Free of obstruction, water quality and quantity, and salinity	Juvenile and adult physiological transitions between salt and freshwater
	Natural cover [a], forage [b], and water quality	Growth and maturation
Nearshore Marine Areas	Free of obstruction, water quality and quantity, natural cover [a], and forage [b]	Growth and maturation, survival
Offshore Marine Areas	Water quality and forage [b]	Growth and maturation

Source: Bambrick et al. 2005.

Notes:

a Forage includes aquatic invertebrate and fish species that support growth and maturation.

b Natural cover includes shade, large wood, log jams, beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.

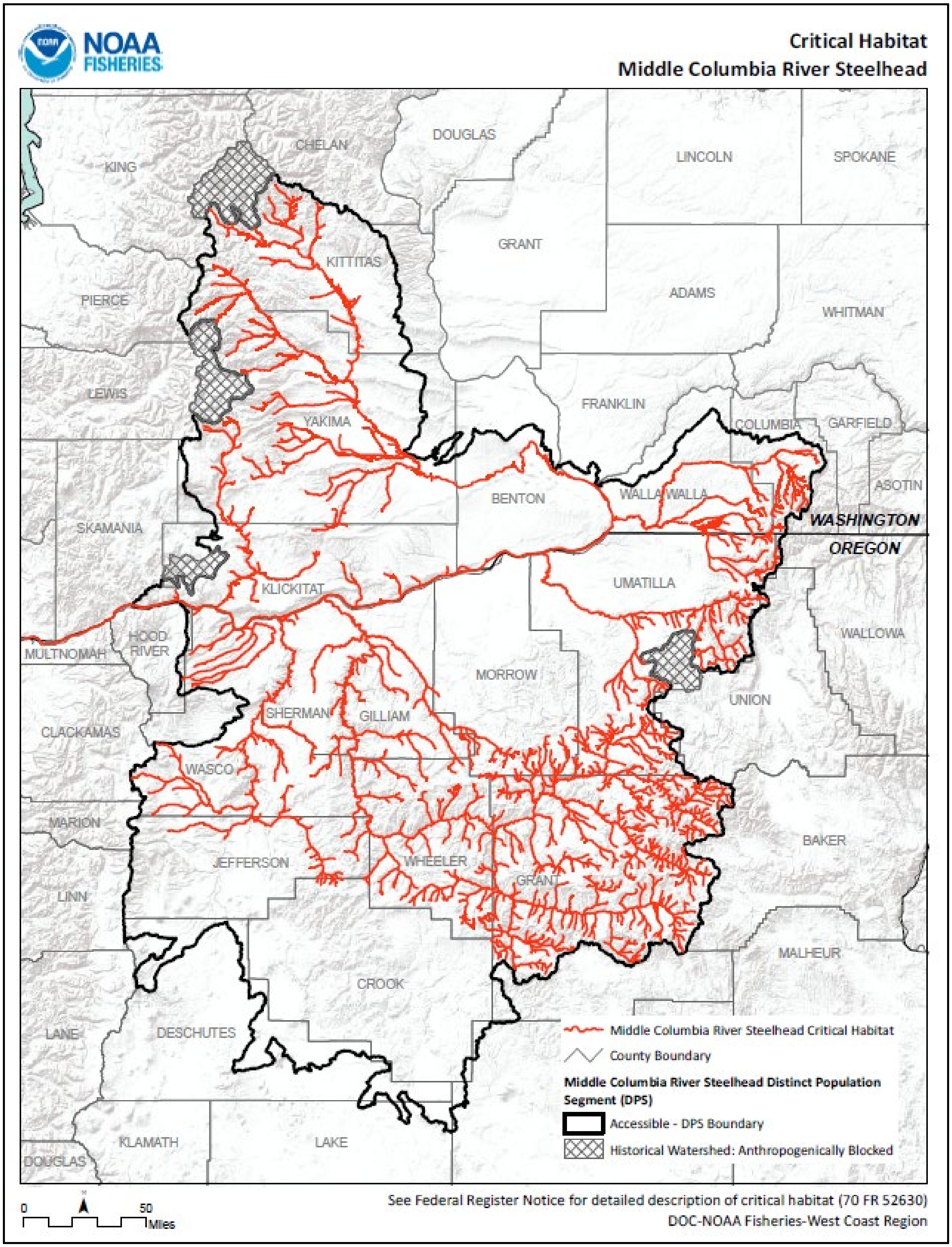

Figure 5-7. Middle Columbia River steelhead designated critical habitat. Source: NMFS 2017.

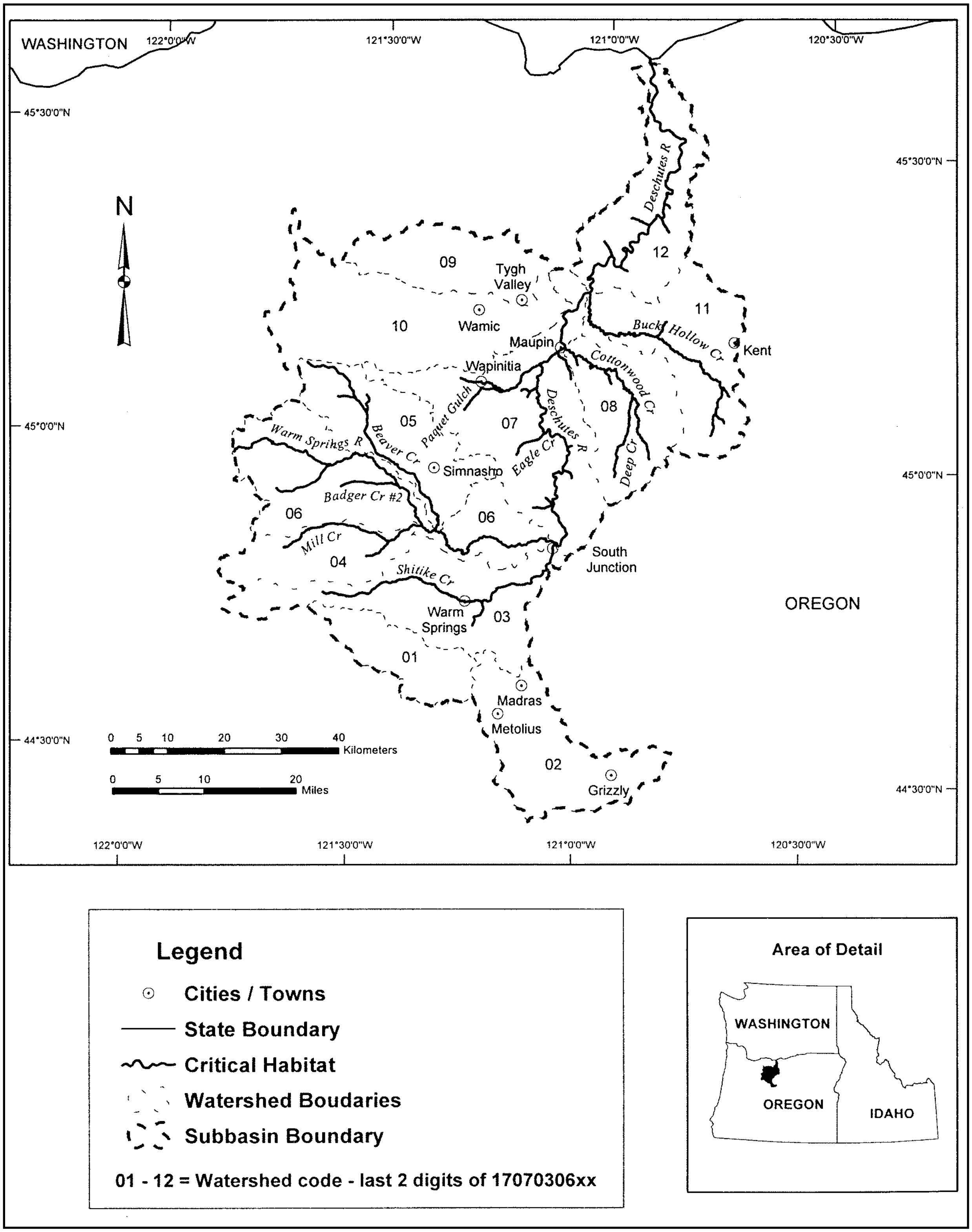

Figure 5-8. Middle Columbia River steelhead designated critical habitat in the lower Deschutes River subbasin. Source: NMFS 2005.

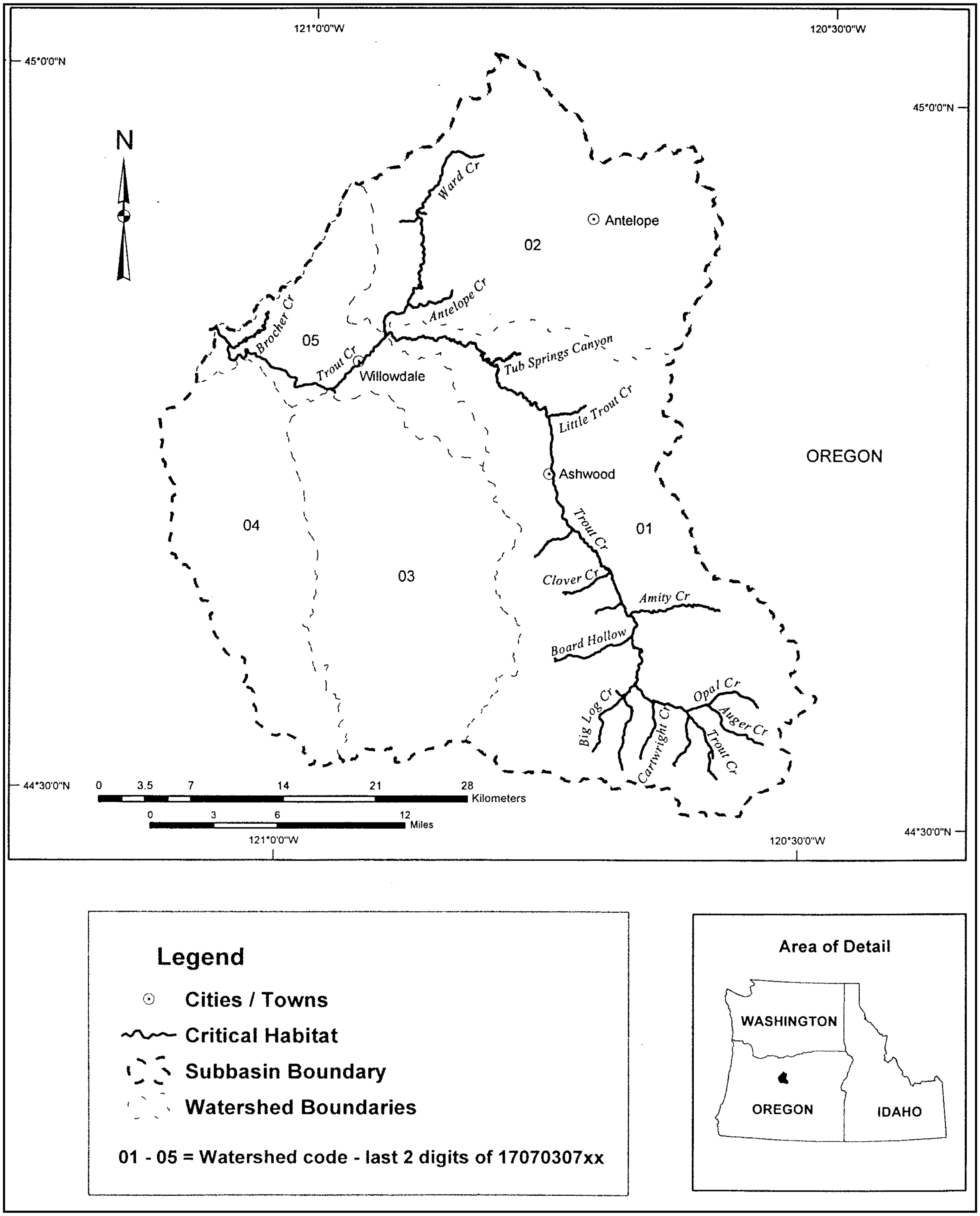

Figure 5-9. Middle Columbia River steelhead critical habitat designated for the Trout Creek subbasin.
Source: NMFS 2005.

5.3 Sockeye Salmon/Kokanee

Sockeye salmon and their non-migratory variant (kokanee) are present on the covered lands, with kokanee making up most of the population. Anadromous sockeye were historically present in the upper Deschutes Basin, but this population was extirpated by passage problems and the construction of Round Butte Dam. Reintroduction efforts have begun. Sockeye/kokanee salmon within the Mid-Columbia ESU are not listed on the state or federal sensitive species lists. If upstream reintroductions of anadromous sockeye are successful, the status of this population could receive an independent ESU designation from NMFS. The DBHCP covers sockeye/kokanee salmon in the Deschutes River upstream to Big Falls, in Whychus Creek, and in the Crooked River subbasin. Kokanee salmon in the Deschutes River upstream of Big Falls are not covered by the DBHCP.

5.3.1 Life History

Sockeye is the anadromous variant of *Oncorhynchus nerka*, and kokanee is the freshwater-resident variant. Partial migration, when one portion of an animal population migrates while the other portion remains sedentary (Lundberg 1988), has been well documented in salmonids (Jonsson and Jonsson 1993). Examples of this type of migratory behavior include fluvial and adfluvial life-histories where migration occurs from mainstem riverine habitats and lakes to spawn in tributaries. A related term, “partial anadromy,” refers to a similar behavioral strategy whereby fish from the same reproductively-mixed population adopt divergent anadromous and resident freshwater life-history strategies (Hendry et al. 2004). Most salmonid species are partially anadromous, and this type of life-history diversity is believed to buffer against extinction (Hilborn et al. 2003; Greene et al. 2010). Juvenile anadromous sockeye migrate from freshwater lakes and streams to the ocean before returning as adults to their natal freshwater tributaries or lake shorelines to spawn. Non-oceangoing sockeye typically mature in freshwater lakes and use tributary streams for spawning and juvenile rearing.

Anadromous sockeye juveniles smolt and migrate to the ocean 1 to 2 years following rearing in a freshwater lake environment, and return to spawn after 1 to 3 years of ocean life (Wydoski and Whitney 2003). Adult sockeye salmon are predominantly 3 years old when they return to spawn, growing up to 33 inches in length and ranging in weight from 5 to 15 pounds. Female sockeye can produce as many as 4,000 eggs and will spawn in three to five redds over a period of a few days. Eggs generally hatch in 6 to 9 weeks, depending on water temperature. The young will remain in the substrate for another 2 to 3 weeks before emerging and moving into lacustrine habitats to rear (Wydoski and Whitney 2003).

Adult kokanee are generally much smaller (less than 14 inches) in size compared with sockeye and reach sexual maturity at 3 years of age. Similar to sockeye, adult kokanee die in the fall after spawning (Fies and Robart 1988). Large numbers of kokanee migrate from Lake Billy Chinook into the Metolius River for spawning. A similar migration of Wickiup Reservoir kokanee occurs annually in the short segment of the Deschutes River below Crane Prairie Dam. Kokanee eggs hatch in the Metolius River Basin from early December through early February, with emergence occurring from January through April. Most fry migrate downstream in late March and early April. Estimated fry recruitment ranged from 1.9 million in 1999 to 2.5 million in 1998. Potential kokanee egg deposition in the Metolius River Basin ranged from about 39 and 67 million for brood years 1998 and 1997, respectively. Therefore, estimated egg to fry survival ranged from about 3.8-4.8 percent (Thiede et al. 2002).

5.3.2 Habitat Requirements

Sockeye salmon spawn in lacustrine and riverine habitats, while kokanee spawn primarily in rivers. Riverine spawners typically seek out tributaries to lakes and reservoirs with suitable riffles or areas with laminar flow (Burgner 1991). Egg and alevin survival are dependent on clean, small to medium-sized spawning gravels (Lorenze and Eiler 1989) with low to moderate stream flows. However, extreme low flows can negatively impact spawner distribution by forcing sockeye/kokanee to construct their redds mid-stream, which can later be disrupted by high winter flows. High flows can scour redds (by moving the spawning gravels downstream), negatively impacting the fall and winter incubation period. Sockeye/kokanee that spawn along the shorelines of lakes and reservoirs require undisturbed shallow water shorelines and clean gravels with an upwelling of ground water (Meehan and Bjornn 1991).

Following emergence from incubation areas, sockeye/kokanee fry rear in a “nursery” lake for 1 to 2 years. Growth rate and survival in lakes and reservoirs are dependent on water quality and food production. The availability of prey species is largely influenced by factors such as water chemistry, depth, and temperature in the lakes. Newly emerged fry feed on aquatic insects in the littoral (shoreline) zones of lakes and on large zooplankton species (*Daphnia* or large copepods) in the limnetic (open or deep water) zone in the summer months. Poor habitat or overpopulation within lakes and reservoirs (i.e., overpopulation of kokanee in Suttle Lake; Fies et al. 1996a) can negatively impact the growth of juvenile sockeye, resulting in increased vulnerability to predation by other salmonids (e.g., bull trout) and piscivorous fish species (e.g., pikeminnow). Small size can also impact survival in estuarine and marine habitats upon emigration. For their successful growth, survival and emigration to the ocean, anadromous sockeye smolts require a productive freshwater/saltwater transition zone with abundant food resources and refuge from fish and bird predators.

Successful kokanee and sockeye production and survival are dependent on sufficient instream temperature (Bell 1990) and flows for migration, spawning, egg incubation, and juvenile outmigration. In addition, sockeye salmon survival requires stream conditions with minimal siltation, stable stream banks, and overhanging vegetation (Hartman et al. 1962).

5.3.3 Range and Distribution in the Deschutes Basin

5.3.3.1 Historical and Current Range and Distribution

Anadromous sockeye salmon were indigenous to a portion of the Deschutes River subbasin, specifically to the Lake Creek/Suttle Lake complex (Fies and Robart 1988). Historically, fish migrated up the Metolius River and into the Lake Creek through Suttle Lake and into Link Creek to spawn. Link Creek (which connects Suttle Lake to Blue Lake) and the shores of Suttle Lake also provided spawning habitat. Juvenile sockeye also reared upstream in Blue Lake, while others dropped downstream into Suttle Lake to rear. By the 1940s, passage problems near the outlet of Suttle Lake and small dams on Lake Creek reduced access for sockeye; ultimately the construction of the Round Butte Dam in 1962 resulted in extirpation from the upper Deschutes Basin (Nehlsen 1995; Gustafson et al. 1997; Marx 2003).

Since the completion of Round Butte Dam, adult sockeye have returned in small numbers (1 to 332 fish annually) to the Pelton Fish Trap. These returning fish have three possible origins: 1) out-of-basin strays from other Columbia River populations, 2) the result of sockeye spawning in the Lower Deschutes River, or 3) returning fish from Deschutes River kokanee smolts that escaped from the upper reservoirs.

Kokanee salmon were also indigenous to the Suttle Lake complex, as reported by a 1941 lake survey (Marx 2003). Although kokanee populations currently exist in the Suttle Lake complex, it is unknown whether indigenous kokanee remain (Fies et al. 1996a). Kokanee are currently present above Pelton Dam in Lake Simtustus and above Round Butte Dam in Lake Billy Chinook. Kokanee from these reservoirs will migrate upstream from Lake Billy Chinook each fall to spawn in the first 2 miles of Whychus Creek (Fies et al. 1996a) and within the tributaries of the Metolius River (Schulz and Thiesfeld 1996). A few fish from these populations also spawn in the Crooked River below Opal Springs, the Deschutes River, and other small tributaries (Stuart et al. 1996). In the upper basin, Wickiup Reservoir also sustains a kokanee population; these fish migrate and spawn in the short segment of the Deschutes River below Crane Prairie Dam. Due to an unscreened outlet of the reservoir, Wickiup kokanee are often found immediately downstream and as far as Bend, as evidenced by Central Oregon Irrigation District's fish trapping in 1989 (Craven 1991; Fies et al. 1996b).

5.3.4 Populations in the Deschutes Basin

Sockeye and kokanee salmon are present on the covered lands, with kokanee making up a majority of the population (Table 5-10). As noted above, anadromous sockeye have been excluded from the upper basin for about 70 years, and efforts to reintroduce sockeye have only recently begun. Portland General Electric and Warm Springs Power Enterprises (co-FERC License applicants) began these reintroductions by re-establishing passage at Round Butte Dam. Since 2011, about 442,722 yearling kokanee and sockeye have been collected at the downstream fish collection facility to be released below Round Butte Dam (Figure 5-10). However, numbers of adult fish captured at the Pelton Fish Trap have seen only modest gains as a result of these reintroduction efforts (Figure 5-11). Adult sockeye returns originating from rearing sites in the upper basin did not exceed 100 fish annually until 2016 when over 500 fish were passed upstream of the Pelton Round Butte Project (Table 5-11). Genetic analysis determined that over 90 percent of the fish passed had originated from Lake Billy Chinook (Spateholts pers. comm.).

Kokanee populations currently exist in the reservoirs of Lake Billy Chinook, Lake Simtustus, Wickiup and Crane Prairie. The natural lakes with kokanee include the Suttle Lake complex, Davis, Odell, Paulina, East and Elk. However, most kokanee in the Deschutes Basin are associated with Lake Billy Chinook and the Metolius River (NPCC 2004). A Lake Billy Chinook study (1996-2000; Thiede et al. 2002) which monitored spawning adult kokanee, estimated 83,471 and 569,201 adults in the Metolius River Basin in 1996 and 2000, respectively.

Table 5-10. Deschutes River subbasin lakes and reservoirs with kokanee salmon populations.

Water Body	Population Status	First Hatchery Release	Management Program
Lake Billy Chinook	Natural	Hatchery releases into Suttle Lake	Self-sustaining
Lake Simtustus	Fallout from Lake Billy Chinook	Fish escape from Lake Billy Chinook	--
Suttle Lake	Natural	Sockeye releases in 1940s, 1950s	Self-sustaining since 1973
Wickiup Reservoir	Natural	Kokanee releases from 1958-1986	Self-sustaining since 1987
Crane Prairie Reservoir	Hatchery stocks	First kokanee release in 1957	Annual stocking since 1981
Davis Lake	Low numbers from Odell Lake	No hatchery releases	Fish drop out of Odell Lake and Odell Creek
Odell Lake	Natural	First stocking 1950	Self-sustaining since 1983
Paulina Lake	Hatchery stocks	First stocking 1973	Annual stocking
East Lake	Hatchery stocks	First stocking 1993	Annual stocking
Elk Lake	Natural	--	Self-sustaining

Source: data compiled from Fies et al. 1996a and 1996b; table from Deschutes Subbasin Plan (NPCC 2004).

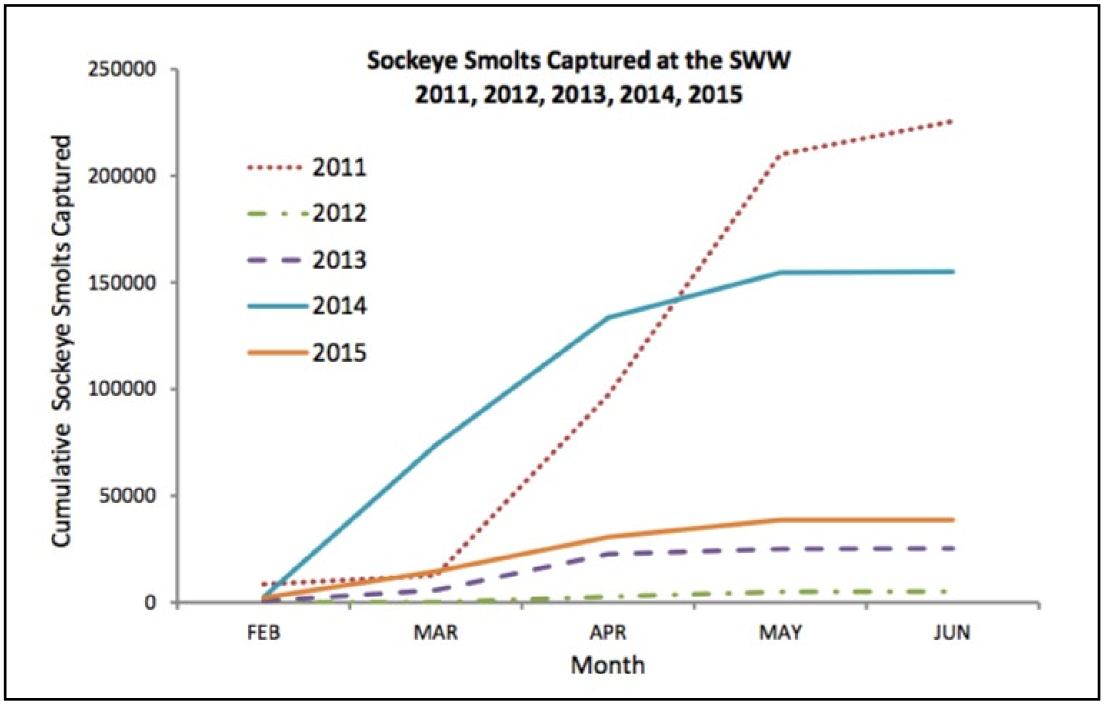

Figure 5-10. Numbers of sockeye smolts captured annually at Round Butte Dam fish collection facility from 2011 through 2015. Source: PGE and CTWSRO 2016.

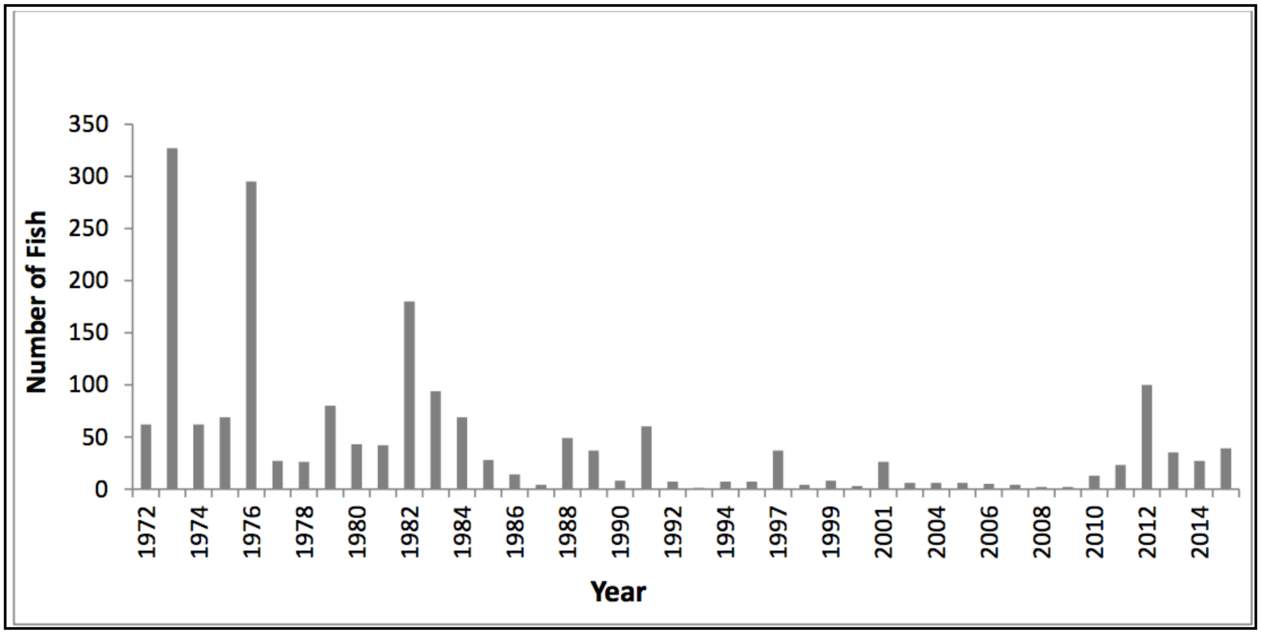

Figure 5-11. Numbers of adult sockeye captured at the Pelton Fish Trap annually from 1972 through 2015. Adult passage upstream of Pelton Round Butte was reestablished in 2010 (see Table 5-10). Source: PGE and CTWSRO 2016.

Table 5-11. Metrics on sockeye smolt releases and smolt/adult passage on the covered lands.

Year	**Smolts released** (hatchery-origin) in habitats upstream of Pelton Round Butte Project [1,2]	**Smolt passage** (natural and hatchery-origin) at Round Butte Dam[3]	**Adult passage** upstream of Pelton Round Butte complex[3]
2010	0	-	12
2011	0	220,627	19
2012	3,870	4,955	86
2013	0	24,708	25
2014	0	153,730	21
2015	0	38,702	36
2016	13,122	49,412	503
Total	**16,992**	**492,134**	**702**

Source: PGE and CTWSRO 2016.
Notes:
[1] Includes Metolius River arm and Crooked River arm of Lake Billy Chinook. Releases were done to support reintroduction of salmon in the upper Deschutes Basin.
[2] ODFW unpublished data
[3] The Selective Water Withdrawal fish collection facility at Round Butte Dam

5.3.5 Habitat in the Deschutes Basin

The Suttle Lake complex was home to one of two historical populations of anadromous sockeye in Oregon. The mainstem Metolius River and Lake Creek (the stream linking Suttle Lake to the Metolius River system) are necessary for the successful migration of sockeye to spawning and rearing grounds in Suttle Lake and Link Creek. Neither of these waters overlaps with the lands covered by the DBHCP. Habitat features including pools, riffles, woody debris, and vegetation cover are regarded as crucial to the successful migration of sockeye through these migratory corridors. Currently, local groups (e.g., the Upper Deschutes Watershed Council and the Deschutes Land Trust) are working to restore naturally functioning stream channels, stream banks, and riparian margins to benefit fish and improve habitat and water quality in these areas.

Following the commencement of sockeye reintroduction efforts in 2009, ODFW developed the HabRate model to assess the habitat quality of streams that were historically occupied above the Pelton Round Butte Project (Burke et al. 2010). The HabRate model estimates habitat suitability and reintroduction success for each life stage. HabRate predicted that current habitat conditions would limit sockeye distribution to the Metolius River drainage, with probable spawning areas in Lake Creek and rearing in Suttle Lake (Figure 5-12). It is estimated that sockeye can access 190 km (118 mi.) of the Metolius River drainage, where 180 km (112 mi.) are expected to be utilized for spawning and juvenile emergence. The HabRate ratings were “Good,” “Fair,” and “Poor” for 21 km (13 mi.), 109 km (68 mi.) , and 50 km (31 mi.) of stream habitat area, respectively (Spateholts 2013).

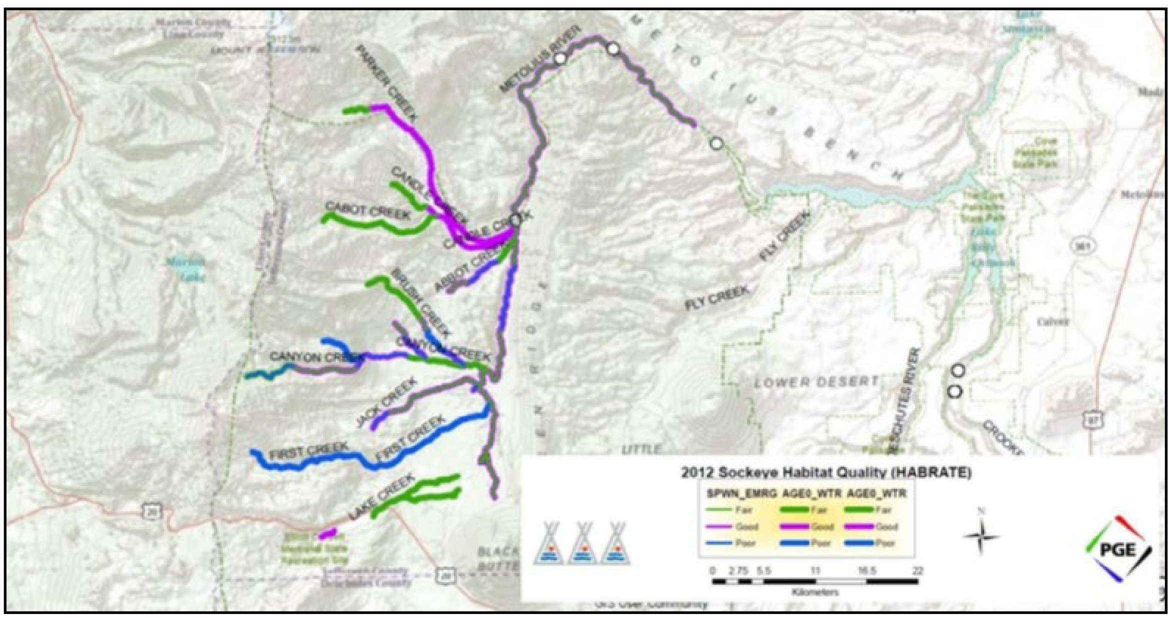

Figure 5-12. **HabRate 2012 sockeye life history ratings by stream reach within the Metolius River drainage. Open circles indicate endpoints of reaches surveyed in 2012.** Source: Spateholts 2013.

5.3.6 Legal Status and Management

5.3.6.1 Federal and State Status

Sockeye/kokanee salmon within the Mid-Columbia ESU are not listed on the state or federal sensitive species lists. If a sustainable anadromous sockeye population is reestablished into the Deschutes Basin under the Pelton Round Butte Project salmon reintroduction plan, it will likely function as an independent species management unit (Marx 2003) and could receive an independent ESU designation from NMFS.

5.3.6.2 Recovery Planning and Management

The purpose of the Sockeye Salmon Reintroduction Plan is to return an anadromous run of *O. nerka* to the Upper Deschutes River to restore self-sustaining and harvestable populations to historical sites within the upper Deschutes Basin (PGE and CTWSRO 2016). The large numbers of resident kokanee from Lake Billy Chinook have been utilized to begin developing an anadromous sockeye run. Juvenile kokanee that exhibit migratory behavior and enter downstream collection facilities are marked and released downstream of Pelton Dam into the Deschutes River. Marked adults returning to the Pelton Fish Trap, originating from the Upper Deschutes River subbasin, are then passed upstream to spawn naturally or moved to Round Butte Hatchery.

As of 2016, specific target numbers for sockeye escapement have not been set, as there are presently too many variables and unknown factors. Decisions by fish managers on the future direction of the reintroduction effort will be dependent on (1) criteria outlined in the Draft Sockeye Reintroduction Plan, and (2) an assessment of progress thus far.

Additional fish passage efforts are currently being considered as part of the reintroduction effort. ODFW and CTWSRO have agreed that an objective assessment will be made in 2018 regarding the potential construction of passage facilities at Lake Simtustus, to be fully operational by 2020 (ODFW and CTWSRO 2016).

5.3.7 Critical Habitat

The Middle Columbia sockeye salmon ESU is not listed under the ESA and therefore no critical habitat has been designated.

5.4 Oregon Spotted Frog

The Oregon spotted frog is federally listed as a threatened species. The State of Oregon lists the frog as sensitive and places it on the sensitive-critical list. USFWS has designated critical habitat for the species, of which 22,690 acres occur on the covered lands (see Chapter 8, Section 8.5.6.1, *Designated Critical Habitat*). There are 34 known occurrences of Oregon spotted frog on the covered lands, including wetlands bordering Crane Prairie and Wickiup reservoirs on the Upper Deschutes River, oxbows wetlands along Crescent Creek and the Little Deschutes River, and sites along the Deschutes River downstream to Bend (USFWS 2019b). Additional sites could be present on unsurveyed portions of the covered lands.

5.4.1 Life History

The Oregon spotted frog is a medium-sized, highly aquatic ranid frog with upturned eyes and black, irregularly shaped spots on the head, back, sides, and legs (Leonard et al. 1993). Adults are brown to reddish brown, with reddish abdomens and inner legs. Juveniles typically have brown or olive green backs, less red on their abdomens and legs, and smaller spots (Hayes 1994; McAllister and Leonard 1997). Adult males are 1.8 to 3.0 inches from snout to vent, and adult females are 2.4 to 3.9 inches; both sexes have extensive webbing between the toes of their hind feet associated with their highly aquatic life history (Cushman and Pearl 2007).

Oregon spotted frog males begin breeding at 1 to 2 years of age, and females at 2 to 3 years, depending upon elevation and latitude. They are known to live more than 7 years, but specific data on lifespan are limited (Licht 1975). They often breed communally, and the same sites tend to be used year-after-year. Breeding sites are typically in perennial, open-water wetlands bordered by seasonally-flooded, low-growing emergent vegetation of low to moderate density (McAllister and Leonard 1997; Bull 2005). Shallow, stable water levels are important for this species during the breeding period from oviposition to metamorphosis (Cushman and Pearl 2007). The preferred exposed shallow breeding sites provide for warm waters so that egg development proceeds maximally during the day. However, the trade-off is that this puts the egg masses at risk during potential freezing temperatures at night and it makes them vulnerable to fluctuations in water levels (Licht 1971). Larval development (hatching to metamorphosis) is variable depending on water temperature, but generally occurs in about 3 to 5 months.

Juveniles and adults overwinter in springs, beaver dams, and slow-moving stream channels associated with breeding habitat, and have been observed to be active beneath surface ice (Leonard et al. 1997; Hallock and Pearson 2001; Hayes et al. 2001). Recent studies in the upper Deschutes Basin indicate adults may also overwinter in upland areas near summer habitats (Pearl et al. 2018). Watson et al. (2003) summarized the conditions required for completion of the Oregon spotted frog's life cycle as shallow water areas for egg and tadpole survival, perennial deep and moderately-vegetated pools for adult and juvenile survival in the dry season, and perennial water for protecting all age classes during cold weather.

Oregon spotted frog larvae (tadpoles) are thought to be generalist grazers that feed on algae, plant matter and bacteria. After metamorphosis, they are carnivorous and feed on a wide array of invertebrate prey, but they have also been documented to prey on juvenile western toads (*Anaxyrus boreas*). Frogs typically feed among aquatic vegetation while almost completely submerged (Cushman and Pearl 2007).

Survival rates are believed to be lowest immediately post hatching, with increasing survival in subsequent life stages. Predation by a variety of native vertebrate and invertebrate predators and non-native bullfrogs and game fish is estimated to have the greatest impact on larval and post-metamorphic abundance (Licht 1974; McAllister and Leonard 1997). Adult Oregon spotted frogs typically avoid predators by hopping into the water and swimming to the bottom to take refuge in vegetation or soft substrates (Licht 1986; McAllister and Leonard 1997).

5.4.1.1 Movement and Home Range

Most available information on the movement and home range size of Oregon spotted frogs is based on radio-telemetry of frogs within their suite of required habitats (breeding, foraging and overwintering). Studies at the Dempsey Creek site in Washington show that movements averaged 16 to 23 feet per day and the average home range was 5.4 acres (Watson et al. 2003). Another radio-telemetry study at Trout Lake in Washington reported similar results, with average daily movements of 19.6 feet (Hallock and Pearson 2001). At Dempsey Creek, home range size during the wet season (September through January) was about double that during the breeding season (February through May). Dry season home ranges were the smallest, and consisted of deeper, permanent pools (Watson et al. 2003). Although overwintering sites used by adults are typically located close to breeding sites, radio-telemetry studies have shown that adults will travel substantial distances (greater than 1 mile) between breeding and overwintering sites (Cushman and Pearl 2007).

Relatively little is known of potential longer movements of this species. The longest reported distances traveled have been annual downstream movements of 1.5 mile of three adults at Dempsey Creek (McAllister and Walker 2003) and two juvenile frogs that traveled over 4,000 feet at Jack Creek (M. Hayes, pers. comm., as reported in Cushman and Pearl 2007). Movements at higher elevation sites in Oregon (which represent the majority of extant Oregon spotted frog populations) are also relatively unknown. At the Sunriver, Oregon site, frogs routinely move 1,640 to 4,265 feet between oviposition and overwintering sites (Bowerman pers. comm. 2016). Pearl et al. (2018) documented fall/early winter movement distances of nearly 400 meters (1,312 feet) for frogs in Deschutes River wetlands.

Although all studies show that Oregon spotted frogs depend on aquatic habitats, the degree to which they rely on aquatic travel pathways is not completely understood. Studies in Washington have shown the importance of both aquatic and semi-aquatic movement routes (Cushman and Pearl 2007). However, few data have been acquired on habitat use during movements at Oregon sites, most of which are at higher elevation than Washington sites (Cushman and Pearl 2007) and are located in different ecoregions. Pearl et al. (2018) tracked the fall/early winter movement of 35 frogs at three Deschutes River wetlands. Three frogs were observed to use the river: one moved out of the river into willow thicket with beaver burrow, and two of the frogs remained in the river’s undercut banks.

5.4.1.2 Reproductive Biology

The timing of egg-laying varies with latitude and elevation. At lower elevations, Oregon spotted frog breeding begins in February or March (McAllister and Leonard 1997). At high elevations, breeding begins soon after breeding sites thaw, and may occur as late as late May or early June in years with high snowpack (C. Pearl, unpubl. data, as cited in Cushman and Pearl 2007). The specific criteria for initiation of breeding is no completely understood, but a combination of day length and water temperatures between 43 and 50 °F are likely involved in triggering breeding (Cushman and Pearl 2007). Surveys in 2015 and 2016 at sites on Crescent Creek in the Little Deschutes River subbasin have shown oviposition between about March 30 and April 12. Breeding at Sunriver and Bend typically begins slightly earlier (Pearl et al. 2010).

Females tend to breed communally, depositing eggs on or adjacent to other spotted frog egg masses. Large communal masses are common in larger populations and the same oviposition sites are often used year-after-year (Cushman and Pearl 2007). Oviposition sites may contain a few to over 100 egg masses (Cushman and Pearl 2007). Egg masses are typically not attached to vegetation, but often are deposited on mats of the previous year's emergent vegetation (Pearl and Hayes 2004); often the upper half of the egg mass is exposed to air (McAllister and Leonard 1997). The female frogs do not remain at the egg-laying site, but the males may be found at the breeding site for days to weeks after egg-laying (McAllister and Leonard 1997).

Hatching occurs typically 18 to 30 days after egg-laying, depending on water temperatures; the shortest record is 14 days (McAllister and Leonard 1997). An average daytime temperature of 68°F is thought to produce the near maximum rate of development (McAllister and Leonard 1997). Licht (1971) noted the thermal tolerance of embryos ranged from 43 to 82 °F at a low elevation site in British Columbia, Canada. However, at higher elevations at Sunriver, Oregon, Bowerman and Pearl (2010) showed high survival of embryos with nighttime water temperatures down to 36°F in the wild and 10 days of 34°F in the laboratory. Surveys of sites on Crescent Creek showed hatching occurred in about 3 to 3.5 weeks in 2015 and 2016, with most hatching by late April to early May.

The duration of the larval life stage (hatchling to juvenile frog) in Oregon spotted frogs is believed to be between 3 and 5 months (Licht 1974, J. Bowerman pers. comm., as cited in Cushman and Pearl 2007). In Oregon, larval frogs are not known to overwinter (Cushman and Pearl 2007).

5.4.2 Habitat Requirements

Oregon spotted frogs breed in pools or backwater shallows, many of which are seasonally inundated. These pools have the following characteristics:

- Depth of 2 to 12 inches (Pearl and Hayes 2004); average 6.6 inches (Watson et al. 2003).
- Low or no flow, but may be located near flowing water and may be connected to larger bodies of water during seasonally high water or at flood stage (McAllister and Leonard 1997).

Native emergent vegetation, with the strongest selection for sedges (Watson et al. 2003), but also including grasses and rushes, as well as filamentous algae and aquatic submergent plants.

Egg masses are typically deposited above the previous year's matted vegetation, rarely at sites with a rock or bare substrate, and in locations that have low overhead canopy cover and high solar insolation (Pearl and Hayes 2004).

Tadpoles prefer somewhat deeper water of perennial pools or creeks with the following characteristics:

- Close to and hydrologically connected by surface water to breeding sites (Germaine and Cosentino 2004).

- Moderately vegetated with sedges, rushes, and other emergent, floating, or submerged vegetation (Watson et al. 2003; Pearl and Hayes 2004).
- Often have a small component of palustrine shrub or forested habitat (Germaine and Cosentino 2004).

Adult and post-metamorphic stages are usually found among herbaceous wetland vegetation in pools, ponds and small floodplain wetlands associated with permanent bodies of water (Cushman and Pearl 2007). In a literature review of habitat associations, Pearl and Hayes (2004) concluded that Oregon spotted frog summer habitat is most likely influenced by demands associated with foraging and predator avoidance. Microhabitats with standing water close to vegetative cover and flocculent organic substrates appeared to be particularly important. Watson et al. (2003) reported that during the dry season at Dempsey Creek in Washington, Oregon spotted frogs moved to deeper, permanent pools, and in central Oregon at Dilman Pond, adults were observed basking and feeding in beds of floating and submerged vegetation (Pearl et al. 2005).

Oregon spotted frogs overwinter in springs, beaver dams, slow moving stream channels associated with breeding habitat and upland sites; and have been reported to be active beneath surface ice (Leonard et al. 1997, Hayes et al. 2001, Pearl et at. 2018). These sites may be located at some distance from the breeding sites.

Winter habitat includes ponds, pools, and channels in either still or moving waters with the following characteristics:

- Over 6 inches (15 cm) deep (Hallock and Pearson 2001; Hayes et al. 2001);
- Reasonably close (maximum distance about 1.5 miles) to breeding and summer season areas, connected by surface water of stream or river, or by wetland habitat.
- Comprised of emergent wetland, scrub-shrub wetland, aquatic bed, and unconsolidated bottom habitats (Watson et al. 2003).
- Not scoured by winter storm flows in the average year (Germaine and Cosentino 2004).
- In-channel flow or springs present, if located in an area where ice forms for more than 1-2 weeks (Germaine and Cosentino 2004)

A recent study by Pearl et al. (2018) documented Oregon spotted frogs overwintering in river banks, semi-terrestrial beaver channels, beaver lodges, and lava flows, including sites on the Deschutes River. Preliminary results of a fall movement and overwintering study at Crane Prairie Reservoir (USGS unpublished, as cited in USFWS 2019b) show that Oregon spotted frogs did not move far from regularly used spring oviposition sites; both the reservoir and its tributaries are used for overwintering.

5.4.3 Range and Distribution in the Deschutes Basin

5.4.3.1 Historical Range and Distribution

The historical range of the Oregon spotted frog extended from southwestern British Columbia to the Pit River drainage in northeastern California (Figure 5-13; USFWS 2014b). Historical populations were documented at a total of 61 locations in 48 watersheds (3 in British Columbia, 13 in Washington, 29 in Oregon, and 3 in California) (USFWS 2014b). By the late 1990s, only 13 of the 61 previously known locations had confirmed populations of spotted frogs and none were present in California (Hayes 1997; McAllister et al. 1993; McAllister and Leonard 1997).

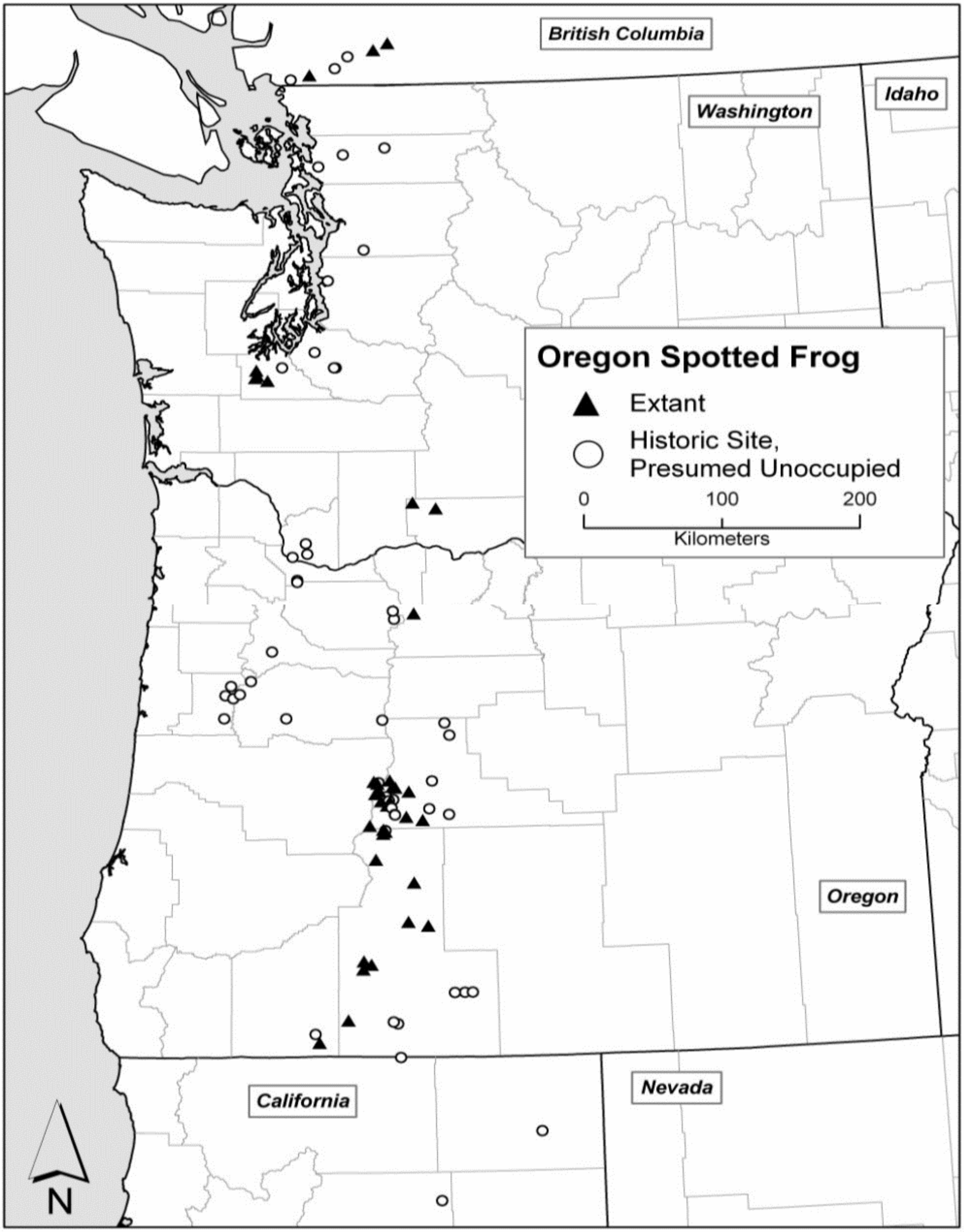

Figure 5-13. Historical and current distribution of the Oregon spotted frog. Sources: McAllister et al. (1993), Hayes (1994, 1997), Haycock (2000), and C. Pearl, unpubl. data.

5.4.3.2 Current Range and Distribution

Currently, Oregon spotted frogs occur from southwestern British Columbia south through Washington to the Klamath Basin of southern Oregon (USFWS 2014b). The species is believed to be extirpated in California and substantially reduced in distribution elsewhere in its historical range. Lowland populations are present in British Columbia, the Puget Trough, and southwestern Washington, while Oregon populations remain only at high elevations (3,160-5,200 ft.), primarily east of the Cascade Mountains (USFWS 2014b; Pearl et al. 2010). Oregon, specifically the Deschutes Basin, remains a primary population center for the species.

Based on data recorded between 2000 and 2014, Oregon spotted frogs occur in a total of 15 subbasins. This total includes 1 subbasin in British Columbia (the lower Fraser River; 4 sites), 6 subbasins in Washington (13 populations/sites), and 8 subbasins in Oregon (about 52 populations/sites) (USFWS 2014b). The species has not been detected in California since 1918, although survey effort has been limited (USFWS 2014b).

About nine Oregon spotted frog populations/sites in Oregon are in the south-central part of the state in the Williamson River, Upper Klamath, and Upper Klamath Lake subbasins (USFWS 2014b, 2014c). Three sites are located just east of the Cascade crest in the McKenzie River subbasin (two sites) and the Middle Fork Willamette River subbasin (one site). A single site is located at Camas Prairie in the Lower Deschutes River subbasin.

Based on survey data through 2018, the number of known Oregon spotted frog sites in the upper Deschutes Basin has increased to 59 (USFWS 2019b). In the Upper Deschutes River subbasin, these frogs occur in the Charlton Creek, Browns Creek, Fall River, and North Unit Diversion Dam watersheds (USFWS 2019b). Known breeding locations are present in lakes, ponds, and riverine wetlands that are tributary to the Crane Prairie and Wickiup Reservoirs, and in wetlands bordering the reservoirs. Breeding locations in the Deschutes River between Wickiup Reservoir and Bend include Dead Slough, La Pine State Park, Sunriver, Slough Camp, East Slough Camp, the Old Mill pond/Les Schwab Amphitheater marsh, and possibly South Ryan Ranch.

In the Little Deschutes River subbasin, five watersheds are known to be occupied by the species: Upper, Middle, and Lower Little Deschutes River, Crescent Creek (including Big Marsh), and Long Prairie (USFWS 2019b).

5.4.4 Populations in the Deschutes Basin

Oregon spotted frogs are known to occur on 34 sites on covered lands in the Upper Deschutes and Little Deschutes river subbasins (Table 5-12). These sites occur at locations where they are potentially influenced by the covered activities, particularly the operation of Crane Prairie and Wickiup reservoirs on the Deschutes River and Crescent Lake Reservoir on Crescent Creek.

Surveys for Oregon spotted frogs have been fairly extensive on public lands in the Upper Deschutes and Little Deschutes river subbasins, but fewer surveys have been conducted on private lands (USFWS 2014b). Additional occupied sites could be present on unsurveyed portions of the covered lands, particularly on private lands along Crescent Creek and the Little Deschutes River.

Table 5-12. Documented occurrences of the Oregon spotted frog in the Upper Deschutes Basin.

Water Body	Site Name	Estimated Number of Breeding Females (USFWS 2019a and 2019b)[1]
A. Sites on Covered Lands in Upper Deschutes Subbasin		
Crane Prairie Reservoir	Crane Prairie (4 reservoir subareas)	915 (2019)
	Northeast Bay	100 (2013); 168 (2015); 18 (2016); 82 (2017); **178 (2018)**
	Northwest Bay	95 (2013); 118 (2015); 10 (2016); 292 (2017); **495 (2018)**
	Southeast Shore	2 (2012); 5 (2015); 6 (2016); 0 (2017); **13 (2018)**
	Osprey Point	**84 (2018)**
	Goldfish Pond (outside reservoir)	40 (2012); 10 (2015); 25 (2016); 13 (2017); 23 (2018); **49 (2019)**
Wickiup Reservoir	Deschutes River Arm Wetland of Wickiup Reservoir	7 (2014); **11+ (2015);** 5 (2016); 0 (2017); 5 (2018); **7 (2019)**
	Southeast Bay	**6 (2013)**
	Reservoir	Unknown
Deschutes River	Bull Bend (RM 211)	5 Pre-metamorphic frogs present (2013)
	Dead Slough (RM 208)	19 (2013); 17 (2015); 45 (2016); 64 (2017); 55 (2018); **89 (2019)**
	Benchleg Pond (RM 206.5)	**18 (2018);** 14 (2019)
	LaPine State Park Southwest Oxbow (RM 205.5)	2 (2013); 2 (2015); 2 (2016); 1 (2017); **7 (2018); 2 (2019)**
	Private (RM 202)	**1 (2016)**
	Island Loop (RM 195)	1 (2015); 8 (2017); 4 (2018); **15 (2019)**
	Sunriver (RM 188-191.5)	**1480 (2011);** 727 (2012); 880 (2013); 579 (2014); 644 (2015); 369 (2016); 355 (2017); 764 (2018); 680 (2019)
	Southwest Slough Camp (RM 180)	13 (2013); 8 (2014); 8 (2015); 18 (2016); **27 (2017);** 20 (2018); 12 (2019)
	East Slough Camp (RM 179-180)	10 (2014); 39 (2015); 67 (2016); **100 (2017**); 58 (2018); 93 (2019)
	S. Ryan Ranch (RM 179)	**1 (2013)**
	Old Mill Pond & LSA Marsh (RM 167.5-168)	**41 (2013);** 14 (2014); 5 (2015); 5 (2016); 2 (2017); 3 (2018); 14 (2019)

[1] Highest egg mass counts for each site are shown in bold text.

Water Body	Site Name	Estimated Number of Breeding Females (USFWS 2019a and 2019b)[1]
B. Sites on Covered Lands in Little Deschutes Subbasin		
Crescent Creek	Upstream of Highway 58	14 (2011); **24 (2012);** 15 (2013); 4 (2014); 17 (2015); 13 (2016); 23 (2017); 23 (2018) ; 12 (2019)
	Downstream of Highway 58	5 (2013); 9 (2014); 7 (2015); 6 (2016); 6 (2017); 7 (2018) ; **12 (2019)**
	Upper Oxbow	**35 (2012)**
	62 Road	**62 (2012)**
	BLM Oxbow	21 (2006); **42 (2013)**; 18 (2015); 9 (2016); 12 (2017); 23 (2018); 10 (2019)
Little Deschutes River	Middle Little Deschutes Complex 1	**8 (2012)**
	Middle Little Deschutes Complex 2	**15 (2012)**
	South Masten Road	**2 (2018); 2 (2019)**
	Leona Park	**88 (2012);** 38 (2017); 10 (2018)
	Oxbows north of LaPine High School	5 (2009); 3 (2016); **20 (2017);** 12 (2018)
	Rosland Park	**15 (2012);** 0 (2017); 3 (2018)
	Riverside Oxbow	10 (2012); **19 (2013);** 15 (2016); 10 (2017); 17 (2018); 3 (2019)
	Casey Tract	23 (2012); 33 (2013); 25 (2014); **43 (2015);** 21 (2016); 7 (2017); 19 (2018); 7 (2019)
	Thousand Trails	**10 (2012);** 1 (2016); 0 (2017)
	Crosswater	42 (2003); 25 (2004); 24 (2005); 86 (2006); 64 (2007); **219 (2008)**; 197 (2009); 149 (2010); 113 (2011); 101 (2012); 156 (2013); 47 (2014); 61 (2015); 65 (2016); 13 (2017); 38 (2018); 17 (2019)

[1] Highest egg mass counts for each site are shown in bold text.

Water Body	Site Name	Estimated Number of Breeding Females (USFWS 2019a and 2019b)
C. Sites Outside Covered Lands		
Isolated	Hosmer Lake	258 (2006 survey); 165 (2015); 110 (2016); 284 (2017);
Isolated	Lava Lake	99 (2006 survey); 33 (2009); 20 (2013); 64 (2015); 23 (2016); 67 (2017); 140 (2018)
Deschutes River	Little Lava Lake	254 (2006 survey); 182 (2015); 58 (2016); 49 (2017); 67 (2018)
	Upper Blue Pool	205 (2006); 139 (2009) ; 23 (2013); 133 (2015); 70 (2016); 43 (2017); 125 (2018)
	Lower Blue Pools	5 (2006); 67 (2013); 32 (2015); 12 (2016); 5 (2017); 2 (2018)
	Oxbow N of FS RD 40	6 (2013); 7 (2015); 5 (2016); 16 (2018)
	Cow Meadow Camp oxbows	21 (2013); 10 (2018)
Cultus Creek	Winopee Lake	330 (2006 survey)
Cultus Creek	Muskrat lake	44 (2002); 18 (2003); 31 (2006); 44 (2007); 4 (2016)
Deer Creek	Little Cultus Lake	36 (2006 survey); 35 (2013); 80 (2015); 27 (2017); 82 (2018)
	Deer Creek Meadow	8 (2019)
Unnamed trib to Odell Creek/Davis Lake	Odell Creek fen - Scotty Big Boy	14 (2010); 71 (2011); 68 (2012); 192 (2013); 54 (2015); 33 (2016); 52 (2018)
Deschutes River	Dilman Meadow	64 (2011); 63 (2012); 91 (2013); 82 (2014); 76 (2015); 35 (2016); 37 (2017); 37 (2018)
Big Marsh Creek	Big Marsh	2,662 (2012); 3,071 (2013); 1,092 (2014); 4,022 (2015); 1,686 (2017); 1,796 (2018)
Crescent Creek	Black Rock lava pond	151 (2013); 7 (2015); 19 (2016); 17 (2017); 6 (2018)
Little Deschutes River	LD Marsh S. Shore	3 (2013)
	Hemlock Creek Marsh	5 (2013)
	5830 Road dogleg	2 (2012); 2 (2013); 11 (2016); 40 (2018)
	Hwy 58 area sites (Upper oxbow, Mowich log pond)	10 (2003); 1 (2012); 7 (2013); 1 (2015); 3 (2018)
	5830 Rd dogleg 3	23 (2016); 17 (2017); 40 (2018); 50 (2019)
	Odell Pasture; 100 road mill pond and oxbows	167 (2006); 27 (2012); 26 (2013); 4 (2014); 4 (2015); 53 (2016); 1 (2017); 13 (2018); 7 (2019)

Water Body	Site Name	Estimated Number of Breeding Females (USFWS 2019a and 2019b)
	LDR 62 road oxbow, floodplain pool, gravel pit, beaver	164 (2012); 121 (2013); 3 (2016)
Long Prairie Creek	Long Prairie Beaver pond marsh (La Pine HS)	1 (2006); 204 (2013); 157 (2017); 36 (2018)
	Long Prairie Hwy 97 City Hall	4 (2017)
	Long Prairie Pond	133 (2013)
	Private site (RM 6.5)	18 (2011); 2 (2012)
	Long Prairie upper BLM	20 (2001)

Oregon spotted frogs are not known or expected to occur along the Deschutes River downstream of Bend. Historical sites on the Deschutes River between Bend and Lake Billy Chinook (Cline Falls State Park and Lower Bridge) were not occupied during a 1997 survey (Hayes 1997). A single historical site at Tygh Valley in the lower Deschutes Basin also was not occupied during the 1997 survey. Bowerman (pers. comm. 2011) has not observed Oregon spotted frogs at any locations in the Lower Deschutes River below Bend. Surveys conducted in 2013 between Bend and Tumalo State Park did not detect adults or egg masses (Biota Pacific and Smayda Environmental 2013).

Oregon spotted frogs are known to occur on 25 additional sites that are near, but not on, the covered lands and likely would not be affected by covered activities (Table 5-12). These three sites are located in relatively close proximity to covered lands, and are described below:

- Big Marsh is located at the headwaters of the Little Deschutes River and supported an estimated 4,022 breeding adults in 2015 (Table 5-12); this is the largest known population of Oregon spotted frogs in the subbasin. Big Marsh is located outside the covered lands; however, Oregon spotted frogs use of the creek may extend downstream to the confluence with Crescent Creek, a short distance upstream of Highway 58.
- The Long Prairie complex includes several documented breeding sites of Oregon spotted frog along the lowermost approximately 6.5 miles of Long Prairie Creek, a tributary to the Little Deschutes River. Long Prairie Creek is located outside the covered lands, but the portion occupied by spotted frogs could extend downstream to the confluence with the Little Deschutes River, where it could be influenced by river flow. The beaver pond marsh site supported 36 Oregon spotted frog egg masses in 2018; it is located about 1,275 feet upstream of the mouth of the creek and is unlikely to be affected by flows in the Little Deschutes River. The lowermost reach of the creek, about 600 feet, is located on private lands not accessible for survey; therefore, use of the confluence area by Oregon spotted frogs is unknown.
- The Dilman Meadow site is located on a tributary to the Deschutes River downstream of Wickiup Dam. This is an experimental population, translocated from the base of Wickiup Dam in 2001. The numbers of adult frogs increased five-fold in the first 5 years after translocation (Chelgren et al. 2007). The number of breeding females was estimated at 63 in 2012 and 37 in 2018 (USFWS 2019a, 2019b).

5.4.5 Habitat in the Deschutes Basin

Oregon spotted frog habitats on the covered lands are a combination of seasonal and perennial wetlands associated with lakes (Crane Prairie and Wickiup reservoirs) and flowing waters (Deschutes River, Little Deschutes River and Crescent Creek). Habitats within Crane Prairie and Wickiup reservoirs are predominantly shoreline wetlands that are directly connected to the reservoirs and have experienced annual water level fluctuations of 3 feet or more due to seasonal storage and release of irrigation water. A few wetlands adjacent to the reservoirs lack direct surface connections, but are connected through sub-surface flow and also experience fluctuations as the reservoirs rise and fall. Most of the reservoir wetlands are dominated by native sedges (*Carex* spp.), rushes (*Juncus* spp.), and willows (*Salix* spp.), although reed canarygrass (*Phalaris arundinacea*) is present in some locations. Where the reservoir bottoms are gently sloping (such as much of the northern and western shorelines of Crane Prairie) the area of vegetated wetland is as much as 1,000 feet wide. The steeper shorelines of the reservoirs support very little wetland vegetation.

Along the Deschutes River, Oregon spotted frog habitats can be found in riverine and oxbow wetlands between Wickiup Dam (RM 223) and the City of Bend (approximate RM 168). These wetlands have varying degrees of surface connection to the river. Most are directly connected during summer high-flow conditions and partially or completely isolated, if not completely dewatered, during the winter. Others are permanently isolated from the river and supported by flows from adjacent uplands that keep them inundated year round. Most of the major identified wetland complexes along this reach of the Deschutes River are known to be occupied by Oregon spotted frogs (Table 5-13). Between these wetlands, the river channel tends to have steep banks, high water velocities (during the summer), and limited vegetation.

Oregon spotted frog habitats along Crescent Creek and the Little Deschutes River also consist of oxbow and riverine wetlands with varying levels of connection to the flowing water. Overall, the density of wetlands (acres of wetland per mile of stream) is higher along Crescent Creek and the Little Deschutes River than along the Deschutes River.

A summary of the acres of Oregon spotted frog habitat affected by the covered activities in the Upper Deschutes and Crescent Creek/Little Deschutes river basins is presented in Table 5-13. The table is based on an analysis of National Wetland Inventory (NWI) and other data provided by USFWS (2017b). USFWS notes these acres are slightly different than acreages presented for critical habitat on the covered lands, as some of the affected wetland areas were excluded in the final critical habitat rule (USFWS 2017b).

The wetland habitat type most likely to be utilized by Oregon spotted frogs for breeding and rearing is freshwater emergent. Other vegetated wetland types (lacustrine and palustrine aquatic bed, palustrine shrub, and forested) may also be used by the species, but these are not as often selected for breeding sites. The USFWS analysis provided acreage values for individual vegetated wetland types at Crane Prairie, but grouped all vegetated wetland types at other sites. Unvegetated, deeper water aquatic habitats of lakes and rivers are also important when associated with vegetated wetlands, as they allow Oregon spotted frogs to move between seasonal habitats, and provide connectivity between occupied sites.

Crane Prairie Reservoir supports 583 acres of emergent wetland, mostly in large contiguous patches along the gently sloping northern shoreline (Table 5-13). These wetlands are known to support extensive breeding by Oregon spotted frogs, including a total of 915 egg masses in 2019 (Table 5-12). Additional egg masses were documented at smaller sites around the reservoir. This site is thought to be extremely important to conservation of the species, due to the consistently high numbers of breeding frogs observed.

An estimated 24 acres of emergent and 15 acres of shrub wetlands exist in the 0.9-mile reach of the Deschutes River between Crane Prairie Dam and the upper extent of Wickiup Reservoir, mostly in small patches of 0.5 acre or less. None of these wetlands is known to be inhabited by Oregon spotted frogs (there are limited areas of calm water), but some sites could support small numbers of undetected frogs. The reach lies between Crane Prairie Reservoir, where all life stages of Oregon spotted frogs are present, and a wetland complex at the upper limit of Wickiup Reservoir where egg masses and adults have been observed in some years (see Deschutes River Arm wetland, below).

Oregon spotted frogs are present upstream and downstream of Wickiup Reservoir, but the numbers of frogs within the reservoir are very low (Table 5-12). GIS mapping indicates that

2,304 acres of emergent wetlands area present; however, widely fluctuating water depths and steeply sloping substrate preclude the development of stable wetland habitats and prevent Oregon spotted frogs from persisting in the reservoir. Partial surveys of Wickiup Reservoir since 2013 have identified attempted breeding (egg masses) at two sites. One site is in a bay in the southeastern portion of the main reservoir, where six egg masses were observed in 2013 (USFWS 2019a). The second site is in the extreme upstream end of the reservoir, downstream of where the Deschutes River enters (Deschutes River arm wetland). This site was monitored during the breeding seasons of 2014 through 2019 (USFWS 2019a and b). Egg masses were detected in all years except 2017; a maximum of 15 egg masses were observed in 2015. USFWS (2019a) notes a lack of consistent survey data in Wickiup Reservoir and suggests that additional undetected breeding may occur.

The 59 miles of the Deschutes River between Wickiup Dam and Colorado Street in Bend support an estimated 1,227 acres of emergent/pond/shrub and forested wetlands. These wetlands occur primarily in oxbows or benches adjacent to the river. Oregon spotted frogs breed at 12 documented locations along the river, with the largest breeding concentration at Sunriver (1,480 egg masses in 2011).

Oxbow and riverine wetlands are particularly abundant along the Little Deschutes River between its mouth and the confluence with Crescent Creek; this 57-mile reach supports 3,322 acres of vegetated wetlands. Crescent Creek has another 1,882 acres of vegetated wetlands between the mouth of the creek and Crescent Lake Dam. Several sites are used consistently by Oregon spotted frogs along these reaches, with annual egg mass counts at most sites numbering between 10 and 20. The largest breeding concentration on these two reaches is located on the lower Little Deschutes River at Crosswater (219 egg masses in 2008).

Table 5-13. Summary of wetlands on DBHCP covered lands within the current range of the Oregon spotted frog.

Reach	Area (acres) by Wetland Type*						
	Emergent	Forest /Shrub	Pond	Lake	River	Unknown	Total
Deschutes River, Wickiup Dam to Colorado Ave.							
Wickiup Dam to Fall River	325			0	321	0	646
Fall River to Little Deschutes River	308			0	226	0	534
Little Deschutes River to Benham Falls	286			0	200	0	486
Benham Falls to Dillon Falls	198			0	61	0	259
Dillon Falls to Lava Island	95			0	67	0	162
Lava Island to Central Oregon Canal	7			0	49	0	56
Central Oregon Canal to Colorado Avenue	8			0	64	0	72
Subtotal	1,227			0	988	0	2,215
Deschutes River, Crane Prairie Reservoir to Wickiup Dam							
Crane Prairie Reservoir	583	0	0	4,238	0	161	4,982
Crane Prairie Dam to Wickiup Reservoir	24	15	0	0	11	0	50
Wickiup Reservoir	2,961		0	7,283	0	90	10,334
Subtotal	3,584		0	11,521	11	251	15,366
Little Deschutes River and Crescent Creek							
Little Deschutes River	3,322			0	118	0	3,440
Crescent Creek	1,882			0	48	0	1,930
Subtotal	5,204			0	166	0	5,370
Total All Covered Lands	**10,014**			**11,521**	**1,165**	**251**	**22,951**

* Source: Based on USFWS 2017b, Tables 47-50, corresponding text, and calculations in Biota Pacific 2019. Note that wetland acres were not reported by individual wetland classes for some sites.

5.4.6 Legal Status and Management

5.4.6.1 Federal and State Status

The Oregon spotted frog was federally listed as a threatened species throughout its range effective September 29, 2014 (USFWS 2014b). The species was designated sensitive by the State of Oregon in 1996 and remains on the sensitive-critical list (ODFW 2019). The Oregon spotted frog was listed as Endangered in Canada in 2003 (Environment Canada 2015).

The 2014 ESA listing concluded that under current conditions, Oregon spotted frogs will likely continue to decline toward extinction. Although the species is not currently in danger of extinction, conservation and recovery measures are deemed necessary to halt or reverse the species' decline.

5.4.6.2 Identified Threats to the Species

At the time of listing, USFWS (2014b) evaluated potential threats to Oregon spotted frogs by breeding location and occupied watersheds, and summarized threats by subbasin. USFWS determined that survival of the species is threatened by one or more of the following factors:

- Threat Factor A: The present or threatened destruction, modification, or curtailment of its habitat or range
- Threat Factor C: Disease or predation
- Threat Factor D: Inadequate existing regulatory mechanisms
- Threat Factor E: Other natural and human-caused factors affecting the species' existence

USFWS found no evidence that Oregon spotted frogs are being over-utilized for commercial, recreational, scientific, or educational purposes (Threat Factor B).

Threat Factor A

Habitat for all life stages of the Oregon spotted frog has been modified and destroyed through human activities that convert wetlands; hydrologic changes due to water diversions, road and residential development, beaver control, and drought; modification of water temperature and vegetation structure as a result of reed canarygrass infestation, plant succession, and restoration plantings; and increased sedimentation and water temperatures, reduced water quality, and vegetation changes caused by the timing, intensity, and duration of livestock grazing.

Threat Factor C

Predation by non-native species, including non-native game fish and bullfrogs, is believed to be a threat to the Oregon spotted frog throughout its range. Introduced fish species prey on tadpoles and are believed to negatively affect juvenile frogs at locations where both species use breeding, overwintering spring and channel habitats. Introduced fish that may prey on the frogs include brook trout in high mountain lakes and warm water game fish in sloughs and reservoirs. Non-native bullfrogs can affect all life stages of Oregon spotted frogs, preying on both juveniles and adults. Bullfrog larvae can also outcompete and displace Oregon spotted frogs larvae. Most subbasins currently occupied by Oregon spotted frogs also support multiple non-native predatory species.

Although several pathogens have been documented in Oregon spotted frogs, none are known to be causing population decline at this time. Disease remains a concern, specifically with regard to the Chytrid fungus *Batrachochytrium dendrobatidis* (Bd), the water mold *Saprolegnia*, and the parasite *Ribeiroia ondatrae*. These pathogens, when compounded by other stressors such as exposure to UV-B, poor quality habitat, or increased predation, may contribute to decline of populations.

Threat Factor D

Analysis of federal, state, and local laws and regulations indicates that existing regulatory mechanisms are insufficient to protect essential habitat for the species. Thus, the Oregon spotted frog remains at continued risk of habitat loss and degradation.

Threat Factor E

Other natural and human-caused factors that are believed to affect Oregon spotted frogs include site sizes, isolation of populations, water quality and contamination, and climate change. Oregon spotted frogs show very high fidelity to breeding locations, and currently many of the known breeding locations are very small and isolated from other breeding sites. This is thought to have contributed to low genetic diversity within and high genetic differentiation among the six groups of Oregon spotted frog that have been genetically analyzed. Poor water quality and contaminants may also affect Oregon spotted frog development and survival. These factors, in combination with other stressors, such as disease and predation and poor quality habitat, may contribute to lethal and sublethal effects to the frogs. Climate change may act to exacerbate the effects of these stressors.

Threats Specific to the Upper Deschutes and Little Deschutes Subbasins

Within the major threat categories, USFWS (2014c) identified several specific threats to Oregon spotted frogs within the Upper Deschutes and Little Deschutes river subbasins (Table 5-14). The analysis noted that all subbasins contain multiple threats to the species, providing a cumulative risk to the populations. Many of the threats are intermingled and may act synergistically. In addition, USFWS concludes that current regulatory mechanisms are not sufficient to protect Oregon spotted frog and its habitat. In fact, programs designed to benefit fish species have resulted in the unintentional reduction of habitat quality for Oregon spotted frogs in some locations.

5.4.6.3 Recovery Planning and Management

As of May 2019, formal recovery planning for the Oregon spotted frog has not been initiated at the state or federal level.

Table 5-14. Threats to the Oregon spotted frog operating in the Upper and Little Deschutes Subbasins

Subbasin	Threat Factor A - Habitat						Threat Factor C - Predation and Disease			Threat Factor E - Other Human-caused		
	Wetland loss	Reed canarygrass	Shrub encroachment	Hydrological changes (water management)	Development	Grazing	Introduced warmwater fish	Introduced coldwater fish	Bullfrogs	Breeding locations disconnected	Cumulative effects of other threats	Climate change
Upper Deschutes	X	X	X	X			X	X	X	X	X	X
Little Deschutes	X	X	X	X	X	X		X	X	X	X	X

5.4.7 Critical Habitat

USFWS formally designated 65,038 acres of critical habitat for the Oregon spotted frog on May 11, 2016 (USFWS 2016). Of this total, 35,065 acres (54%) lie within the Upper Deschutes River and Little Deschutes River subbasins, where 22,690 acres coincide with the covered lands (Table 5-15; Figures 5-14, 5-15 and 5-16).

Critical habitat includes the specific areas occupied by the species at the time of listing that provides the physical or biological features essential to the conservation of the species and which may require special management considerations or protection. Critical habitat also may include specific areas outside the occupied geographical area, if those areas are determined essential for the conservation of the species.

Table 5-15. Federally-designated critical habitat for the Oregon spotted frog within the Upper Deschutes and Little Deschutes River Subbasins.

Critical Habitat Unit	Total Designated Critical Habitat (acres)[1]	Designated Critical Habitat on Covered Lands (acres)[2]		
		Vegetated Wetland	Lakes and Rivers	Total
8A. Upper Deschutes River, Below Wickiup Dam	2,001	1,049	912	**1,961**
8B. Upper Deschutes River, Above Wickiup Dam	22,031	3,841	11,525	**15,366**
9. Little Deschutes River	11,033	5,109	254	**5,363**
Total	**35,065**	**9,999**	**12,691**	**22,690**

Sources: [1]USFWS 2016, [2]Biota Pacific 2019.

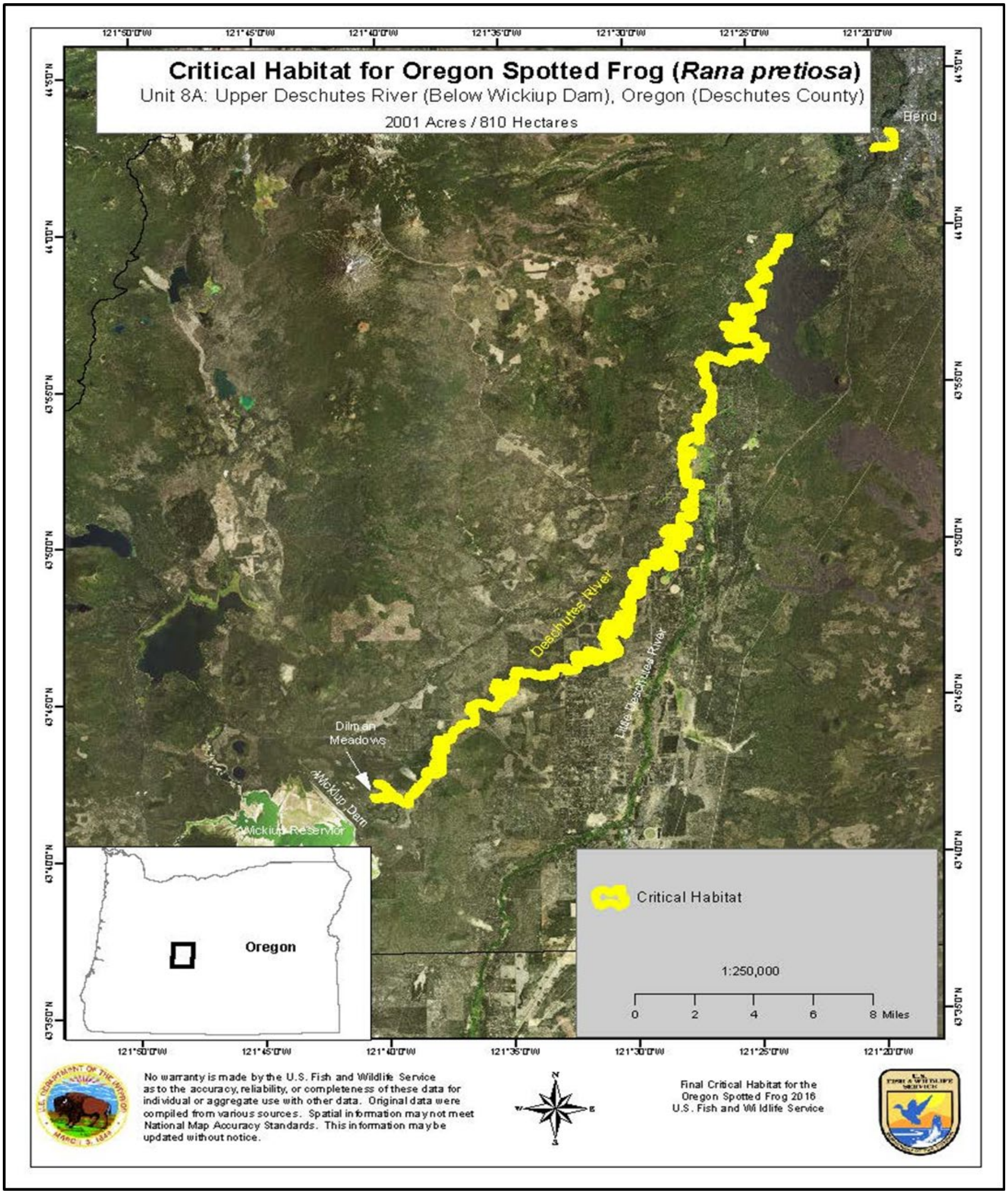

Figure 5-14. Oregon spotted frog Critical Habitat Unit 8A; Upper Deschutes River below Wickiup Dam. Source: USFWS 2017c.

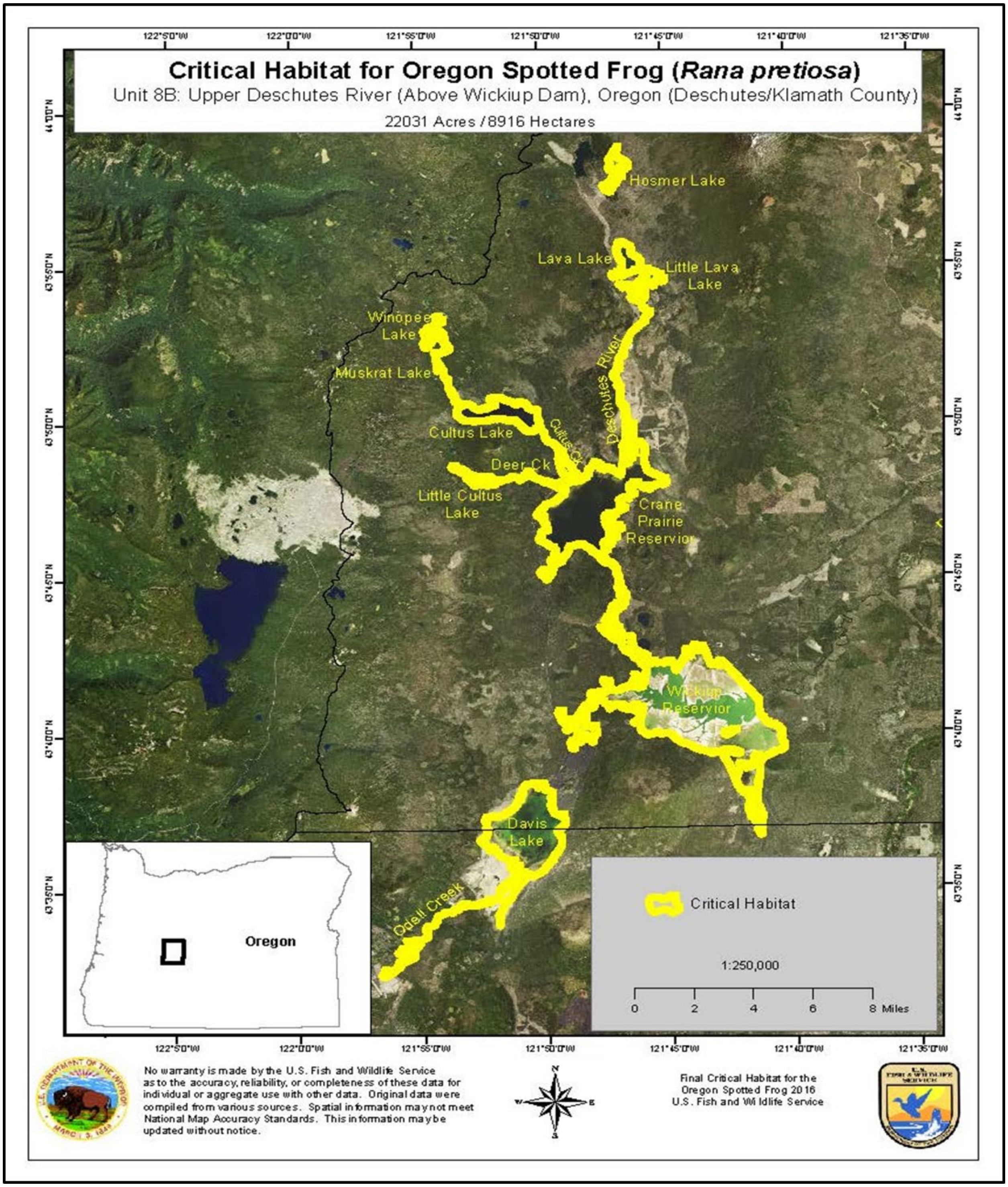

Figure 5-15. Oregon spotted frog Critical Habitat Unit 8B; Upper Deschutes River above Wickiup Dam.
Source: USFWS 2017c.

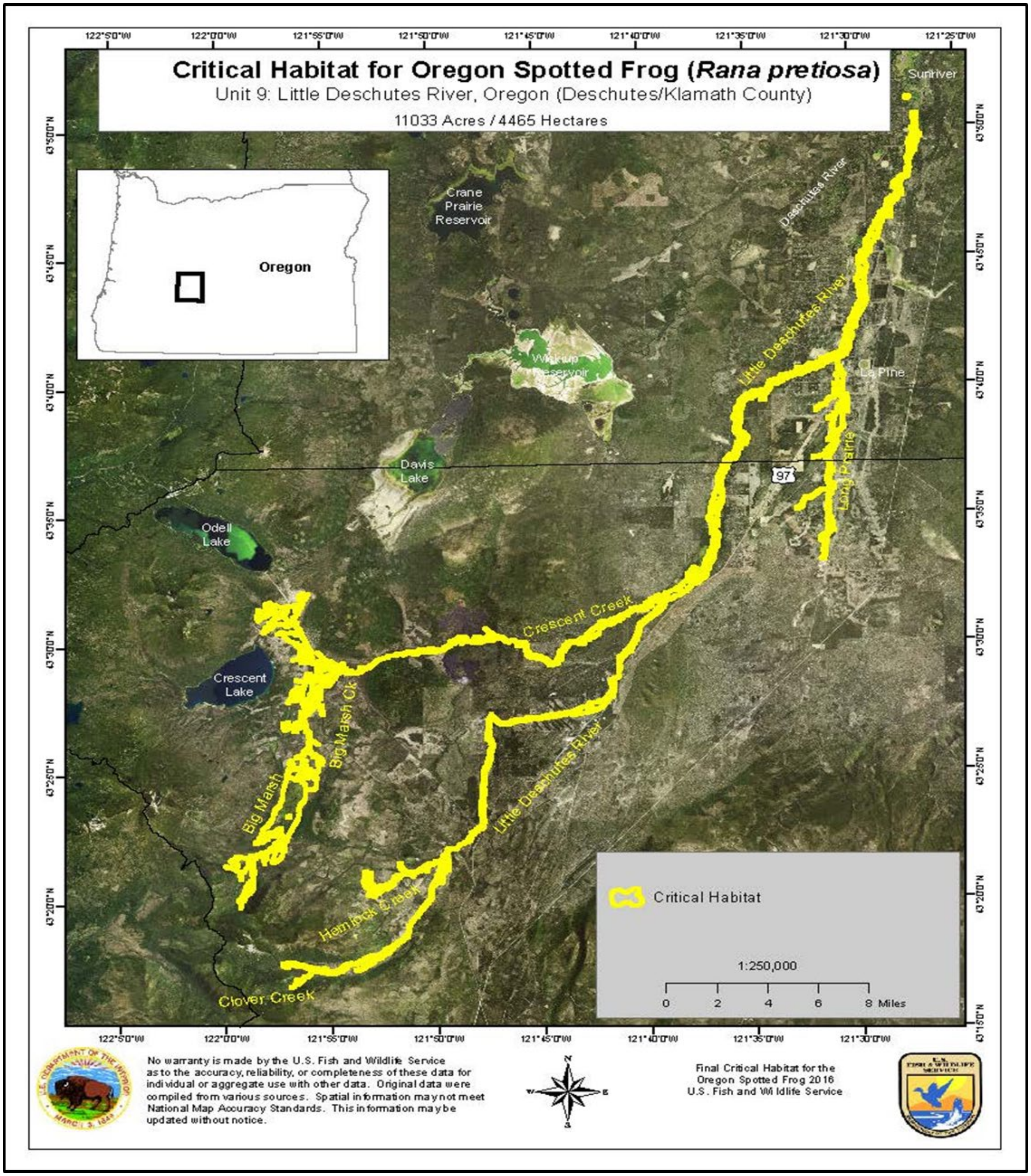

Figure 5-16. Oregon spotted frog Critical Habitat Unit 9; Little Deschutes River. Source: USFWS 2017c.

5.4.7.1 Primary Constituent Elements

The primary constituent elements (PCE) of critical habitat are those specific elements of the physical or biological features supporting the life history processes of the Oregon spotted frog that are essential to the conservation of the species. Three primary constituent elements were identified by USFWS (2016); each is defined below.

PCE 1 – Nonbreeding (N), Breeding (B), Rearing (R), and Overwintering (O) habitat

PCE 1 consists of ephemeral or permanent bodies of fresh water, including but not limited to natural or manmade ponds, springs, lakes, slow-moving streams, or pools within or oxbows adjacent to streams, canals, and ditches, that have one or more of the following characteristics:

- Inundated for a minimum of 4 months per year (B, R) (timing varies by elevation but may begin as early as February and last as long as September).
- Inundated from October through March (O).
- If ephemeral, areas are hydrologically connected by surface water flow to a permanent water body (e.g., pools, springs, ponds, lakes, streams, canals, or ditches) (B, R).
- Shallow-water areas (less than or equal to 12 inches (30 cm), or water of this depth over vegetation in deeper water (B, R).
- Total surface area with less than 50 percent vegetative cover (N).
- Gradual topographic gradient (less than 3 percent slope) from shallow water toward deeper, permanent water (B, R).
- Herbaceous wetland vegetation (i.e., emergent, submergent, and floating-leaved aquatic plants), or vegetation that can structurally mimic emergent wetland vegetation through manipulation (B, R).
- Shallow-water areas with high solar exposure or low (short) canopy cover (B, R).
- An absence or low density of non-native predators (B, R, N).

PCE 2 – Aquatic movement corridors

PCE 2 consists of ephemeral or permanent bodies of fresh water that allow Oregon spotted frogs to move from one seasonal habitat to another. These corridors have one or more of the following characteristics:

- Less than or equal to 3.1 miles linear distance from breeding areas.
- Impediment free (including, but not limited to, hard barriers such as dams, impassable culverts, lack of water, or biological barriers such as abundant predators, or lack of refugia from predators).

PCE 3 – Refugia habitat

This PCE consists of nonbreeding, breeding, rearing, or overwintering habitat or aquatic movement corridors with habitat characteristics (e.g., dense vegetation and/or an abundance of woody debris) that provide refugia from predators (e.g., non-native fish or bullfrogs).

5.4.7.2 Special Management Considerations or Protection

Certain areas occupied by Oregon spotted frogs may require special management considerations to protect the physical or biological features identified as essential for the conservation of this species (USFWS 2016). Threats to these essential features include, but are not limited to the following:

- Habitat modifications brought on by non-native plant invasions or native vegetation encroachment (trees and shrubs)
- Loss of habitat from conversion to other uses
- Hydrologic manipulation
- Removal of beavers and features created by beavers
- Livestock grazing
- Predation by invasive fish and bullfrogs

Management activities that could ameliorate the threats described above include, but are not limited to the following:

- Treatment or removal of exotic and encroaching vegetation (for example mowing, burning, grazing, herbicide treatment, shrub/tree removal)
- Modifications to fish stocking and beaver removal practices in specific water bodies.
- Non-native predator control
- Stabilization of extreme water level fluctuations
- Restoration of habitat features
- Implementation of appropriate livestock grazing practices

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FINAL

DESCHUTES BASIN
HABITAT CONSERVATION PLAN

Chapter 6 – Habitat Conservation

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6 – HABITAT CONSERVATION

6.1 Introduction

6.1.1 DBHCP Approach to Minimization and Mitigation

The DBHCP addresses the negative effects of the covered activities on covered species by reducing or eliminating those effects to the extent practicable, and by mitigating effects that cannot be eliminated altogether. In general, negative effects on listed species can result from direct harm or injury of individuals of the species, and through changes in habitat that interfere with the essential life activities of the species. The DBHCP is primarily a habitat-based HCP, which means that most effects of the covered activities on the covered species occur indirectly through changes in the habitats for those species. To a lesser extent, the DBHCP addresses the small number of potential direct impacts to covered species, such as entrainment of fish at irrigation diversions.

The covered activities affect covered species primarily through changes in the hydrology of occupied waters that result from the storage, release, diversion and return of irrigation water. Changes in hydrology are addressed in detail in the DBHCP, with the assumption that reducing or eliminating those changes will simultaneously reduce or eliminate the potential for associated harm or injury of covered species.

The effects of the covered activities on hydrology and associated habitats are determined by calculating differences between habitat quantity and/or quality with the covered activities and without the covered activities. For example, where the diversion of irrigation water reduces the quantity and/or quality of aquatic habitat, the effect of that activity would be the difference in habitat quantity/quality with and without the diversion. Similarly, the effect of irrigation storage and release on habitat is the difference between operation of a reservoir and the cessation of operation. Activities that are not covered by the DBHCP (such as irrigation diversions by parties other than the DBBC Districts and City) are held constant in the assessment of effects of the covered activities because it is assumed those non-DBHCP activities would continue with or without incidental take coverage for DBBC and City activities. Activities that permanently affected or altered habitat for covered species prior to implementation of the DBHCP are also held constant in the analysis of effects. Consequently, habitat conditions without the covered activities are not assumed to be natural conditions that existed prior to initiation of irrigation activities in the early 20th Century; rather, they are conditions that could exist over the term of the DBHCP without the continued influence of the covered activities.

The quantification of hydrologic effects of the covered activities was accomplished by comparing flows that actually occurred in recent years to flows that would have occurred during those same years in the absence of the covered activities. The period of analysis for this comparison was water years 1981 through 2018 (October 1980 through September 2018), or subsets of those years where data are not available for the entire period. In these analyses, the covered activities are referred to as *historical operations* to reflect that fact that they do not include the minimization and mitigation measures contained in the DBHCP. The hydrologic conditions produced by historical operations are referred to as *regulated conditions.* Flows that would have occurred over the analysis period without the covered activities are referred to as *unregulated conditions.* The unregulated condition is distinguished from the natural condition in that it only considers the absence of the covered activities. Ongoing water use and land use activities, as well as land development patterns in the surrounding basin that may affect streamflow, are part of both the historical and the unregulated conditions.

The one exception to this approach for evaluating the effects of covered activities concerns habitat conditions for covered species within the irrigation reservoirs. There are no reliable records of habitat conditions for covered species in these areas prior to reservoir construction; therefore, there is no way to meaningfully compare regulated conditions to unregulated conditions within the reservoirs.

While the hydrologic effects of the covered activities are described by comparing historical regulated conditions to unregulated conditions, the benefits of the DBHCP are described by comparing historical regulated conditions to DBHCP conditions. The key difference here is that DBHCP conditions include the effects of the minimization and mitigation measures, while historical regulated conditions do not. The comparison of historical regulated conditions to DBHCP conditions also used the analysis period of 1981 through 2018, except in instances where irrigation operations changed during the 38-year period due to early implementation of DBHCP conservation measures. Inclusion of these changes in the historical conditions can make it difficult to discern the effects of the DBHCP. In these cases, a subset of years within the historical record was used for analysis instead of the full 38 years. When such subsets of the data were used for comparison with DBHCP conditions listed in this chapter, the reasons for doing so are noted in the discussion.

The comparisons of regulated, unregulated and DBHCP conditions were accomplished largely through use of the RiverWare water resources model (Zagona et al. 2001). The RiverWare model characterizes reservoir volumes and stream flows based on precipitation, groundwater-surface water interactions, water rights and water management regimes (reservoir operations and diversions). RiverWare was adapted to the Deschutes Basin by Reclamation (2020a) specifically to evaluate the effects of potential changes in management (e.g., DBHCP conservation actions) on aquatic habitat conditions and availability of water for irrigation.

6.1.2 Organization of Chapter 6

This chapter is organized by geographic units within the covered lands. The DBHCP covers a large area and a complex set of activities conducted by a large number of parties. The effects of the covered activities vary considerably by location within the larger Deschutes Basin, and the appropriate methods for minimizing and mitigating those effects also vary. Consequently, this chapter is divided into sections by subbasin or stream reach. The individual section for each geographic unit begins with a statement of the biological goals and objectives for that unit, followed by the conservation measure(s) that will be implemented to meet those objectives, and the rationale for the measure(s). Within the rationale is a brief summary of historical conditions that provides context for the measure, followed by a description of the hydrologic effects of the measure on habitat in general. Detailed assessments of the effects of conservation measures on covered species and their habitats are provided in Chapter 8.

In Chapter 6 the conservation measures are numbered and presented in text boxes to avoid any confusion that may arise through inadvertent contradictions between the measures and the remaining information in this chapter. In the case of any such contradictions, the numbered conservation measures within the text boxes should be considered the authoritative text.

Throughout this and other chapters of the DBHCP, the term "Year … of DBHCP implementation," is used to describe when particular activities will occur and requirements will be met. In all instances, Year 1 of DBHCP implementation shall begin on January 1, 2021 and end on December 31, 2021.

6.2 Upper and Middle Deschutes River

6.2.1 Conservation Goals and Objectives for Crane Prairie Reservoir

6.2.1.1 Crane Prairie Goal No. 1

Provide wetland habitat in Crane Prairie Reservoir capable of sustaining Oregon spotted frog numbers at or above levels supported by historical reservoir operation.

6.2.1.2 Measurable Resource Objectives for Crane Prairie Goal No. 1

Crane Prairie Objective 1-A: Maintain or increase the surface area (acres) of Oregon spotted frog breeding/rearing/nonbreeding habitat in Crane Prairie Reservoir, where this habitat is defined as portions of the reservoir meeting all of the following criteria:

- Water depth of 6 to 12 inches from the onset of breeding through the completion of metamorphosis.
- Direct surface connection to the main body of the reservoir *or* a minimum depth of 9 inches from the onset of breeding through the onset of overwintering.
- Substrate cover of at least 50 percent vegetation dominated by herbaceous emergent, submergent or floating-leaved aquatic species.
- Less than 25 percent coverage of woody plants and tall-growing emergent wetland species such as cattails.

Crane Prairie Objective 1-B: Reduce the potential for stranding and desiccation of Oregon spotted frog eggs and larvae in Crane Prairie Reservoir by keeping reservoir water surface elevation within a 0.25-foot (3-inch) range during breeding, egg incubation and metamorphosis, and by limiting the rate of reservoir drawdown at the end of metamorphosis to a maximum of 0.10 foot (1.2 inches) per day.

Crane Prairie Objective 1-C: Provide Oregon spotted frog overwintering habitat in Crane Prairie Reservoir by maintaining water depths of at least 12 inches over substrate with emergent, submergent or floating-leaved aquatic vegetation from October 1 through March 31.

6.2.1.3 Rationale for Crane Prairie Goal No. 1

Oregon spotted frogs are present in Crane Prairie Reservoir during the spring and summer, and are presumed to be present in or near the reservoir during the fall and winter as well. Partial surveys of the reservoir in recent years have documented as many as 915 Oregon spotted frog egg masses, indicating a minimum population of 915 breeding adult females (see Section 5.4.4, *Populations in the Deschutes Basin*). Historically the reservoir was operated to store water from mid-October through mid-April and release water for irrigation from mid-April through mid-October. This storage and release of water resulted in annual fluctuations in reservoir water surface elevation (from the high at the beginning of the irrigation season to the low at the end of the irrigation season) of as much as 9 feet in some years.

Fluctuations in water surface elevation can be detrimental to Oregon spotted frogs in a number of ways. Adult females prefer to deposit eggs in shallow waters with vegetated substrates along the margin of the reservoir. As the water level in the reservoir is raised and lowered the location of the shallow margin changes with respect to substrate and shoreline vegetation, often in ways unfavorable to egg development and survival. Extremely low water levels at the onset of breeding in the spring can force female frogs to deposit eggs over bare soil substrate toward the center of the reservoir where they are vulnerable to predation and dispersal by wind. Extremely high water levels in the spring can inundate upland vegetation (dense shrubs and trees) along the shoreline and force females to deposit eggs where larval development is delayed by lack of direct solar radiation. Increasing water levels during egg incubation can set egg masses adrift and expose eggs and larvae to predation. Decreasing water levels during and after incubation can leave eggs and young tadpoles stranded out of water where they cannot survive. Rapidly decreasing water levels in mid- and late summer can cause similar stranding of tadpoles and juveniles. Extremely low water levels in the fall and winter can reduce options for overwintering habitat, and expose frogs to high levels of predation while migrating long distances to and from overwintering sites.

The goal of the DBHCP for Crane Prairie Reservoir is to maintain water surface elevations at levels suitable for all life stages of the Oregon spotted frog and reduce seasonal and year-to-year fluctuations in water surface elevation. Three measurable resource objectives have been identified for achieving Crane Prairie Goal No. 1. Crane Prairie Objective 1-A addresses Oregon spotted frog breeding/rearing/nonbreeding habitat by quantifying the physical conditions that will be maintained in the reservoir during the spring and summer. These are site-specific descriptions of habitat based on current scientific literature describing Oregon spotted frog habitat selection, and on the characteristics of Oregon spotted frog habitat previously described by USFWS (2014). (A detailed discussion of Oregon spotted frog habitat requirements is provided in Chapter 8, *Effects of the Proposed Incidental Take on the Covered Species*.) Without a quantifiable definition of habitat it would be difficult to monitor for progress toward achieving the goal of maintaining or increasing the amount of habitat in the reservoir. Crane Prairie Objective 1-B sets limits on the magnitude of reservoir fluctuation during Oregon spotted frog breeding, egg development and larval metamorphosis. These are the life stages most sensitive to changes in wetland water depth, and most vulnerable to harm if the reservoir is raised or lowered rapidly. Crane Prairie Objective 1-C establishes quantifiable criteria for Oregon spotted frog overwintering habitat. The combination of these three objectives will enable the Permittees and the Services to verify that Crane Prairie Goal No. 1 is being achieved and habitat for Oregon spotted frogs is being maintained in the reservoir.

6.2.1.4 Crane Prairie Goal No. 2

Reduce the effects of Crane Prairie Reservoir operation on aquatic and wetland habitats in the Deschutes River downstream of the reservoir (between Crane Prairie Dam and Wickiup Reservoir) to the extent possible without compromising management of the reservoir for Oregon spotted frog habitat.

6.2.1.5 Measurable Resource Objective for Crane Prairie Goal No. 2

Crane Prairie Objective 2-A: Whenever possible without compromising the management of Crane Prairie Reservoir for Oregon spotted frogs, maintain the flow in the Deschutes River below Crane Prairie Dam (OWRD Gage 14054000) at or above 75 cfs.

6.2.1.6 Rationale for Crane Prairie Goal No. 2:

To accomplish Crane Prairie Goal No. 1 it will be necessary to manage the reservoir for specific water levels (storage volumes) on a seasonal basis. This management will include filling the reservoir during the winter even when inflow is low and holding reservoir storage volume relatively constant during the spring and summer when inflow normally fluctuates. An unavoidable consequence of this management will be greater seasonal fluctuation in reservoir outflow (flow in the Deschutes River downstream of Crane Prairie Dam) than has occurred in the past. Outflows may be lower in the winter and they may fluctuate more on a daily or weekly basis during the spring and summer than they have historically. Oregon spotted frogs may use the Deschutes River between the reservoirs for dispersal, and although recent surveys have failed to detect them in this reach, small numbers could breed in the limited number of wetlands that are present in the future. In addition, the reach is utilized by spawning kokanee salmon and all life stages of resident trout. The presence of these species should be taken into account when developing and implementing the operating regime for Crane Prairie Reservoir. Oregon Department of Fish and Wildlife (ODFW) recommends minimum and maximum flows in this reach of the Deschutes River to protect habitat for salmonids (Table 6-1). These flow recommendations will serve as a guide for the management of Crane Prairie Reservoir to the extent they do not impair or reduce the effectiveness of conservation measures to improve and maintain habitat for Oregon spotted frogs within the reservoir.

Table 6-1. Recommended minimum and maximum flows in the Deschutes River between Crane Prairie Dam and Wickiup Reservoir.

Months	Minimum Flow	Maximum Flow
Dec - Aug	100 cfs	400 cfs
Sep - Nov	75 cfs	400 cfs

6.2.2 Conservation Measure for Crane Prairie Reservoir

One conservation measure has been developed for Crane Prairie Reservoir. It addresses both goals and all four measurable resource objectives for the reservoir.

Conservation Measure CP – 1: Crane Prairie Reservoir Operation *

Crane Prairie Reservoir will be operated according to provisions A through F below for the entire term of the DBHCP. Water surface elevations will be measured at Hydromet Station CRA (OWRD Gage 14053500) at Crane Prairie Dam. Corresponding storage volumes are provided for reference only, and will not be used for verification of compliance with this measure. Flows will be measured at Hydromet Station CRAO (OWRD Gage 14054000) downstream of Crane Prairie Dam.

A. From March 15 through July 15, the water surface elevation of Crane Prairie Reservoir will be maintained between 4,443.23 feet and 4,443.48 feet, which correspond to storage volumes of about 46,800 acre-feet and 48,000 acre-feet, respectively.

B. From July 16 through July 31, the water surface elevation of Crane Prairie Reservoir may be lowered at a rate of no more than 0.05 foot per day.

C. From August 1 through October 31, the water surface elevation of Crane Prairie Reservoir may be lowered at a rate of no more than 0.10 foot per day.

D. From July 16 through October 31, the water surface elevation of Crane Prairie Reservoir will be no lower than elevation 4,441.23 feet (storage volume of about 37,870 acre-feet) and no higher than 4,443.48 feet (storage volume of about 48,000 acre-feet).

E. From November 1 through March 14, the water surface elevation of Crane Prairie Reservoir will be increased from elevation 4,441.23 feet (storage volume of about 37,870 acre-feet) to at least 4,443.23 feet (storage volume of about 46,800 acre-feet), but no more than 4,443.48 feet (storage volume of about 48,000 acre-feet).

F. The minimum instream flow in the Deschutes River between Crane Prairie Dam and Wickiup Reservoir (CRAO) will be 75 cfs at all times unless total inflow to the reservoir is not sufficient to maintain this level of instream flow and meet the water surface elevations requirements in Items A through D. When total inflow is not sufficient to maintain a minimum instream flow of 75 cfs and meet the water surface elevation requirements in Items A through D, the instream flow at CRAO may be reduced to 30 cfs. If total inflow to the reservoir is not sufficient to meet the water surface elevation requirements in Items A through D and maintain an instream flow of 30 cfs, the instream flow will remain at 30 cfs and the water surface elevation requirements in Items A through D will be relaxed until such time as inflow increases.

G. For the term of the DBHCP, USFWS and COID will coordinate monthly on the implementation of this conservation measure.

H. After coordination with and concurrence of USFWS, COID may release up to 5,000 acre-feet of additional stored water from Crane Prairie Reservoir for Oregon spotted frog flow management downstream of Wickiup Dam. Such releases of stored water may occur up to two times during Years 1 through 7 of DBHCP implementation, and once every 5 years thereafter. The timing and rate of release shall be determined through coordination with USFWS to minimize impacts to Oregon spotted frogs. These releases of stored water may be timed to serve the dual purpose of contributing water to the Oregon spotted frog flow management account in Wickiup Reservoir, and controlling undesirable plant and animal species in Crane Prairie Reservoir. If a release conducted under this Item H results in the lowering of Crane Prairie Reservoir at a rate faster than allowed by Items B and C of this conservation measure, COID shall be exempt from those limits during the release. If such a release causes the water surface elevation of Crane Prairie Reservoir to drop below 4,441.23 feet (storage volume of about 37,870 acre-feet), COID shall not be required to comply with Items A, D and E of this conservation measure until such time as the water surface elevation again reaches 4,443.23 feet (storage volume of about 46,800 acre-feet). However, COID shall make a good faith effort after a release to reach a water surface elevation of 4,443.23 feet in the reservoir by the first March 15 following the release.

I. Reservoir water surface elevations and instream flows within the allowable ranges of deviation specified in Table CP-1 shall be considered in compliance with this conservation measure. However, values outside the required ranges specified in Table CP-1 shall be reported to USFWS as specified in DBHCP Section 7.2.1. Reservoir water surface elevations and instream flows outside the allowable ranges of deviation specified in Table CP-1 that are the result of release of additional stored water under Item H of this conservation measure shall not be considered out of compliance with this conservation measure.

** USFWS is not a water manager. All references here and elsewhere in this DBHCP regarding USFWS involvement in water management decisions are intended to define where USFWS technical assistance will be sought to remain in compliance with the Conservation Measures.*

Table CP-1. Required ranges and allowable ranges of deviation for Crane Prairie Reservoir water surface elevation at CRA and Deschutes River flow at CRAO.

Time Period	Metric	Required Range		Allowable Range of Deviation	
		Elevation	Approximate Storage Volume (acre-feet) [1]	Elevation	Approximate Storage Volume (acre-feet) [1]
Mar 15 – Jul 15	Water surface elevation (feet) at CRA	4,443.23 – 4,443.48	46,800 – 48,000	4,443.05 – 4,443.69	46,000 – 50,000
Jul 16 – Mar 14	Water surface elevation (feet) at CRA	4,441.23 – 4,443.48	37,870 – 48,000	4,441.03 – 4,443.69	37,000 – 49,000
Jul 16 – Jul 31	Decrease in water surface elevation (feet/day) at CRA	≤0.05	225	≤0.06	270
Aug 1 – Oct 31	Decrease in water surface elevation (feet/day) at CRA	≤0.10	450	≤0.11	495
Time Period	**Metric**	**Flow (cfs)**		**Flow (cfs)**	
Jan 1 – Dec 31	Deschutes River flow at CRAO (cfs) [2]	≥ 75; ≥ 30		≥ 70; ≥ 25	

Notes:

1 Approximate storage volumes are provided for reference purposes only. DBHCP compliance will be based on water surface elevation alone.

2 See Item F for detailed explanation of CRAO flow requirements.

6.2.3 Rationale for Conservation Measure CP-1

6.2.3.1 Overview

Conservation Measure CP-1 establishes minimum and maximum water surface elevations for Crane Prairie Reservoir that will serve the dual purpose of minimizing overall reservoir fluctuations and maintaining desirable water depths in existing emergent wetlands. The target maximum water surface elevation of the reservoir will be 4,443.48 feet during the spring and summer. The target minimum water surface elevation will be 4,441.23 feet during the fall and winter. The water surface elevation of the reservoir will fall outside this range only if extreme high or low streamflow situations exceed the operational capacity of the dam; events that are considered unlikely to occur. Maintaining the reservoir within this elevational range will provide consistent wetland conditions from year to year, and allow for a maximum seasonal difference in water surface elevation of only 2.25 feet.

The sedge-dominated emergent wetland that provides Oregon spotted frog habitat in Crane Prairie Reservoir lies primarily within the 4.5-foot elevation zone between 4,443.90 feet (normal full reservoir at 50,000 acre-feet) and 4,439.32 feet (approximate volume of 29,900 acre-feet). A reservoir elevation of at least 4,443.23 feet from March 15 through July 15 will inundate nearly all emergent sedge wetland throughout Oregon spotted frog breeding and summer rearing. A minimum water surface elevation of 4,441.23 feet from November 1 to March 15 will similarly inundate emergent wetlands to depths of nearly 2 feet for migrating and overwintering Oregon spotted frogs. Extremely high water surface elevations (above 4,443.90) that have been suggested as contributing to poor Oregon spotted frog reproductive success under historical reservoir operation will no longer occur. In a like manner, extremely low water surface elevations that have been suspected of limiting opportunities for overwintering in the reservoir and impairing seasonal migration will be nearly eliminated.

Fluctuations in water surface elevation during Oregon spotted frog breeding and summer rearing will be kept low by maintaining the reservoir within the 3-inch range between 4,443.23 feet and 4,443.48 feet from March 15 through July 15. A constant water surface elevation might be preferable for developing Oregon spotted frog eggs and larvae, but this 3-inch range is necessary due to the operational constraints of the reservoir. Surface inflow to the reservoir can change daily at any time of year, and the outlet structure of Crane Prairie Dam is not designed to maintain a constant water surface elevation as inflow changes. Based on operational experience, however, it is believed the dam can be operated to maintain surface elevations within a 3-inch range. This is well within the range of fluctuation experienced in unregulated wetlands occupied by Oregon spotted frogs, and is believed to be sufficiently small to support successful reproduction and rearing.

When annual drawdown of the reservoir begins in mid-July, the initial rate of drawdown will be 0.05 foot (0.6 inch) per day to maintain desirable water depths for late-developing tadpoles, which cannot leave the water. After July 31, when all but a very small percentage of tadpoles will have completed metamorphosis, the rate of drawdown will increase to 0.10 foot (1.2 inches) per day.

The exception to these operational constraints will be when the reservoir is lowered below elevation 4,441.23 feet to accomplish one or more desired improvements to Oregon spotted frog habitat. In coordination with USFWS, an additional 5,000 acre-feet of stored water may be removed from Crane Prairie Reservoir (allowing the water surface elevation to drop to 4,440.05

feet) to achieve the following: a) make additional water available for Oregon spotted frog habitat management in the Deschutes River downstream of Wickiup Dam (see Conservation Measure WR-1); b) facilitate the removal of non-native fish that prey upon Oregon spotted frogs in the reservoir; and/or c) facilitate the control of non-native vegetation within the upper elevations of the reservoir. With proper advance consideration of the timing and rate of this additional drawdown, it is believed long-term benefits to Oregon spotted frogs can be derived without any additional short-term impacts.

6.2.3.2 Effects of Historical Crane Prairie Reservoir Operation

Crane Prairie Reservoir was historically operated to capture and store water between mid-October and mid-April and release storage for irrigation use from mid-April through mid-October. Dates for transition from storage to release varied up to several weeks in either direction, depending on weather conditions and irrigation demands in a particular year. In dry summers, high demand for irrigation water resulted in the release of storage from as early as April 1 to as late as October 31. In wet summers, when a larger percentage of irrigation demand was met by natural flow, storage may have continued into May and begun again in early October. The net result of historical irrigation storage and release was seasonal fluctuations in storage volume, with annual peak volume occurring in April or May and low volume occurring in September or October (Figure 6-1).

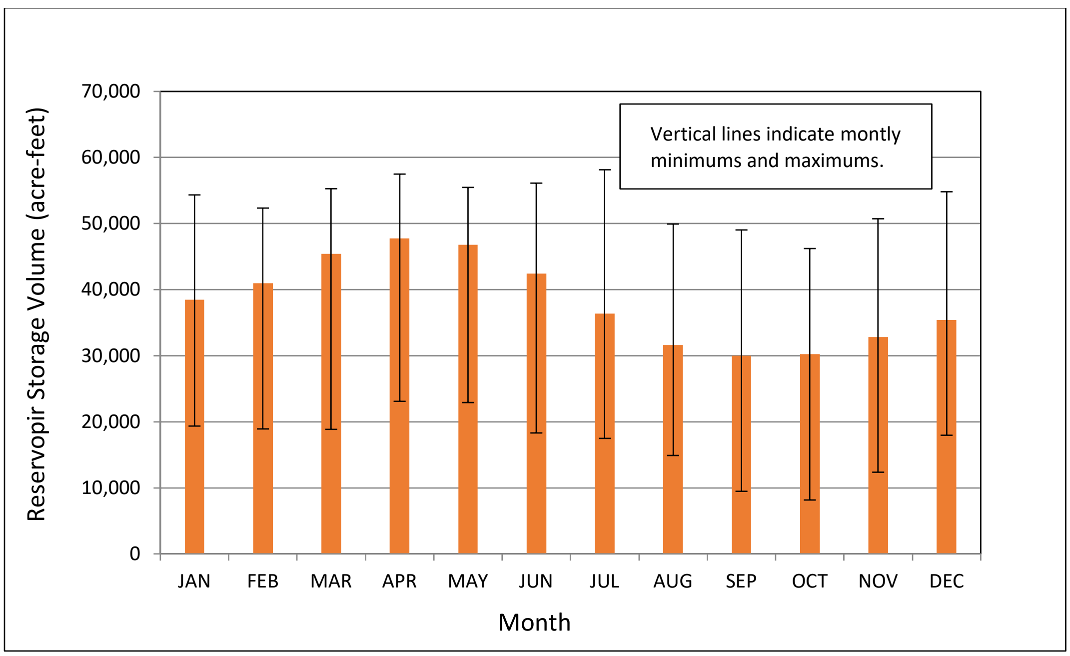

Figure 6-1. Monthly medians of daily storage volume in Crane Prairie Reservoir from 1984 through 2018. Source: Reclamation 2020b**.**

The storage capacity of Crane Prairie Reservoir is over 50,000 acre-feet, but demand for storage has historically been less than this and it has been variable over time. Detailed data on the use of Crane Prairie Reservoir storage are available from OWRD (2016) beginning at water year 2002. Demand for storage changed slightly in 2010 as AID, COID and LPID began taking conservation actions in anticipation of the DBHCP. The use of storage changed again in 2015 when COID began limiting the use of storage on an experimental basis to benefit Oregon spotted frogs. This experimental operation, with minor additional modifications, continued through 2019 under the conditions of a 2016 settlement agreement between AID, COID, LPID, the Center for Biological Diversity, WaterWatch of Oregon and others. Therefore, data on storage demand from 2002 through 2015 provide the most accurate representation of historical (pre-DBHCP) conditions. Available data for 2002 through 2015 indicate that total annual release of Crane Prairie storage for irrigation ranged from about 2,500 to 13,516 acre-feet and averaged 7,714 acre-feet (Figure 6-2). Historically, similar variations in annual irrigation demand combined with natural variations in reservoir inflow to result in substantial year-to-year differences in reservoir storage volume (Figure 6-3). From 1984 through 2018, annual peak volume ranged from as high as 58,146 acre-feet (2008) to as low as 27,739 acre-feet (1992). Annual fluctuation (the difference between high volume and low volume in a given year) during that same period ranged from to 10,923 acre-feet (1992) to 33,432 acre-feet (1994) and averaged 21,258 acre-feet.

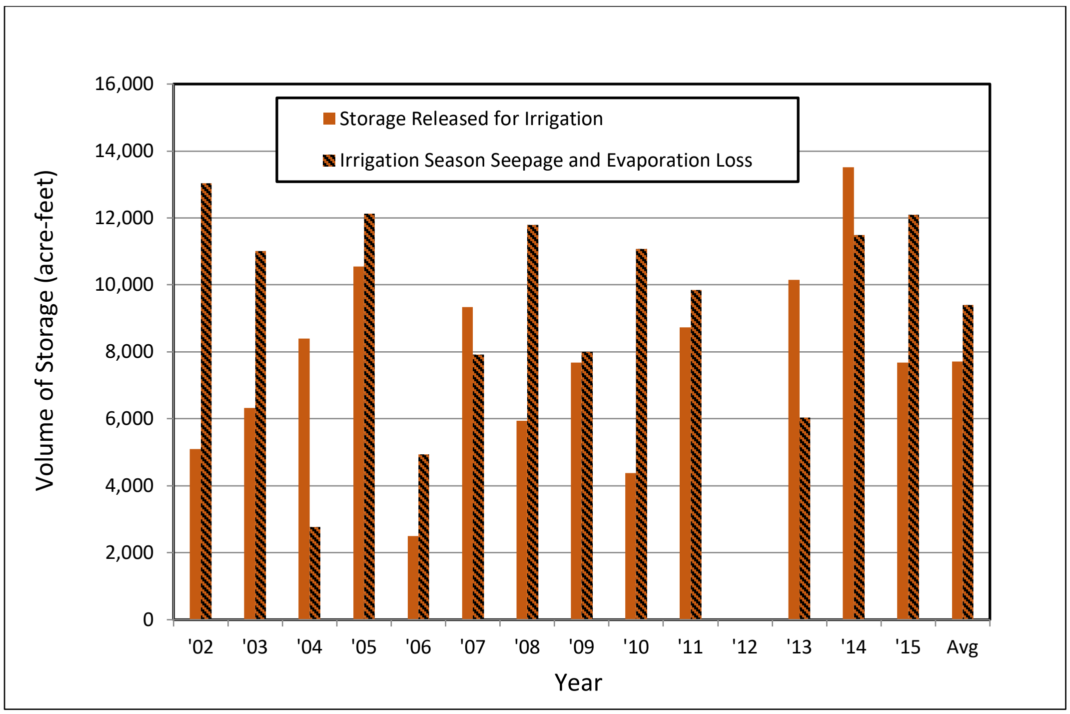

Figure 6-2. Use of Crane Prairie Reservoir irrigation storage from 2002 through 2015. Source: OWRD 2016.

Annual fluctuations in storage volume typically exceed annual irrigation use (compare Figure 6-2 and 6-3) because Crane Prairie Reservoir loses a considerable volume of water to seepage and evaporation. Seepage is by far the predominant cause for water loss, and alone it can reach nearly 7,000 acre-feet per month when the reservoir is full (Figure 6-4). From 2002 through 2015 losses of storage during the irrigation season alone ranged from 2,700 to 13,000 acre-feet and averaged almost 9,400 acre-feet (Figure 6-2). Seepage losses continue through the storage season and annual totals can be double the amounts shown in Figure 6-2. As a result, storage volume can continue to decline in October after irrigation releases have ended, even if inflow is constant. It is assumed that a significant portion of the seepage loss from Crane Prairie Reservoir moves through a shallow aquifer and reemerges as spring discharge to Wickiup Reservoir (OWRD 2019).

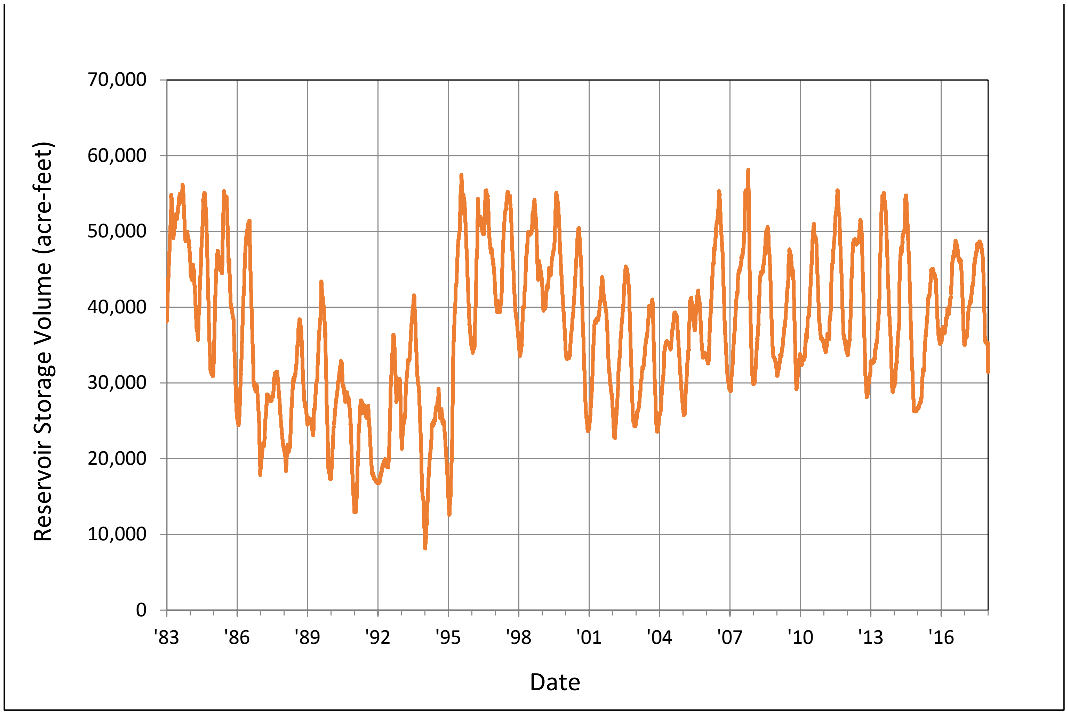

Figure 6-3. Crane Prairie Reservoir daily (midnight) volume from 1984 through 2018. Source: Reclamation 2020b.

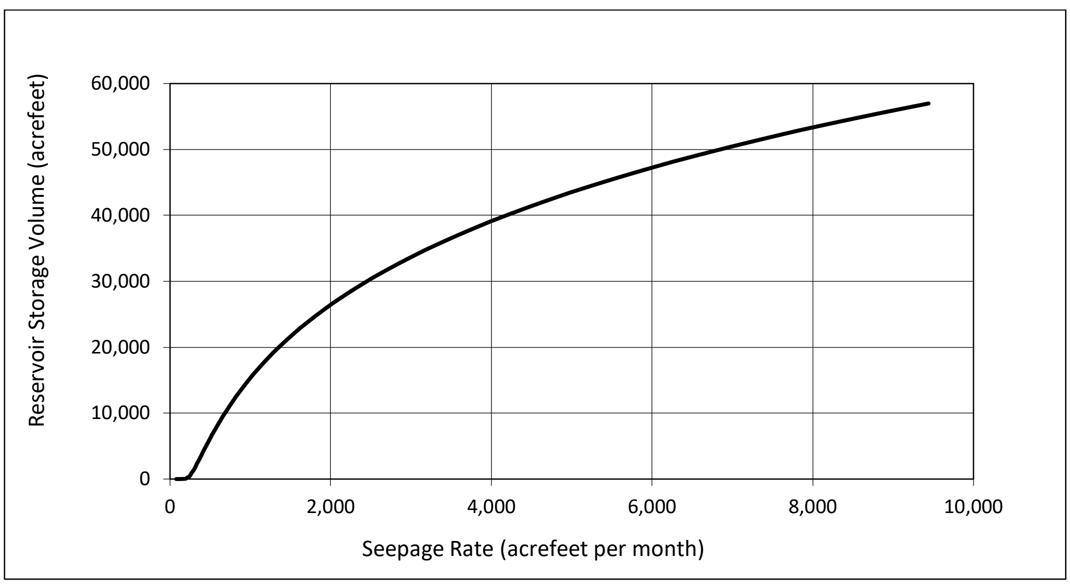

Figure 6-4. Relationship between storage volume and seepage in Crane Prairie Reservoir. Source: OWRD 2015.

The historical fluctuations in reservoir volume illustrated in Figure 6-3 resulted in corresponding fluctuations in water surface elevation (Figure 6-5). Between 1983 and 2018 reservoir elevation was as high as 4,445.4 feet in the spring and as low as 4,433.0 feet in the fall. Annual fluctuations were as much as 9 feet in years of extreme demand for water.

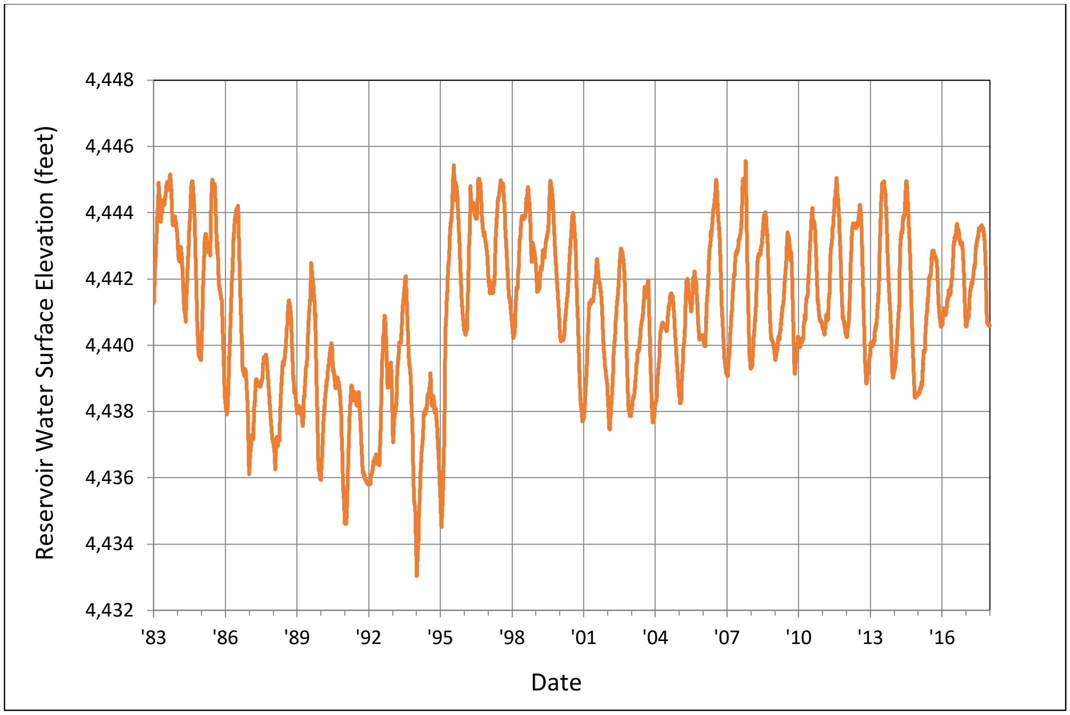

Figure 6-5. Crane Prairie Reservoir daily (midnight) water surface elevation from 1984 through 2018. Source: Reclamation 2020b.

6.2.3.3 Effects of DBHCP Measure CP-1 on Storage Volume and Water Surface Elevation

The intent of Conservation Measure CP-1 is to improve habitat for Oregon spotted frogs within Crane Prairie Reservoir by reducing the magnitude and frequency of fluctuations in water depth. While the reservoir historically fluctuated as much as 33,000 acre-feet in volume and 9 feet in water surface elevation on an annual basis, Conservation Measure CP-1 will limit the annual fluctuation to no more than 10,000 acre-feet and 2.25 feet in most years. RiverWare modeling of this management change (Reclamation 2020a) indicates that seasonal and year-to-year fluctuations in water surface elevation will be reduced significantly from historical conditions (Figure 6-6). This will result in less fluctuation in water depth, but it will also result in considerable reduction in the volume of water that is stored and released for irrigation on an annual basis.

From the beginning of the storage season, Crane Prairie Reservoir will be given priority over Wickiup Reservoir for filling to enable it to reach at least elevation 4,443.23 feet (3 inches below the allowable maximum) no later than March 15. From March 15 through July 15, the reservoir will be operated to keep the water surface elevation within a 3-inch range (between 4,443.23 and 4,443.48 feet). From July 15 through July 31, irrigation storage may be released from Crane

Prairie Reservoir provided the water surface elevation does not drop more than 0.05 foot per day. After July 31 the maximum rate of drop in reservoir elevation will be 0.10 foot per day.

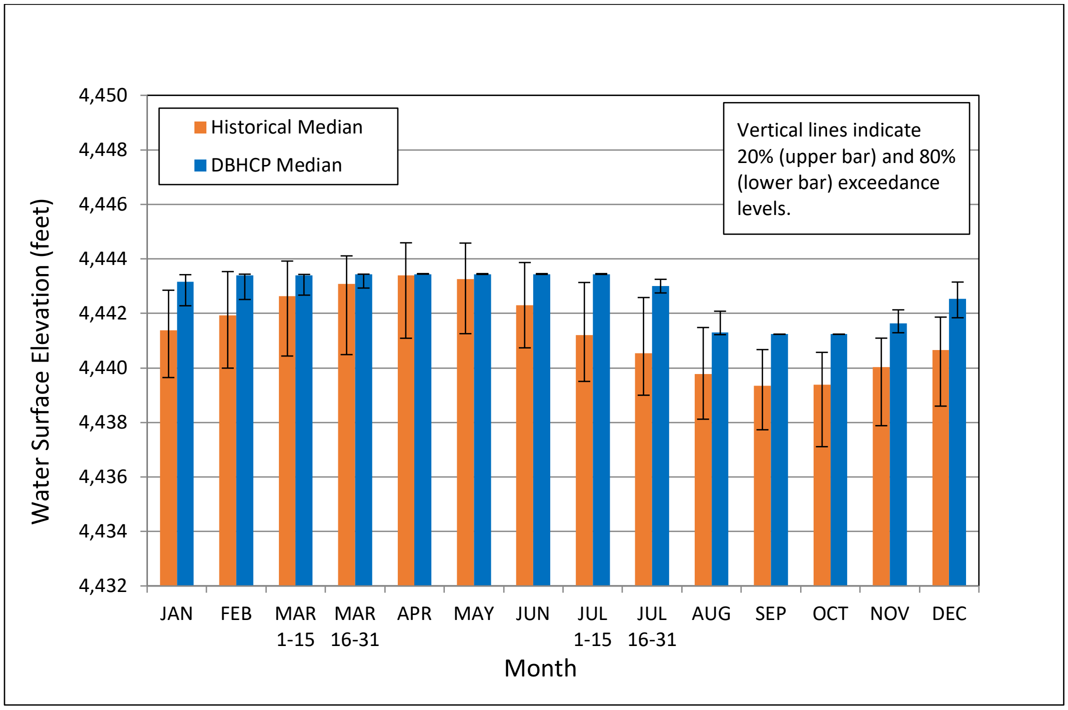

Figure 6-6. Monthly medians of daily water surface elevations in Crane Prairie Reservoir for historical and DBHCP projected conditions. Sources: Reclamation 2020a, 2020b.

Total decrease in reservoir volume during drawdown in most years will be 8,976 to 10,161 acre-feet, depending on the starting surface elevation (Table 6-2). The amount of water released from Crane Prairie for irrigation use by AID, COID and LPID during reservoir drawdown will be considerably less than the total change in reservoir volume due to concurrent seepage (loss of reservoir volume to groundwater) and evaporation that will contribute to overall lowering of the reservoir.

If reservoir inflow is constant during drawdown, total annual irrigation release from Crane Prairie Reservoir will be 4,372 to 4,905 acre-feet (Table 6-2). If reservoir inflow decreases during reservoir drawdown, the rate of irrigation release will be reduced by a corresponding amount to keep water surface elevation from dropping more than the specified 0.05 or 0.10 foot per day, and the total amount of water released for irrigation will be less than indicated in Table 6-2.

In years when USFWS identifies the need to lower Crane Prairie Reservoir an additional 5,000 acre-feet, there may be additional water available for irrigation use by the Permittees, depending on the timing of the release (i.e., during versus after the irrigation season). The annual low elevation of the reservoir will be reduced by as much as 1.2 feet (14 inches), but this additional lowering of the reservoir is not expected to prevent refilling to at least elevation 4,443.23 feet by the following March 15 to support Oregon spotted frog breeding.

Table 6-2. Estimated releases of irrigation storage from Crane Prairie Reservoir during annual drawdown under the DBHCP.

Period	Total Change in Reservoir Volume During Drawdown (acre-feet)	Portion of Drawdown Lost to Seepage (acre-feet)	Portion of Drawdown Released for Potential Irrigation Use by AID, COID and LPID (acre-feet)
Reservoir Drawdown Starting at Maximum Summer Elevation 4,443.48 feet			
Jul 16 - 31	3,712.0	3,044.8	667.2
Aug 1 – Oct 31	6,449.0	2,210.8	4,238.2
Total	**10,161.0**	**5,255.6**	**4,905.4**
Reservoir Drawdown Starting at Minimum Summer Elevation 4,443.23 feet			
Jul 16 - 31	3,654.0	2,877.9	776.1
Aug 1 – Oct 31	5,322.0	1,725.7	3,596.3
Total	**8,976.0**	**4,603.7**	**4,372.3**

During some months of extremely low inflow to Crane Prairie Reservoir, seepage loss and evaporation could prevent the water surface elevation requirements of Measure CP-1 from being met (see monthly minimum water surface elevations in Figure 6-6). At a water surface elevation of 4,441.23 feet (the minimum allowed from November through February) seepage loss alone is estimated to be 3,746 acre-feet per month (Figure 6-4). This is equivalent to a constant flow of 63 cfs. At elevation of 4,443.23 feet (the minimum from mid-March through mid-July) the estimated seepage loss is 5,800 acre-feet per month (equivalent to a constant flow of 99 cfs). To maintain a constant water surface elevation while releasing 75 cfs at Crane Prairie Dam and compensating for seepage, inflow to the reservoir must be at least 63 + 75 = 138 cfs from November through February and 99 + 75 = 174 cfs from mid-March through mid-July. Transition months between these periods will have intermediate needs for inflow. Historical data show that from 1981 through 2014 the median of monthly average inflow to Crane Prairie Reservoir from the six tributary streams (Deschutes River, Cultus River, Quinn River, Cultus Creek, Deer Creek and Charlton Creek) was above 138 cfs in all months and above 174 cfs from April through December (Figure 6-7), indicating that median inflows will be sufficient to maintain desired water surface elevations and allow a flow of 75 cfs in the Deschutes River downstream of Crane Prairie Dam. However, historical reservoir inflows at the 90 percent exceedance level (10th percentile) only exceeded 174 cfs in 2 months (May and June) and never reached 134 cfs in November through February. This means that roughly 10 percent of the time, inflow to the reservoir may not be sufficient to simultaneously maintain desired water surface elevations and support an instream flow of 75 cfs downstream of the dam. When this occurs, the instream flow below the dam will be reduced to as low as 30 cfs so that reservoir inflows as low as 129 cfs (mid-March through mid-July) and 93 cfs (fall and winter) will be sufficient to maintain desired water surface elevations. However, it still may not be possible to increase the water surface elevation of the reservoir in early March at inflows this low. In these extremely dry years, the water surface elevation of the reservoir could unavoidably remain below the desired elevation of 4,443.23 feet through much of the summer.

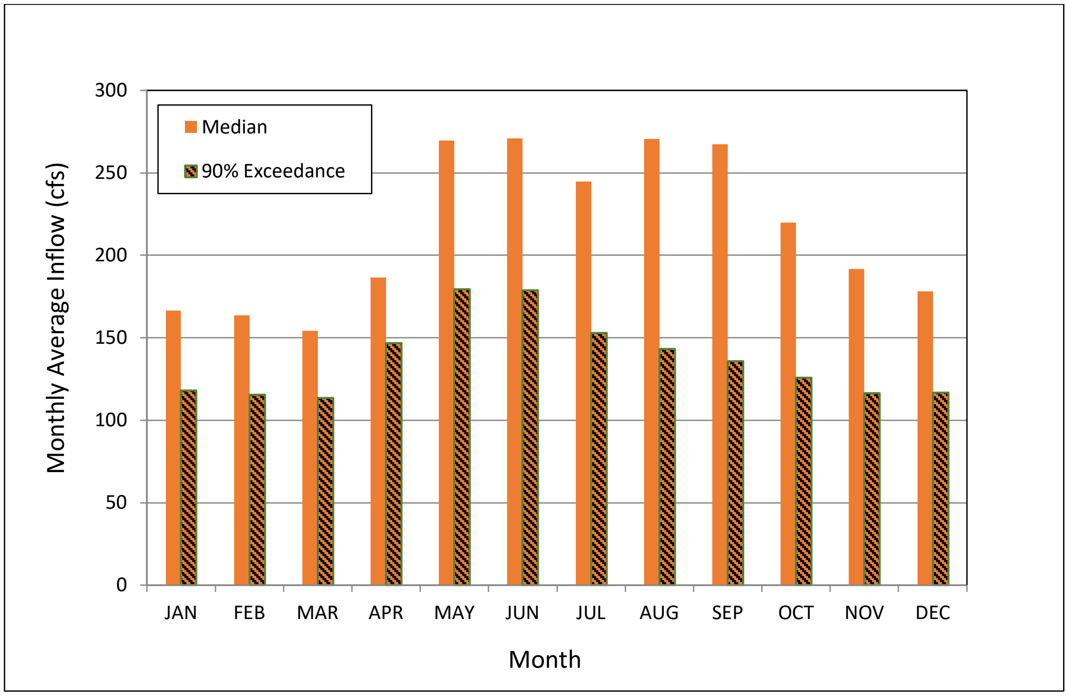

Figure 6-7. Monthly average inflow to Crane Prairie Reservoir from 1981 through 2014.
Source: OWRD 2017a.

6.2.3.4 Effects of DBHCP Measure CP-1 on Deschutes River Flow below Crane Prairie Dam

Based on the results of RiverWare modeling, daily average flows in the Deschutes River below Crane Prairie Dam (measured at Hydromet Station CRAO) will go down in some months and up in other months as a result of Conservation Measure CP-1 (Figure 6-8). In November, December and January, when the reservoir was historically held low, the outflow will be reduced by the DBHCP because refilling of the reservoir will take priority to allow the target volume of 4,443.23 to be reached no later than March 15. In addition, since the reservoir will be held higher during these months, associated seepage losses will be higher and this will reduce outflow. In February and March, the small predicted increases in median outflow would likely be the results of a need to spill water during periodic winter storms; this spillage would occur because there will be less room within the reservoir than was historically available to contain pulses of runoff. In April, outflow will be higher than historical levels because the reservoir will be at the target level for the summer, but inflow will be increasing due to snowmelt. In May, June and July DBHCP outflows will again be lower because irrigation storage will not be released like it was in the past, and also because seepage losses will consume a greater proportion of inflow. In August, releases of irrigation storage will begin and the outflow will be higher than it was historically. Since the total volume of irrigation storage released from the reservoir will be less than historical levels, the release will end sooner and median outflow for September will be less than it was in the past. In October, the difference between historical and DBHCP outflow will be small. During all months, the 80 percent exceedance outflows will remain at or above the minimums specified in Conservation Measure CP-1.

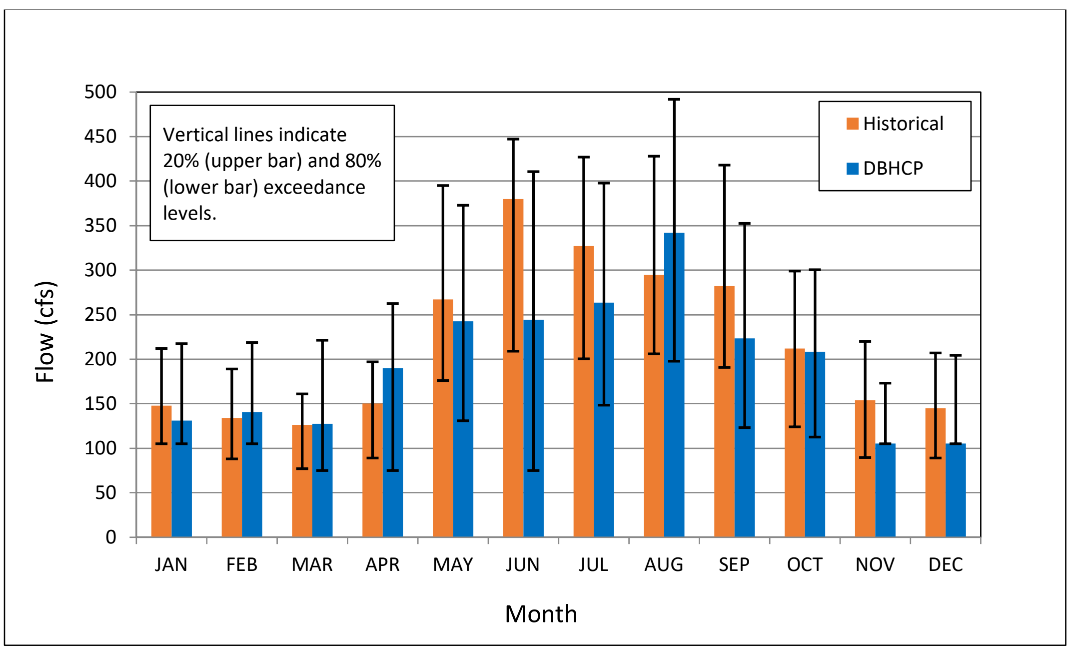

Figure 6-8. Monthly medians of daily average flows in the Deschutes River below Crane Prairie Dam (Hydromet Station CRAO) for historical and DBHCP projected conditions. Sources: OWRD 2020a, Reclamation 2020a.

6.2.4 Conservation Goal and Objectives for Wickiup Reservoir and the Upper Deschutes River

6.2.4.1 Wickiup Reservoir Goal No. 1

Manage flows in the Deschutes River between Wickiup Dam and Bend to support riverine and wetland habitats capable of sustaining Oregon spotted frogs within this reach over the long term.

6.2.4.2 Measurable Resource Objectives for Wickiup Reservoir Goal No. 1

Wickiup Reservoir Objective 1-A: Provide flows in the Upper Deschutes River sufficient to sustain Oregon spotted frog breeding/rearing/nonbreeding habitat at multiple sites between Wickiup Dam and Bend, where breeding/rearing/nonbreeding habitat is defined as riverine wetlands meeting all of the following criteria:

- Water current velocity of 1 foot/second or less.
- Water depth of 6 to 12 inches from the onset of breeding through the completion of metamorphosis.
- Year-round water depth of at least 9 inches or direct surface connection to the main river channel from the onset of breeding to the onset of overwintering.
- Substrate cover of at least 50 percent vegetation dominated by herbaceous emergent, submergent or floating-leaved aquatic species.
- Less than 25 percent coverage of woody plants and tall-growing emergent wetland species such as cattails.

Wickiup Reservoir Objective 1-B: Provide flows in the Upper Deschutes River sufficient to sustain Oregon spotted frog overwintering at multiple sites between Wickiup Dam and Bend as well as seasonal movement and dispersal between overwintering sites and breeding/rearing/nonbreeding sites.

Wickiup Reservoir Objective 1-C: Limit management-induced fluctuations in flow in the Upper Deschutes River that cause a reduction of more than 2 inches in the depth of water in Oregon spotted frog breeding habitat from the onset of breeding to the completion of egg incubation.

Wickiup Reservoir Objective 1-D: Limit the rate of management-induced changes in flow in the Upper Deschutes River to reduce the potential for flushing or stranding of Oregon spotted frogs.

6.2.4.3 Rationale for Wickiup Reservoir Goal No. 1

Oregon spotted frogs are present in the Deschutes River and associated riverine wetlands between Wickiup Dam and Bend, but the distribution of frogs within this reach is fragmented and the total number of frogs in the reach may have been limited by the effects of Wickiup Reservoir operation on the hydrology of the river. The storage of water in Wickiup Reservoir historically resulted in extremely low flows between Wickiup Dam and Bend in many winters, and the release of stored water during the irrigation season resulted in unnaturally high flows in most summers. Low winter flows, particularly in the upper portion of this reach, may deprive Oregon spotted frogs of overwintering habitat and prevent local populations from maintaining a year-to-year presence. Low flows that extend into the early spring can leave the river channel and associated wetlands nearly dry, thereby inhibiting dispersal and breeding. Unnaturally high summer flows support occupied wetlands in the lower portions of the reach, but they also accelerate bank erosion and modify channel morphology in ways that may be detrimental to riverine wetlands and Oregon spotted frogs over the long term. The intent of Wickiup Reservoir Goal No. 1 is to reduce the seasonal extremes in flow associated with historical reservoir operation and provide hydrologic support for all Oregon spotted frog life stages (breeding, rearing, summer foraging, overwintering and seasonal movement/dispersal) within the Deschutes River between Wickiup Dam and Bend. The USFWS (2016) management goal for this reach is, "maintenance or improvement of the existing nonbreeding, breeding, rearing, and overwintering habitat, aquatic movement corridors, or refugia habitat." The DBHCP will support this USFWS goal by providing hydrologic conditions conducive to wetland development and maintenance.

There are four measurable resource objectives related to Wickiup Reservoir Goal No. 1. Wickiup Reservoir Objective 1-A is a quantification of Oregon spotted frog breeding/rearing/nonbreeding habitat that can be used to verify progress toward meeting the goal. Wickiup Reservoir Objective 1-B states the intent of the DBHCP to provide overwintering and seasonal movement habitats for Oregon spotted frogs along the Upper Deschutes River. It is less detailed than Wickiup Reservoir Objective 1-A because the requirements for Oregon spotted frog overwintering habitat in riverine wetlands are not well documented. Wickiup Reservoir Objective 1-C quantifies the maximum desired decrease in water depth (2 inches) along this reach of the Deschutes River during Oregon spotted frog breeding and egg development to prevent exposure and desiccation of eggs. Wickiup Reservoir Objective 1-D specifies the desire to avoid rapid and extreme changes in water depth to avoid stranding or flushing of Oregon spotted frogs and eggs at all times of year.

6.2.5 Conservation Measures for Wickiup Reservoir and the Upper Deschutes River

One conservation measure has been developed for Wickiup Reservoir, and one has been developed for the Upper Deschutes River. These conservation measures address all four resource objectives related to Wickiup Reservoir Goal No. 1.

Conservation Measure WR – 1: Wickiup Reservoir Operation *

Wickiup Reservoir will be operated according to the following items. Except as otherwise indicated, flows and water surface elevations specified in this measure will be verified at Hydromet Station WICO (OWRD Gage 14056500) below Wickiup Dam.

A. From April 1 through September 15, flow at WICO will be at least 600 cfs. An adaptive management element will be used to test whether going directly to 600 cfs by April 1 provides enhanced survival of OSF. In coordination with USFWS, flows may be set at 400 cfs by April 1 and increased to 600 cfs within the first 2 weeks of April. Annual snow pack, weather and in-stream conditions will inform this decision.

B. From April 1 through April 30, flow at WICO shall not exceed 800 cfs unless USFWS or a biologist approved by USFWS and funded by the Permittees has verified that

Oregon spotted frog eggs at Dead Slough in La Pine State Park have hatched or are physically situated in a portion of the slough where an increase in flow will not harm them.

C. If the flow at WICO is increased above 600 cfs during the month of April, it will not subsequently be allowed to decrease more than 30 cfs, whether in a single flow adjustment or cumulatively over the course of multiple flow adjustments, until after April 30 or an earlier date approved after coordination with USFWS.

D. From May 1 through June 30, flow decrease at WICO over any 5-day period shall be no more than 20 percent of total flow at the time the decrease is initiated.

E. Flow at BENO gauge (OWRD Gage 14064500) shall be no less than 1,300 cfs from July 1 through at least September 15.

F. For the first 7 years of DBHCP implementation, flow at WICO shall be at least 100 cfs from September 16 through March 31. Beginning in Year 1 of implementation, minimum flow at WICO from September 16 through March 31 shall be increased above 100 cfs in proportion to the amount of live Deschutes River flow made available to NUID during the prior irrigation season as a result of the piping of COID owned canals. For each acre-foot (or portion thereof) of live flow made available to NUID as a result of the piping of COID owned canals after the date of incidental take permit issuance, an equal volume of water shall be added to the minimum flow below Wickiup Dam from September 16 through March 31. This water shall be in addition to the amount of water needed to maintain a flow at WICO of at least 100 cfs. The timing for release of the additional water shall be determined in coordination with USFWS for optimal benefit to Oregon spotted frogs.

G. Beginning no later than Year 8 of DBHCP implementation, flow at WICO shall be at least 300 cfs from September 16 through March 31, and not more than 1,400 cfs for more than 10 days per year between April 1 and September 15. If the volume of live Deschutes River flow made available to NUID as a result of the piping of COID owned canals exceeds the volume of water needed to increase the minimum flow at WICO from 100 to 300 cfs from September 16 through March 31, the minimum flow at WICO shall be increased above 300 cfs in proportion to the amount of additional water available and in the manner described in Item F of this conservation measure. The cap of 1,400 cfs on flow specified in this item is in addition to, and not a replacement for, any other caps on flow at WICO required under this conservation measure. If NUID anticipates the need to exceed 1,400 cfs at WICO in Years 8 through 12, it will contact USFWS in advance to discuss options for minimizing the adverse effects on the Deschutes River and Oregon spotted frogs, such as conditioning the rate or timing of flow increases above 1,400 cfs.

H. Beginning no later than Year 13 of DBHCP implementation, minimum flow at WICO shall be between 400 cfs and 500 cfs from September 16 through March 31, with actual flow during this period determined according to the variable flow tool described below and in Section 7.3.3, *Wickiup Reservoir and Upper Deschutes River*, and not more than 1,200 cfs for more than 10 days per year between April 1 and September 15. The variable flow tool shall be developed collaboratively by USFWS and the Permittees in consultation with OWRD and Reclamation. USFWS must approve the final variable flow tool for use. A prototype of the variable flow tool shall be developed by the end of Year 10 of DBHCP implementation and tested in Years 11 and 12. The final variable flow tool shall be implemented beginning in Year 13. The variable flow tool shall be used to establish the September 16 to March 31 minimum flow at WICO each year based on available storage in Wickiup Reservoir at the beginning of the storage season and anticipated inflow to the reservoir during the storage season. Monitoring, reporting and adaptive management provisions for the variable tool shall also be developed by the end of Year 10. For purposes of this calculation, target reservoir storage volume at the end of the storage season shall never be less than 92,000 acre-feet. The cap of 1,200 cfs on flow specified in this item is in addition to, and not a replacement for, any other caps on flow at WICO required under this conservation measure in Years 13 and later. If NUID anticipates the need to exceed 1,200 cfs at WICO in Year 13 and later, it will contact USFWS in advance to discuss options for minimizing the adverse effects on the Deschutes River and Oregon spotted frogs, such as conditioning the rate or timing of flow increases above 1,200 cfs.

I. For all years, the volume of water equivalent to the amount scheduled for winter releases in excess of 100 cfs may be stored in Wickiup Reservoir for release later in the same water year. These releases would be designed to provide the maximum conservation benefit to the covered species, based on the current condition of the covered lands. The timing of release of the stored water will be determined in coordination with USFWS, based on its review of potential benefits to Oregon spotted frogs and/or covered fish species. Water stored in this manner and released during the irrigation season will be treated as NUID storage and available for diversion by NUID at North Canal Dam. Water stored in this manner and not released for Oregon spotted frogs or fish by the end of the same water year can be used to meet the minimum flow requirements of this conservation measure at WICO through March 31 of the subsequent water year. Any water stored in this manner and not released to meet DBHCP minimum flow requirements by March 31 will become NUID storage and available for irrigation use.

J. Whenever the flow at WICO is at or below 800 cfs, the maximum rate of increase in flow, as measured by change in water surface elevation at WICO, shall be 0.1 foot per 4-hour period, and the maximum rate of decrease shall be 0.2 foot per 12-hour period. In addition during fall ramp-down, flow reductions at WICO shall be halted for 5 days when the corresponding flow at BENO gage reaches 1,200, and again for 5 days when the corresponding flow at BENO reaches 1,100 cfs.

K. Flows and water surface elevations at WICO and BENO within the allowable ranges of deviation specified in Table WR-1 shall be considered in compliance with this conservation measure; however, values outside the required ranges specified in Table WR-1 shall be reported to USFWS as specified in DBHCP Section 7.2.2. Flows outside the allowable ranges of deviation specified in Table WR-1 that are beyond the control of NUID and the other Permittees shall not be considered out of compliance with this conservation measure.

L. For the term of the DBHCP, USFWS, NMFS and NUID will coordinate monthly on the implementation of this conservation measure. OWRD will also be invited to participate in this monthly coordination.

* *USFWS is not a water manager. All references here and elsewhere in this DBHCP regarding USFWS involvement in water management decisions are intended to define where USFWS technical assistance will be sought to remain in compliance with the Conservation Measures.*

Table WR-1. Required ranges and allowable ranges of deviation for Deschutes River flow and water surface elevation at WICO and BENO.

Item	Time Period	Metric	Required Flow or Water Surface Elevation	Allowable Range of Deviation
A.	Apr 1 – Sep 15	Flow at WICO	≥ 600 cfs (≥400 cfs if allowed by USFWS)	≥ 570 cfs (≥ 370 cfs if target is 400 cfs)
B.	Apr 1 – Apr 30	Flow at WICO	≤ 800 cfs (unless higher flow approved by USFWS)	≤ 830 cfs (when target is ≤ 800 cfs)
C.	Apr 1 – Apr 30	Decrease in flow at WICO after flow is ≥ 600 cfs	≤ 30 cfs	≤ 50 cfs
D.	May 1 – Jun 30	Decrease in flow at WICO over any 5-day period	≤ 20% of total flow	≤ 25% of total flow
E.	Through Sep 15	Flow at BENO	≥ 1,300 cfs	≥ 1,260 cfs
F.	Sep 16 – Mar 31	Flow at WICO in Years 1 – 7	≥100 cfs (higher if conserved water is available)	≥ 90 cfs (or ≥ 10 cfs below target if target is >100 cfs)
G.	Sep 16 – Mar 31	Flow at WICO in Years 8 – 12	≥ 300 cfs (higher if conserved water is available)	> 280 cfs (or ≥ 20 cfs below target if target is > 300 cfs)
	Apr 1 – Sep 15	Flow at WICO in Years 8 – 12	> 1,400 cfs for no more than 10 days	> 1,440 cfs for no more than 10 days
H.	Sep 16 – Mar 31	Flow at WICO in Years 13 – 30	≥ 400 – 500 cfs, as determined by variable flow tool	No lower than 25 cfs below target set by variable flow tool
	Apr 1 – Sep 15	Flow at WICO in Years 13 – 30	> 1,200 cfs for no more than 10 days	> 1,240 cfs for no more than 10 days
J.	Jan 1 – Dec 31	Rate of increase in water surface elevation at WICO when total flow at WICO is < 800	0.10 foot per 4-hour period	0.18 foot per 4-hour period
	Jan 1 – Dec 31	Rate of decrease in water surface elevation at WICO when total flow at WICO is < 800	0.20 foot per 12-hour period	0.28 foot per 12-hour period
	Sep 15 – Oct 31	First 5-day pause in flow at BENO during ramp-down	1,200 cfs	1,160 – 1,240 cfs
	Sep 15 – Oct 31	Second 5-day pause in flow at BENO during ramp-down	1,100 cfs	1,060 – 1,140 cfs

Conservation Measure UD – 1: Upper Deschutes Basin Conservation Fund

Within 6 months after issuance of the Incidental Take Permits, and no later than March 1 of each year thereafter for the term of the Permits, the Permittees collectively will contribute a combined total of $150,000 annually to the Upper Deschutes Basin Conservation Fund. This amount will be adjusted annually for inflation in direct proportion to the change in annual average Consumer Price Index for all urban consumers (CPI-U), West Region, all items, Base Period 1982-84=100, published by the Bureau of Labor Statistics. The fund shall be held, managed and distributed by a third-party designated by USFWS. The fund shall be used to improve or enhance habitat in the Upper Deschutes Basin for the Oregon spotted frog and other aquatic species, or otherwise address conditions in the Upper Deschutes Basin that affect the conservation and recovery of the Oregon spotted frog in the wild. The DBHCP Permittees shall have no responsibility for determining the use of the fund for the outcome of activities supported by the fund.

6.2.6 Rationale for Conservation Measure WR-1

6.2.6.1 Overview

The 200,000 acre-foot storage capacity of Wickiup Reservoir is heavily utilized each year, resulting in fluctuations of more than 20 feet in surface elevation (water depth) between spring and fall. Operation of the reservoir also has a profound influence on flow downstream in the Deschutes River. The storage of water in the winter has historically reduced downstream flow to as little as 20 cfs, while the release of stored water for irrigation nearly doubles the natural flow in some summer months.

Oregon spotted frogs are known to be present upstream and downstream of Wickiup Reservoir, but the numbers of frogs within and immediately downstream of the reservoir are very low. Widely fluctuating water depths within the reservoir preclude the development of stable wetland habitats and reduce the potential for Oregon spotted frogs to persist there. Several locations along the Deschutes River further downstream, from Wickiup Reservoir to Bend, have been documented to support Oregon spotted frogs. High summer flows downstream of the reservoir may provide suitable wetland habitats for Oregon spotted frog breeding and summer foraging, but habitat suitability for overwintering may be adversely affected when river level drops.

Habitat conditions for Oregon spotted frogs cannot be simultaneously improved within and downstream of Wickiup Reservoir. Any effort to reduce seasonal fluctuations in storage volume to benefit wetland habitat conditions within Wickiup Reservoir (similar to Conservation Measure CP-1 for Crane Prairie Reservoir) would negatively impact flows and riverine wetland habitats downstream of the reservoir. If seasonal reservoir fluctuations were reduced, the release of stored water during the summer would also be reduced and downstream wetlands would be deprived of water they need to support Oregon spotted breeding and summer foraging. Conversely, the provisions in Conservation Measure WR-1 to improve habitat conditions downstream of Wickiup Reservoir will reduce storage in the reservoir and increase seasonal fluctuations in reservoir volume, with negative impacts to reservoir wetlands. These impacts are unavoidable.

Conservation Measure WR-1 is designed to address the effects of Wickiup Reservoir operation (seasonal storage and release of water) on Oregon spotted frog habitats downstream along the Deschutes River, with the understanding that habitats within the reservoir may continue to be less than optimal. This approach is based on the assumptions that: a) Wickiup Reservoir and Deschutes River wetland habitats cannot be simultaneously improved from their current conditions, and b) wetland habitats along the 59 miles of Deschutes River between Wickiup Dam and Bend are more important to the long-term conservation and recovery of the Oregon spotted frog than potential wetland habitats within the reservoir. The existing wetland habitats within Wickiup Reservoir are largely artifacts of reservoir creation that raised water surface elevations more than 20 feet; they are not sustainable without the storage of large volumes of water and the associated impacts on downstream habitats. Riverine wetlands downstream of the reservoir, on the other hand, are assumed to be at least in part of natural origin and capable of supporting Oregon spotted frogs under proper hydrologic regimes. The documented presence of Oregon spotted frogs in a number of the Deschutes River wetlands is evidence of their potential to contribute to conservation and recovery. In contrast, the historically low numbers of Oregon spotted frogs documented within Wickiup Reservoir, and the lack of any documented presence along that reach of the river prior to reservoir development (Hayes 1997), would make efforts to maintain or increase the number of frogs in the reservoir highly speculative.

Conservation Measure WR-1 calls for a series of incremental increases in minimum instream flow immediately downstream of Wickiup Dam over a period of 20 years. By Year 13 of the DBHCP, the minimum instream flow during the storage season (October through March) will be 400 cfs, compared to the historical minimum of 20.8 cfs. This increase in flow will be accomplished by passing water through the reservoir during the winter rather than storing it. Since inflow to the reservoir will not change under the DBHCP, the increase in pass-through will reduce winter storage, which will in turn reduce the release of stored water during the irrigation season (April through September). Conservation Measure WR-1 will not represent a complete return to natural flows in the Upper Deschutes River; winter flows will still be lower than natural flows in many years and summer flows will still be higher. This is intentional, because a complete return to natural flows would have a negative impact on Oregon spotted frog habitats that are currently dependent on the high summer flows provided by irrigation releases. Without these artificially high flows, some of the occupied wetlands along the Upper Deschutes River would not be inundated to the levels necessary to support Oregon spotted frog breeding and summer foraging. Measure WR-1 is therefore a balance between improving overwintering conditions for Oregon spotted frogs and maintaining existing conditions for breeding and summer foraging.

6.2.6.2 Effects of Historical Wickiup Reservoir Operation

NUID holds rights to store up to 200,000 acre-feet of irrigation water annually in Wickiup Reservoir. The actual amount of water stored and released on an annual basis is a function of availability (reservoir inflow) and irrigation demand. From 2002 through 2015, annual use of storage in Wickiup Reservoir averaged 122,387 acre-feet, and ranged from 69,024 to 175,816 acre-feet (Figure 6-9). During that same period annual storage losses (primarily to evaporation) averaged 12,171 acre-feet and ranged from 7,153 to 16,744 acre-feet.

The seasonal storage and release of irrigation water results in substantial fluctuation in the volume of water in the reservoir from month to month and year to year (Figure 6-10). The annual high in reservoir volume typically occurs at the beginning of the irrigation season in April and the annual low occurs at the end of the irrigation season in September. From year to year, high volume in April can vary by as much as 43,000 acre-feet and low volume in September can vary as much as 129,000 acre-feet. Corresponding water surface elevations (Figure 6-11) can differ by as much as 4 feet in April and over 40 feet in September. Years of high and low reservoir volume at the end of the irrigation season occur in a slightly cyclical pattern, with multiple successive years of high volume (the result of high natural flow and/or low demand) alternating with multiple years of low reservoir volume (Figure 6-12). As would be expected, water surface elevation of the reservoir follows a similar pattern (Figure 6-13). The historical data presented in Figures 6-10 through 6-13 include recent years during which operation of the Wickiup Reservoir was modified to improve conditions for Oregon spotted frogs, but inclusion of these recent years does not substantially alter the long-term medians and ranges depicted in Figures 6-10 and 6-11.

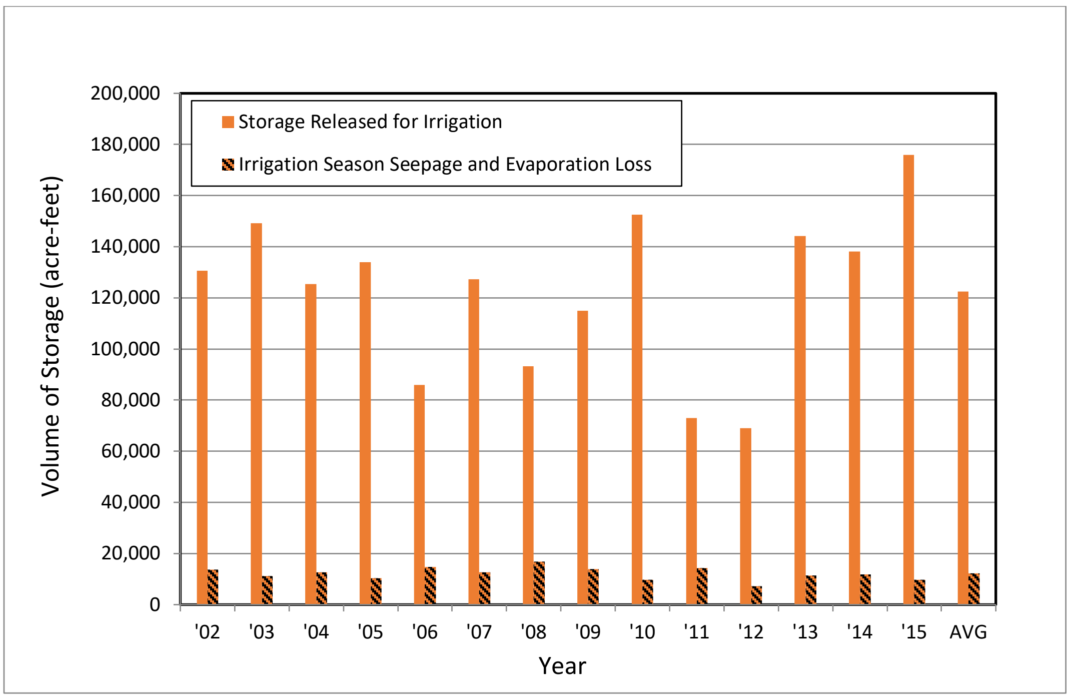

Figure 6-9. Use of Wickiup Reservoir irrigation storage from 2002 through 2015. Source: OWRD 2016.

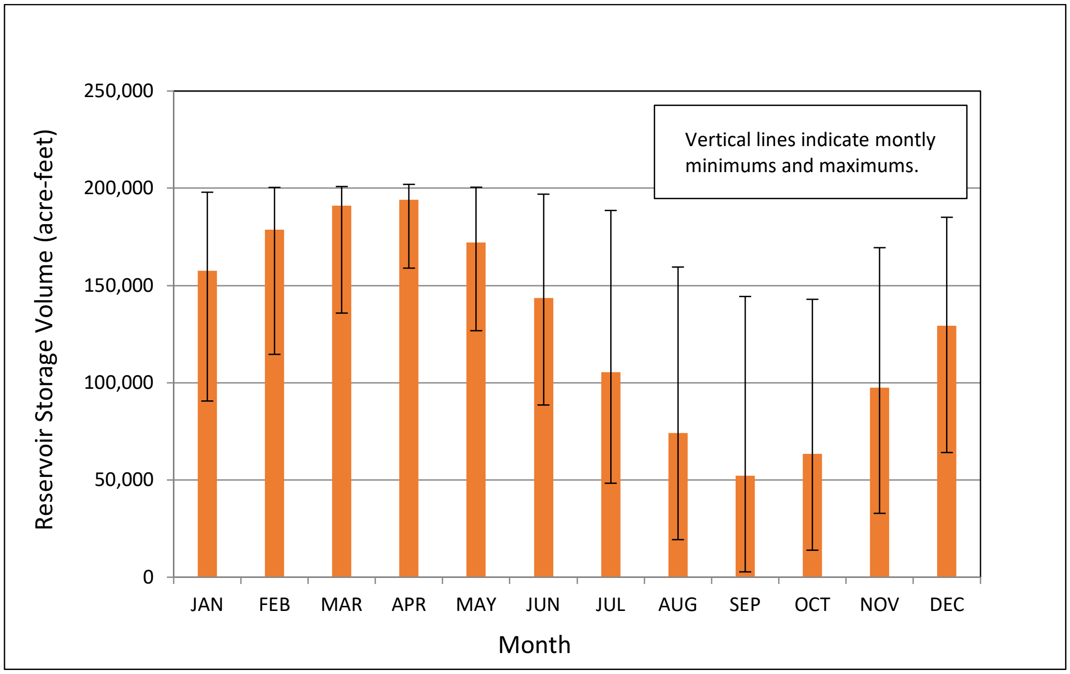

Figure 6-10. Monthly medians of daily storage volumes in Wickiup Reservoir from 1984 through 2018. Source: Reclamation 2020c.

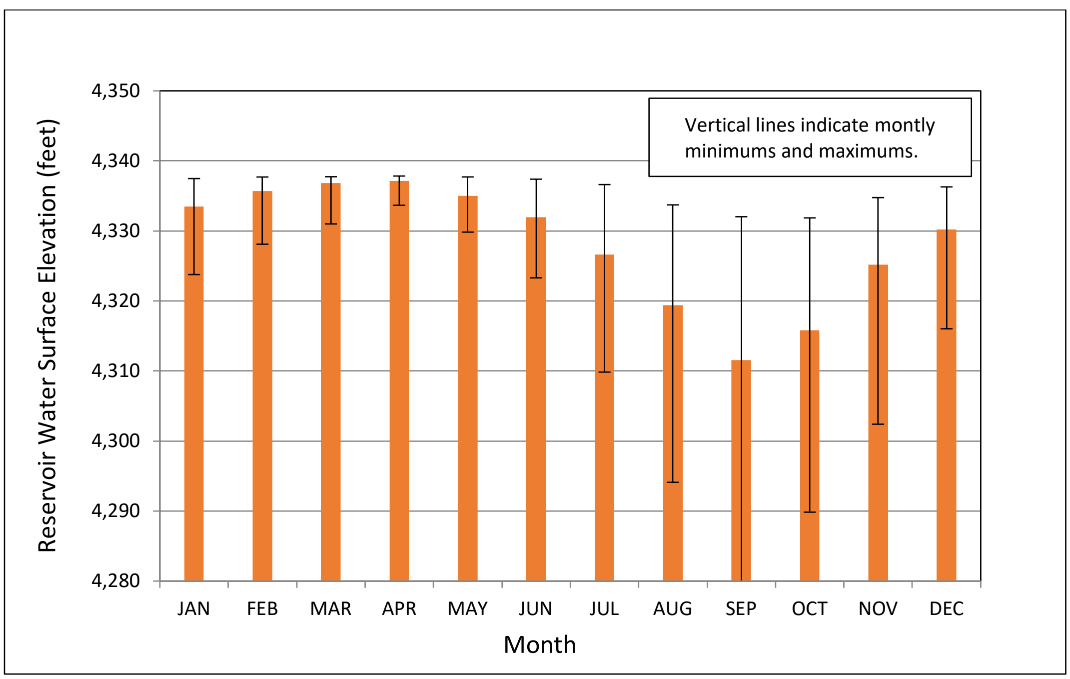

Figure 6-11. Monthly medians of daily water surface elevations in Wickiup Reservoir from 1984 through 2018. Source: Reclamation 2020c.

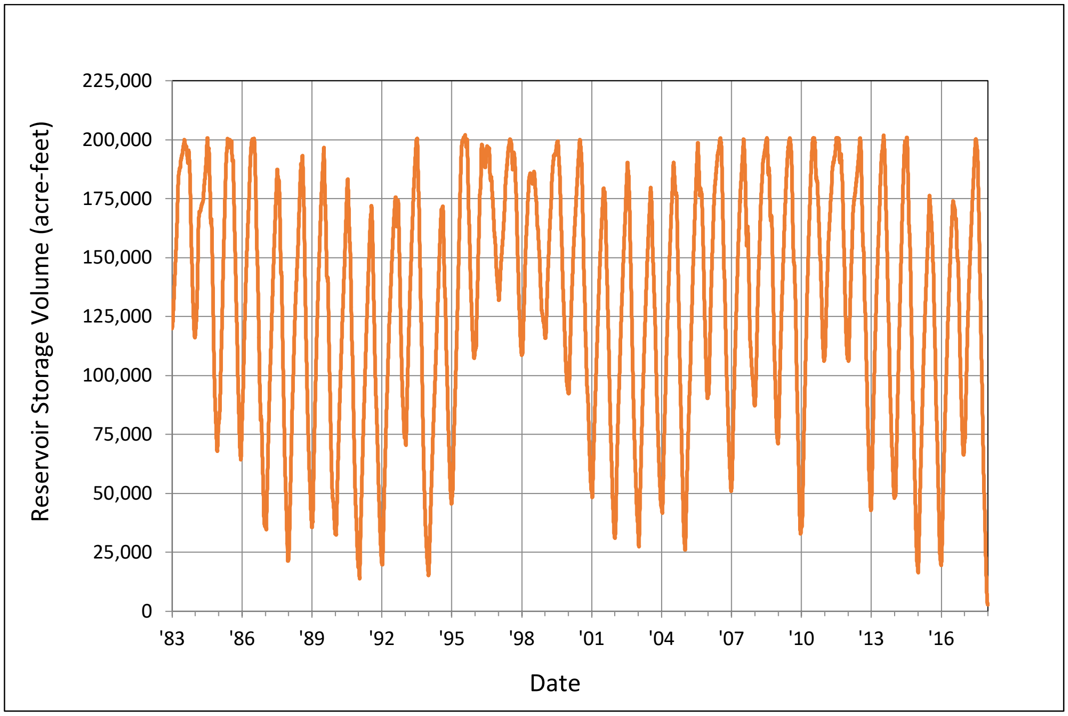

Figure 6-12. Wickiup Reservoir daily volume from 1984 through 2018. Source: Reclamation 2020c.

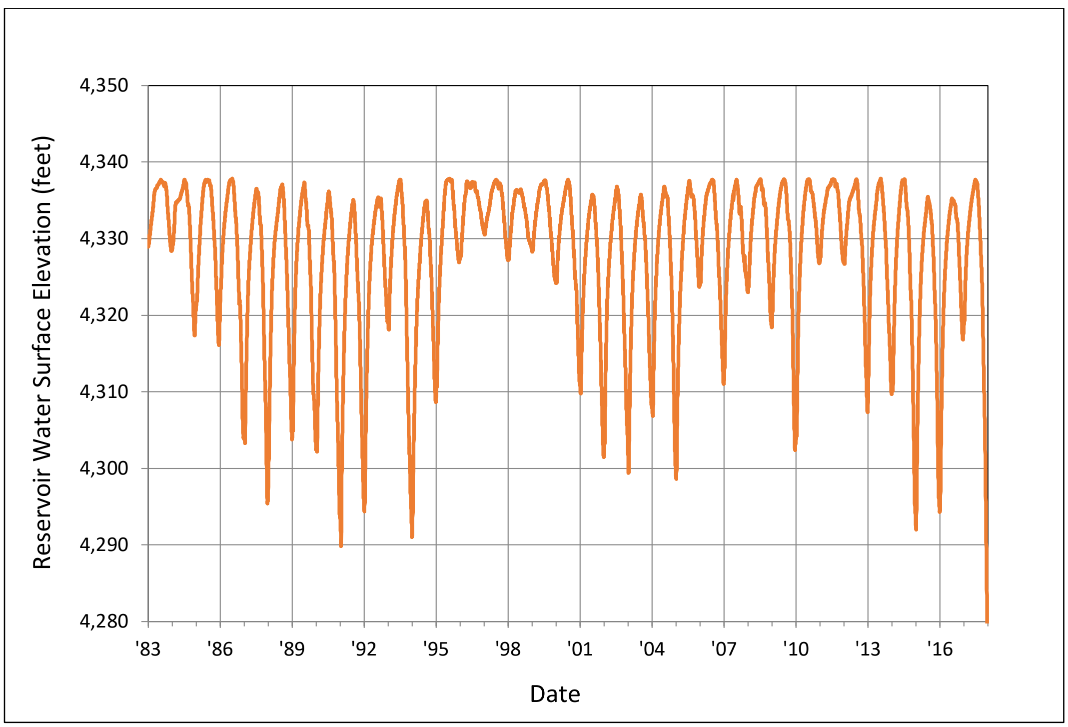

Figure 6-13. Wickiup Reservoir daily water surface elevation from 1984 through 2018. Source: Reclamation 2020c.

The net effect of Wickiup Reservoir operation on downstream flow in the Deschutes River has historically been extremely high flows during the irrigation season and extremely low flows during the storage season. Unregulated flows below Wickiup Dam would have fluctuated roughly 300 to 400 cfs between the high in mid-summer and the low in mid-winter (Figure 6-14). In contrast, regulated flows below Wickiup Dam were historically 1,500 cfs or higher during the summer and 20 cfs or lower during the winter. This same general pattern is seen downstream at Benham Falls (Figure 6-15), although total flow (both unregulated and historical) is higher at that point due to tributary inflow and groundwater discharge. Downstream of Bend, the effects of reservoir operation are counteracted during the summer by irrigation diversions, while decreases in flow due to irrigation storage during the winter persist to the mouth of the Deschutes River (see detailed discussion of existing hydrology in Chapter 4).

The estimates of unregulated flows in Figures 6-14 and 6-15 reflect minor daily fluctuations that are the result of calculation methods; these estimates are not fully representative of flows that would have occurred in the absence of the reservoirs. Unregulated flows downstream of reservoirs are estimated by using historical records to calculate differences in reservoir inflow, volume and outflow on a daily basis. Minor changes in daily gage readings of reservoir volume caused by wind and waves can produce minor apparent changes in volume and flow that do not reflect reality. Trends in flow over weeks and months, however, are unaffected by these inaccuracies.

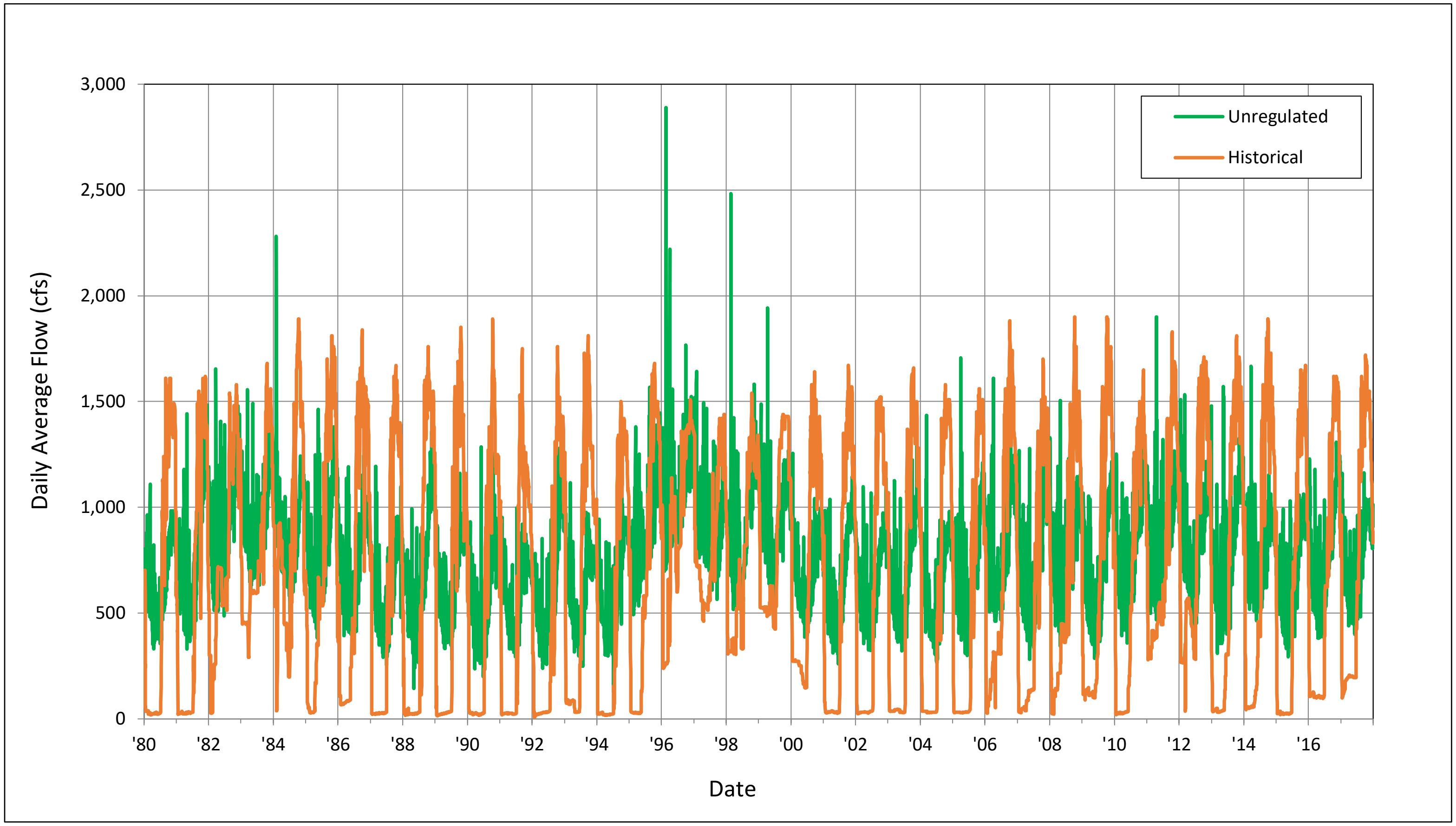

Figure 6-14. Unregulated and historical daily average flows in the Deschutes River below Wickiup Dam (Hydromet Station WICO) from 1981 through 2018. Sources: OWRD 2020b, Reclamation 2020a.

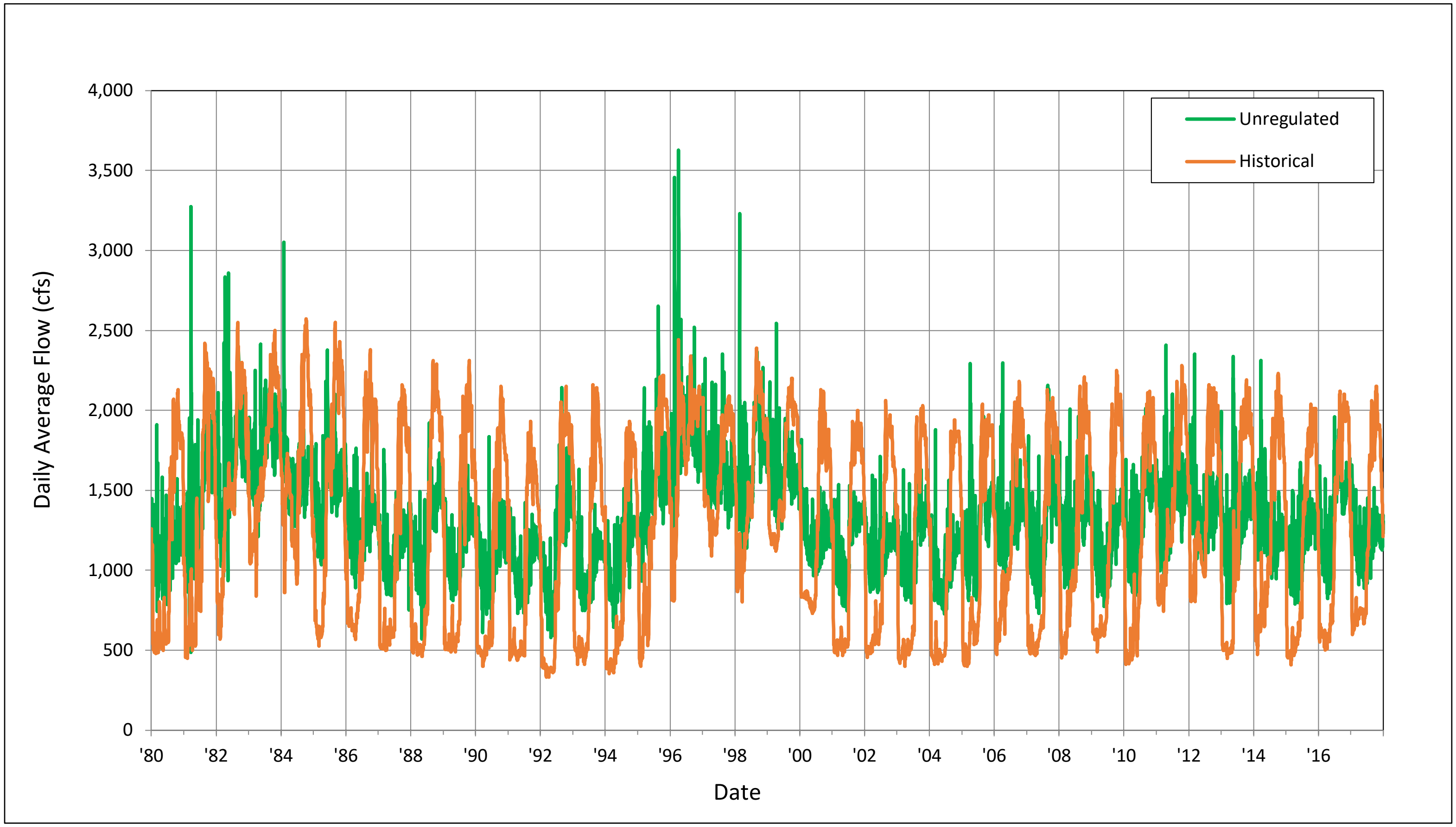

Figure 6-15. Unregulated and historical daily average flows in the Deschutes River at Benham Falls (Hydromet Station BENO) from 1981 through 2018. Sources: OWRD 2020c, Reclamation 2020a.

6.2.6.3 Effects of DBHCP Measures WR-1 on the Hydrology of the Upper Deschutes River

Measure WR-1 will increase flows in the Deschutes River below Wickiup Dam during the storage season. The minimum instream flow from September 16 through March 31 will be 100 cfs in Years 1 through 7 of DBHCP implementation, 300 cfs beginning no later than Year 8, and 400 cfs beginning no later than Year 13. Flows could be higher than the specified minimums in Years 1 through 12 if NUID acquires replacement water quicker than anticipated. Flows could be higher than 400 cfs in Years 13 through 30 if inflow to Wickiup Reservoir exceeds the amount needed to meet storage targets. Higher flows in Years 13 through 30 will be determined with the aid of a variable flow tool to be developed by the Services and Permittees during the first 10 years of implementation.

The required flow increases during the fall and winter will directly reduce average annual storage in Wickiup Reservoir, which in turn will reduce the amount of water released from the reservoir into the Upper Deschutes River during most irrigation seasons. To keep summer flows in the Upper Deschutes River from becoming too low, Measure WR-1 also specifies a minimum instream flow of 600 cfs below Wickiup Dam from April 1 through September 15, unless it is determined in a given year that Oregon spotted frog breeding is delayed. If breeding is delayed, a corresponding delay in the ramp-up to 600 cfs in early April may be made after coordination with USFWS. In addition, Measure WR-1 requires the flow in the Deschutes River downstream at Benham Falls be no less than 1,300 cfs from July 1 through September to maintain wetland habitats used by Oregon spotted frog through the summer. This provision will require corresponding releases of water at Wickiup Dam, although the flow at WICO may be less than 1,300 cfs and still satisfy this requirement due to the considerable inflow from springs and tributary streams between Wickiup Dam and Benham Falls.

Historically, the storage season flow below Wickiup Dam exceeded 100 cfs only in years of abundant water when the reservoir filled early and it was necessary to release more than the allowable minimum. Examples of this are 1982 – 1984 and 1996 – 2000 (see Figure 6-14). For the first 7 years of DBHCP implementation the flow below Wickiup Dam will be at least 100 cfs at all times. By Year 13, this minimum will increase to 400 cfs.

From April 1 through September 15, the minimum flow below Wickiup Dam will be 600. For most of the irrigation season the requirement to release at least 600 cfs will represent little change from historical operations because the combination of live flow and irrigation releases at Wickiup Dam already exceeded 600 cfs from mid-April through September. For the first 2 weeks of April, however, Measure WR-1 will increase the flow below Wickiup Dam from the historical minimum of 20.8 cfs. The flow below Wickiup Dam may have historically exceeded 500 cfs during early April in abundant water years (see Figure 6-14), but in most years the flow remained at or near the allowable minimum until mid-April. Under the DBHCP the flow below Wickiup Dam will be ramped up in late March to reach at least 600 cfs by April 1 in all years unless USFWS determines Oregon spotted frog breeding is delayed.

Measure WR-1 will also limit fluctuations in flow during the months of April, May and June. In April, the maximum allowable flow below Wickiup Dam in April will be 800 cfs, and decreases in flow will be limited to 30 cfs. This will eliminate the possibility for flows below the dam to fluctuate widely in response to sudden changes in weather and water demand at the start of the irrigation season. In May and June, the flow at WICO may be reduced no more than 20 percent over any 5-day period. As with the restriction on April flow decreases, the May and June restriction will limit the impacts of operational flow adjustments on Oregon spotted frog tadpoles.

In addition to requiring minimum flows in the Upper Deschutes River, Measure WR-1 specifies maximum flows at WICO of 1,400 cfs from Years 8 to 12 and 1,200 cfs from Years 13 through 30. The intent of these limits is to facilitate the establishment of riparian vegetation and restoration of aquatic and wetland habitats. Flows will be allowed to exceed these levels for short periods of time to accommodate operational demands during the irrigation season, but overall they will result in lower maximum and median flows from May through September.

The final provision of Measure WR-1 establishes limits on the rate of change in flow below Wickiup Dam when total flow is less than 800 cfs (i.e., at the beginning and end of the irrigation season). These ramping rates are based on recommendations made in conjunction with the Wild and Scenic Rivers Act designation of the Upper Deschutes River (USFS 1996) and they have been implemented on a voluntary basis at Wickiup Dam since 1996. Measure WR-1 will not result in a material change from recent operations, but it will make the ramping rates mandatory.

The ability to maintain target storage season flows below Wickiup Dam will be determined by the combination of inflow to Wickiup Reservoir and available storage in the reservoir. Net inflow to the reservoir from surface and groundwater sources is expected to meet or exceed minimum outflow targets during most winters, but it will be necessary to release storage whenever inflow is less than the outflow target. This may occur during some winters in Years 13-30 of DBHCP implementation when the target flow below Wickiup Dam is 400 cfs and net inflow is less than this. If storage is available, it will be released to meet the flow target. In extreme cases, such as dry years when Wickiup Reservoir storage volume in the fall is quite low and inflow during the winter is also low, it may not be possible to meet the target flows. This situation is expected to be infrequent.

The ability to maintain target flows will also be influenced to a limited extent by seepage losses in Crane Prairie Reservoir, particularly during extended dry periods. As per Measure CP-1, Crane Prairie Reservoir will be maintained between 37,870 and 48,000 acre-feet at all times (see Section 6.2.2). This will result in increased seepage losses that will reduce Crane Prairie surface outflow (Wickiup surface inflow) compared to historical levels. An undetermined amount of the seepage from Crane Prairie Reservoir returns to Wickiup Reservoir through groundwater discharge, but at least a small portion is lost to a deeper aquifer and does not return to the Deschutes River until several miles downstream of Wickiup Dam.

As with all flow requirements in this DBHCP, the flow requirements of Conservation Measure WR-1 have allowable ranges of variation (Table WR-1) to account for multiple factors beyond the control of the Permittees that can influence instream flow. These factors include, but are not limited to, minor inaccuracies in the gages being used to monitor instream flow, natural fluctuations in flow from unregulated tributaries between measurement points, and actions by parties other than the Permittees that increase or decrease flow. In all cases, the allowable ranges of deviation are small and they are within limits that are designed to have insignificant or immeasurable effects on habitat for the covered species.

The hydrologic effects of Measure WR-1 have been modeled by Reclamation (2020a) and compared to historical conditions. The intended hydrological consequences of these changes are readily apparent in the comparison of modeled flows directly below Wickiup Dam (Figures 6-16 through 6-18). Winter flows under the DBHCP will get progressively higher than they were historically, while summer flows will get progressively lower. Throughout the year, DBHCP flows will be closer to the unregulated condition. In dry years, low inflow and/or lack of storage may result in insufficient water to maintain the specified flows below Wickiup Dam. In all other years, the minimum flows will be met.

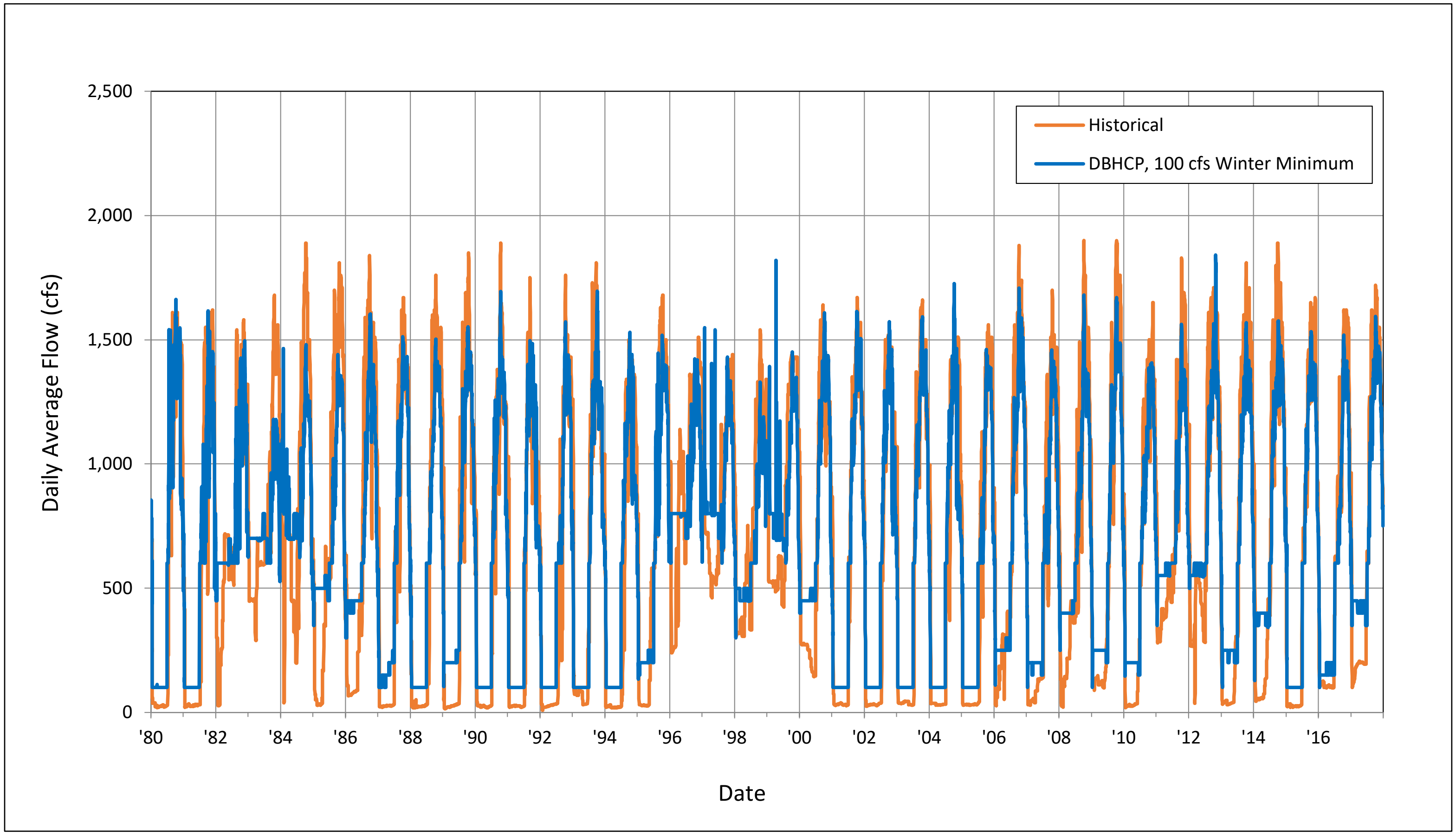

Figure 6-16. Daily average flows in the Deschutes River below Wickiup Dam (Station WICO) for historical conditions and projected DBHCP conditions with a winter minimum instream flow of 100 cfs. Sources: OWRD 2020b, Reclamation 2020a.

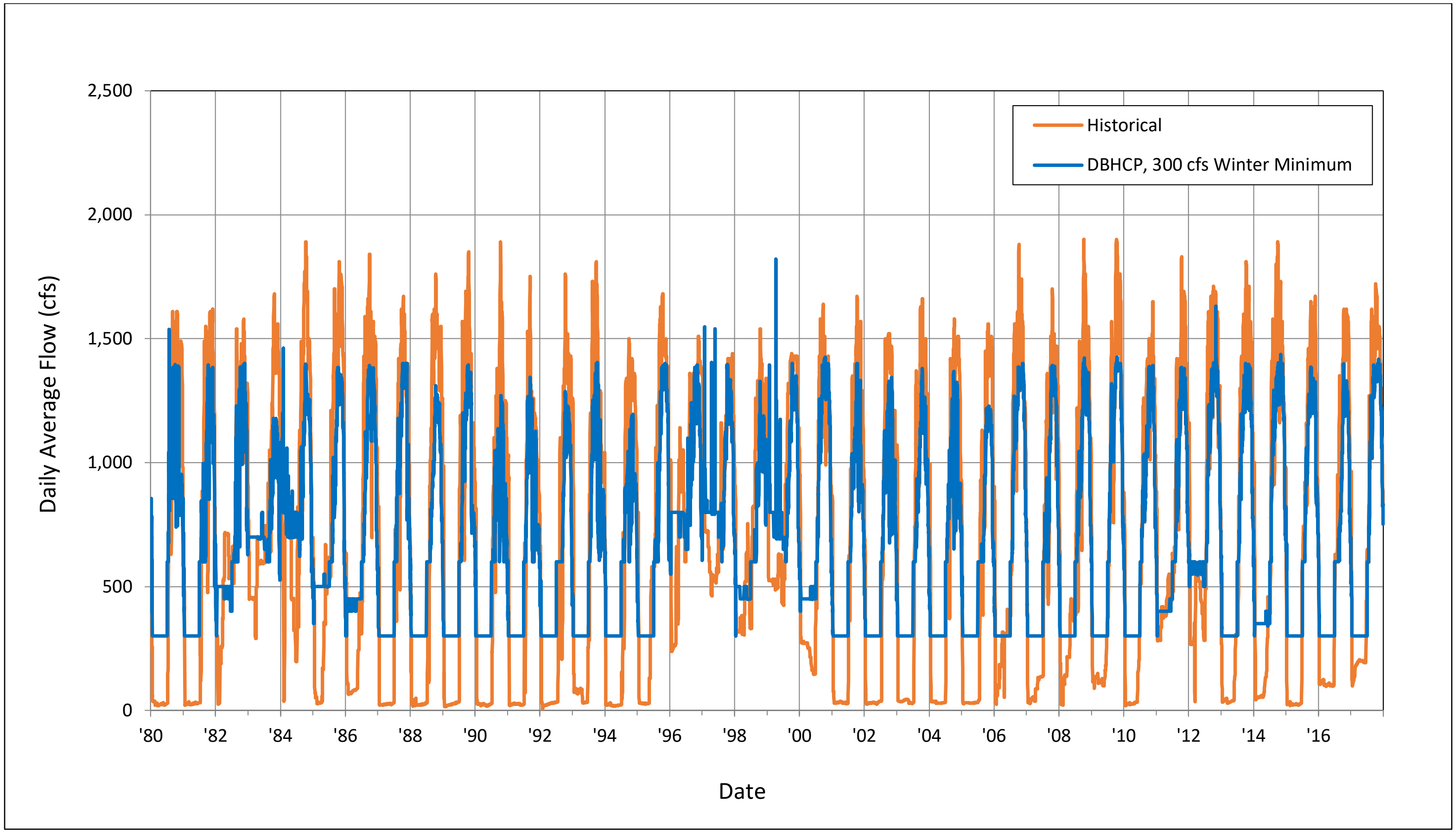

Figure 6-17. Daily average flows in the Deschutes River below Wickiup Dam (Station WICO) for historical conditions and projected DBHCP conditions with a winter minimum instream flow of 300 cfs. Sources: OWRD 2020b, Reclamation 2020a.

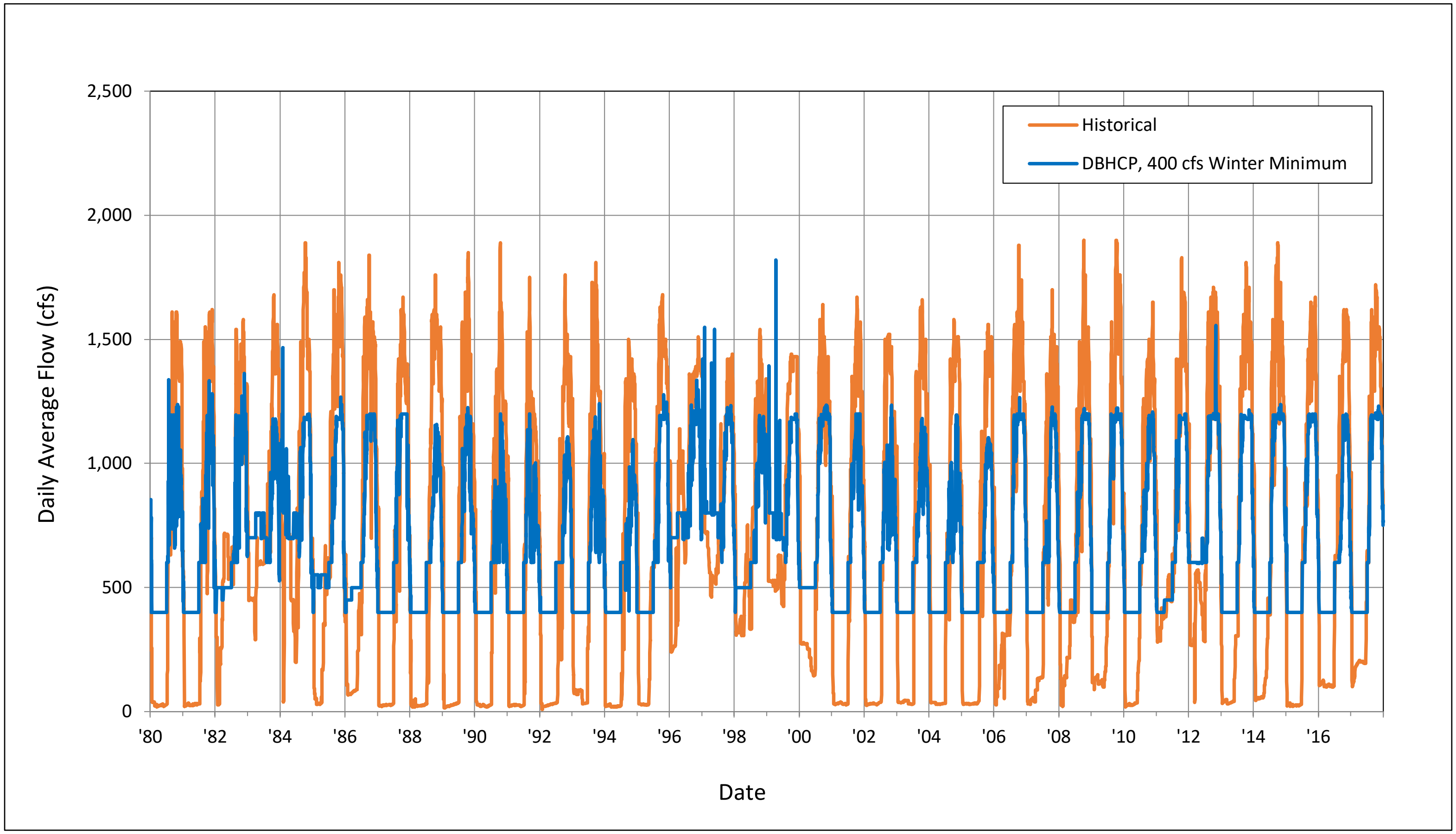

Figure 6-18. Daily average flows in the Deschutes River below Wickiup Dam (Hydromet Station WICO) for historical conditions and projected DBHCP conditions with a winter minimum instream flow of 400 cfs. Sources: OWRD 2020b, Reclamation 2020a.

The seasonal shift in hydrology under the DBHCP will be observable from Wickiup Dam to the mouth of the Deschutes River, although the relative magnitude of change will diminish with downstream distance due to the moderating effects of tributary inflow and counteracting effects of irrigation diversions. By Year 13, the minimum flow directly below Wickiup Dam during the winter will increase by nearly 380 cfs from historical conditions (minimum 20.8 cfs) and 300 cfs from current conditions (Year 1 minimum 100 cfs). However, the relative increase in median flows will be less than the relative increase in minimum flows because the flow at WICO is expected to exceed the required minimum of 100 cfs during wet winters in Years 1 through 7, and the median winter flow during this period will be closer to 200 cfs (Figure 6-19). This is consistent with historical hydrology, which indicates that natural inflow to Wickiup Reservoir often required releasing more than the required minimum of 20.8 cfs to keep the reservoir from overtopping. When the required minimum reaches 300 cfs by Year 8, however, the reservoir will be less likely to fill and the median flow will be the same as the minimum. During mid-summer there will be a decrease of less than 200 cfs in the median flow at WICO by Year 13 (Figure 6-19).

Median flows at Benham Falls will show similar trends, but the percentages of increase in winter and decrease in summer will be less because total flows will be higher (Figure 6-20). Downstream of Bend (Hydromet Station DEBO) the increase in winter flow will be similar to upstream locations, but summer flows will continue to be dominated by irrigation diversions and instream flows at Bend (Figure 6-21).

Annual storage in Wickiup Reservoir under the DBHCP will be progressively reduced as fall and winter flows are increased (Figure 6-22). As less water is stored, less will be available for release during the irrigation season. The average volume and water surface elevation of the reservoir will decrease from historical conditions. The average high elevation in April will be less than it has been historically, as will the average low in September (Figure 6-23). Infrequently in years of abundant water, the reservoir may fill and the annual difference between high and low water volume (and surface elevation) may be comparable to historical conditions. In most years, however, the reservoir will begin the irrigation season with less than the historical average volume, and it will be more likely to end the season with little or no remaining storage.

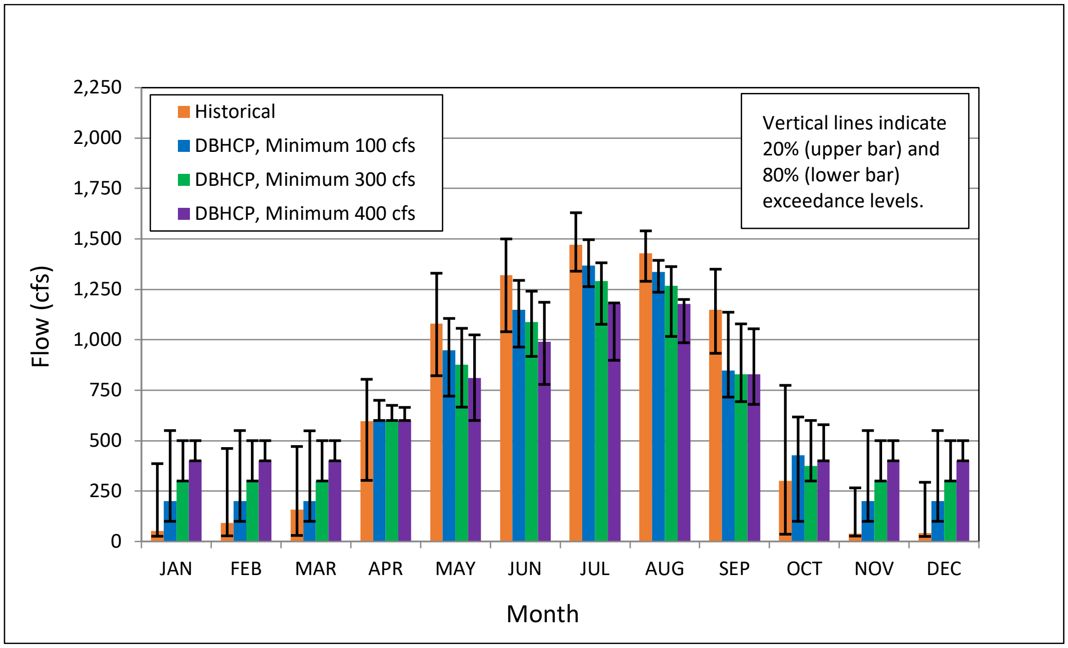

Figure 6-19. Monthly medians of daily average flows in the Deschutes River below Wickiup Dam (Hydromet Station WICO) for historical and DBHCP projected conditions. Sources: OWRD 2020b, Reclamation 2020a.

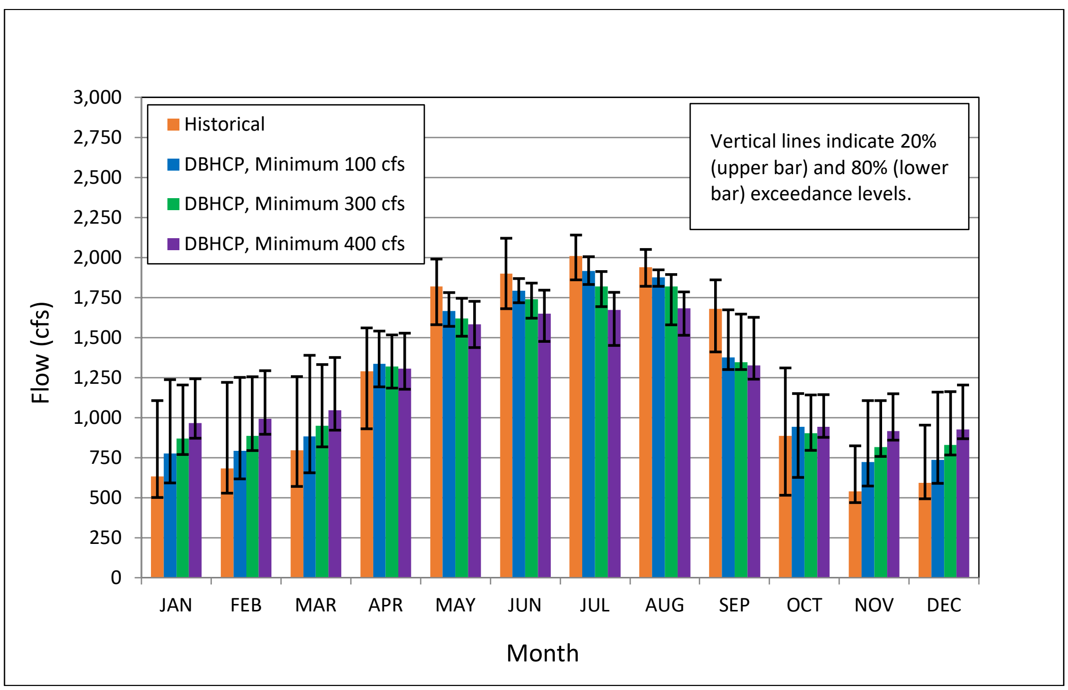

Figure 6-20. Monthly medians of daily average flows in the Deschutes River at Benham Falls (Hydromet Station BENO) for historical and DBHCP projected conditions. Sources: OWRD 2020c, Reclamation 2020a.

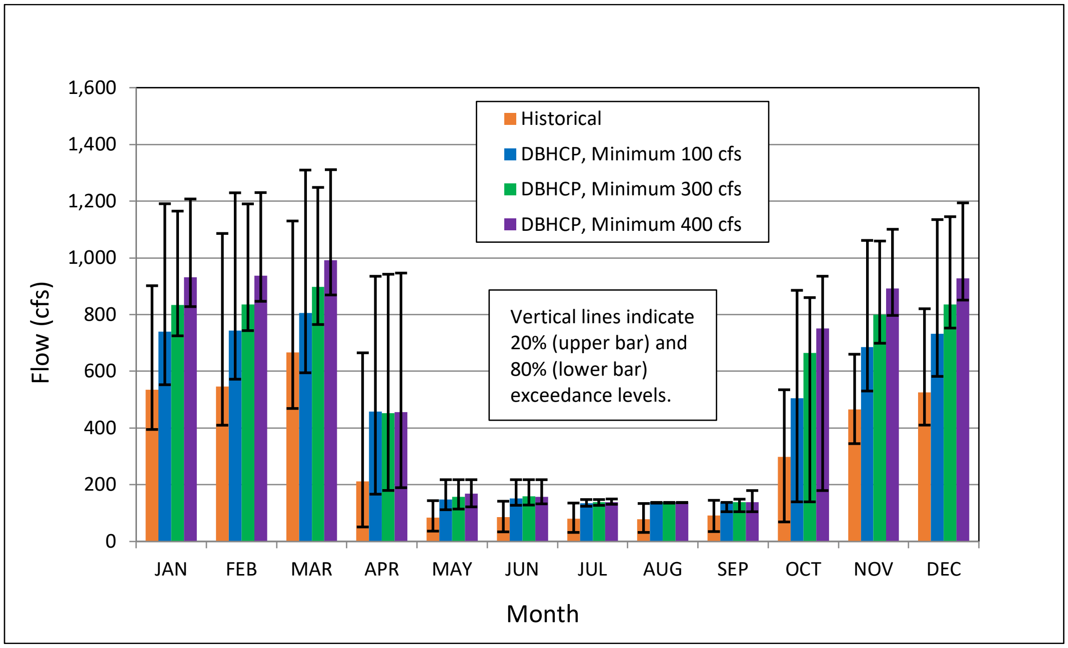

Figure 6-21. Monthly medians of daily average flows in the Deschutes River below Bend (Hydromet Station DEBO) for historical and DBHCP projected conditions. Sources: OWRD 2020d, Reclamation 2020a.

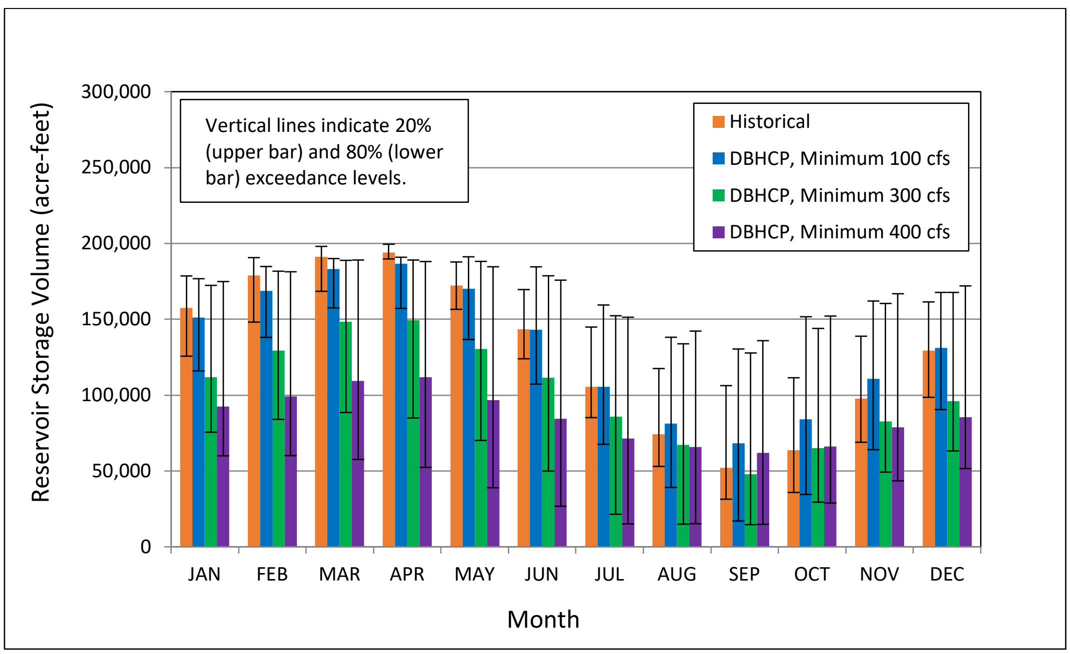

Figure 6-22. Monthly medians of daily storage volumes of Wickiup Reservoir for historical and DBHCP projected conditions. Sources: Reclamation 2020a, 2020c.

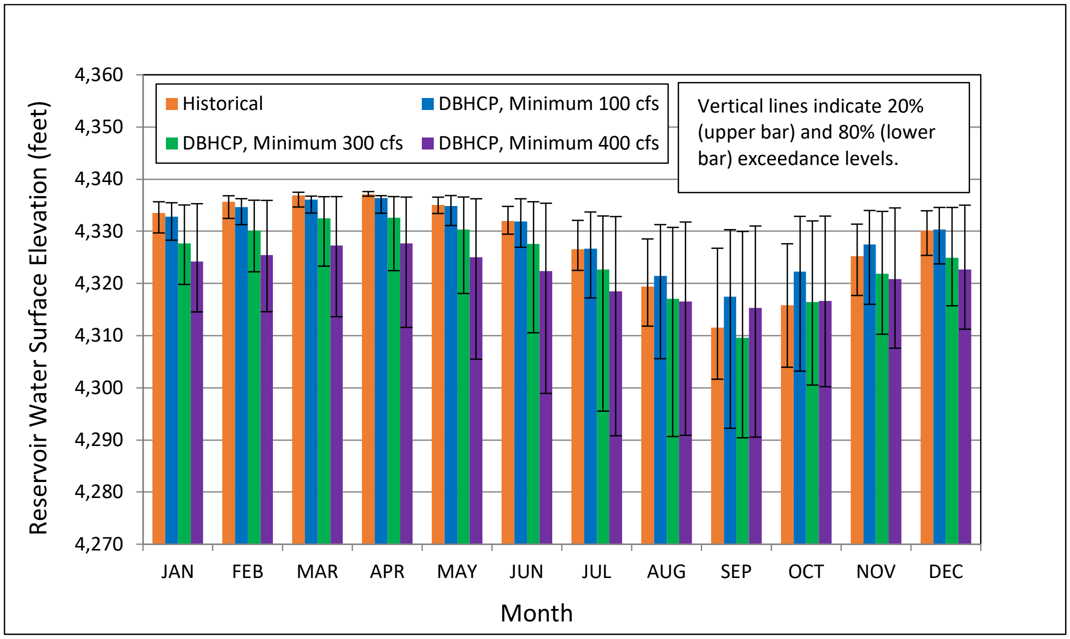

Figure 6-23. Monthly medians of water surface elevations in Wickiup Reservoir for historical and DBHCP projected conditions. Sources: Reclamation 2020a, 2020c.

6.2.7 Rationale for Conservation Measure UD-1

As of 2020 USFWS is developing a draft range-wide Recovery Plan for the Oregon spotted frog and a draft recovery strategy for the species in the Upper Deschutes Basin. It is anticipated the conservation strategy for the Upper Deschutes Basin will include the following biological goals:

1. Expand the overall distribution of populations and increase population viability and abundance of Oregon spotted frogs to contribute to the regional recovery of the species.
2. Reduce threats to existing populations of the species.
3. Increase the number of individuals in all age classes at known sites.
4. Increase connectivity between disjunct populations.

The lands covered by the DBHCP make up about 35 percent of the designated critical habitat for the Oregon spotted frog. Threats to Oregon spotted frogs within the covered lands identified by USFWS (2014, 2017 and 2019) include not only hydrological changes due to water management, but continued wetland habitat loss due to a lack of natural disturbance processes (e.g., floods, fire, beaver activity, etc.) unrelated to the covered activities. Open water areas within wetlands are being encroached upon by lodgepole pine, cattails and shrubs. Reed canarygrass, an invasive species, is present within a number of occupied sites where it can spread and render habitats less suitable for Oregon spotted frogs. Introduced vertebrate predators such as bullfrogs and nonnative fish also are present within a number of occupied sites on the covered lands, and active management is necessary to reduce the associated threats to Oregon spotted frogs.

Conservation measures in the DBHCP will adjust the timing and volume of water that is stored and released from covered reservoirs. These changes will improve hydrological conditions within Oregon spotted frog habitat at key times during the species' life cycle. The hydrologic changes will occur over time as the DBHCP is implemented in phases. Therefore, the full anticipated benefits to Oregon spotted frogs from the DBHCP will vary spatially and temporally within the Upper Deschutes Basin. In particular, long-term target flows for the mainstem Deschutes River between Wickiup Dam and Bend will not be fully realized until Year 13 of DBHCP implementation. Entities other than the Permittees will implement habitat restoration and enhancement activities in the Upper Deschutes River concurrent with the changes in hydrology provided by the DBHCP. Restoration and enhancement activities that will depend on the long-term target flows will be delayed until those flows are realized in Year 13. In the interim, restoration and enhancement activities that do not depend on the long-term flows can be implemented, along with temporary habitat maintenance activities in areas where the long-term flows are ultimately necessary. Conservation Measure UD-1 will provide a source of funding for both short-term and long-term activities that will work in parallel with flow improvements to address the threats to Oregon spotted frogs in the Upper Deschutes Basin.

The following are examples of the types of activities that will be supported by the Upper Deschutes Basin Conservation Fund. It is not anticipated the DBHCP will fully fund these activities; rather, it will provide seed money or matching funds to be used in consort with funding from other entities responsible for Oregon spotted frog management in the basin.

6.2.7.1 Crane Prairie Reservoir

Invasive species are among the existing threats to Oregon spotted frogs in Crane Prairie Reservoir. USFS is currently working to control invasive aquatic weeds in the reservoir, but reed canarygrass is not among the aquatic weeds currently being treated. Treatment of reed canarygrass at Crane Prairie Reservoir will be necessary to prevent spread into Oregon spotted frog breeding sites. ODFW is simultaneously working to control nonnative brown bullheads within the reservoir. Funds to continue these invasive species control efforts will be necessary in the future.

6.2.7.2 Deschutes River and Adjacent Wetlands Downstream of Wickiup Dam

Restoring the historical ecological function of the Deschutes River is considered a key path to restoring Oregon spotted frog habitat and improving connectivity between populations in this reach from Wickiup Dam to Bend. Restoration in this segment of the river is primarily dependent upon improvement to flows coupled with site-specific improvements to the river bed and banks to more effectively convey water into oxbows and wetlands where Oregon spotted frogs occur. Short-term actions that can be taken in Years 1 through 12 could include:

- Reed canarygrass treatment at multiple existing Oregon spotted frog sites
- Bull frog removal in Sunriver wetlands
- Treatment of encroaching vegetation (cattails, lodgepole, etc.) in Sunriver, Slough Camp and Les Schwab Amphitheatre Marsh in Bend
- Beaver dam analog at Dead Slough to mitigate headcut formation and maintain higher winter water elevations in the slough

Winter flows of 400 cfs or more beginning in Year 13 will allow for additional localized and site-specific restoration activities. Some passive restoration (i.e., natural expansion of native wetland vegetation) is likely to occur under this flow scenario, but active management of occupied Oregon spotted frog sites will be necessary. In addition to the short-term actions that can occur prior to Year 13, flows of 400 cfs or more during the winter will facilitate the following types of restoration and conservation actions:

- Bank restoration and planting of riparian vegetation
- Wood placement within channel to improve depositional aggradation to reduce cross-sectional area of river channel thus improving floodplain/wetland connectivity to river channel
- Beaver dam analogs in oxbows, side channels and wetlands to moderate the effects of flow fluctuations
- Excavation of existing wetlands and river to improve hydrological connectivity
- Excavation of oxbows on floodplain to intercept groundwater
- Physical habitat modifications at site scale to benefit specific life stages of Oregon spotted frogs

6.2.7.3 Little Deschutes Subbasin (including Crescent Creek)

There are potential opportunities to conduct conservation actions for Oregon spotted frogs on federal and private lands in the Little Deschutes subbasin almost immediately under the DBHCP. About 70 percent of the lands adjacent to the Little Deschutes River and Crescent Creek are in private ownership. Therefore, private lands are important to conservation and recovery of Oregon spotted frogs.

Current plans are underway to implement bull frog control on private lands in the lower reaches of the Little Deschutes River. A team of volunteers and consultants, with help from federal and state agencies, are developing a strategy to control bull frogs and reduce threats to Oregon spotted frogs. The Upper Deschutes Basin Conservation Fund can help support this effort.

Additional conservation and restoration activities that could be conducted within the Little Deschutes subbasin to support Oregon spotted frog conservation include, but are not limited to:

- Installation of beaver dam analogs and wood structures within channel to increase duration and spatial extent of water on the floodplain and within oxbow habitats to support Oregon spotted frog life cycles and habitat connectivity
- Riverbank restoration
- Reed canary grass treatment along the river and at Oregon spotted frog sites
- Bull frog removal to reduce predation on Oregon spotted frogs
- Excavation of oxbows on floodplain to intercept groundwater

6.2.7.4 Restoration of Oregon Spotted Frog Sites Outside the Covered Lands

There are several Oregon spotted frog sites outside of the area affected by the covered activities where wetland function could be restored to promote conservation of the species. Some of these sites (e.g., Dilman Meadow) need maintenance to reduce existing threats to the frogs.

6.2.8 Conservation Goal and Objective for the Middle Deschutes River

6.2.8.1 Middle Deschutes River Goal No. 1

Reduce the adverse effects of stock water diversions on the Deschutes River downstream of Bend during the storage season.

6.2.8.2 Measurable Resource Objective for Middle Deschutes River Goal No. 1

Middle Deschutes River Objective 1-A: Avoid stock water diversions that would reduce the flow in the Deschutes River below Bend to less than 250 cfs during the storage season (November 1 through March 31).

6.2.8.3 Rationale for Middle Deschutes River Goal No. 1

Water is not released from storage or diverted from the Deschutes River for irrigation purposes during the winter, but three of the DBBC Districts (AID, COID and SID) divert natural flow from the Deschutes River for livestock watering every 4 to 6 weeks from November through March. These diversions (known as stock water runs) are typically much smaller than irrigation diversions and they last only about 5 days at a time. While the three districts have not historically coordinated the timing of their stock runs, the runs have tended to occur simultaneously because all three Districts are responding to the same weather conditions (warm spells) to reduce icing in the canals. When stock runs occur simultaneously they have the potential to significantly reduce Deschutes River flows downstream of Bend. The intent of Middle Deschutes River Goal No. 1 is to avoid adverse effects on flow from simultaneous stock water runs. There is a single measurable resource objective for this goal.

6.2.9 Conservation Measure for the Middle Deschutes River

There is one conservation measure for the Middle Deschutes River. This measure addresses Middle Deschutes River Goal No. 1 and Middle Deschutes River Objective 1-A.

Measure DR – 1: Middle Deschutes River Flow Outside the Irrigation Season

Three DBBC Districts (AID, COID and SID) will coordinate stock water diversions and other diversions of live flow from the Deschutes River between November 1 and March 31 to prevent such diversions from resulting in a 1-day average flow of less than 250 cfs (±25 cfs) at Hydromet Station DEBO (OWRD Gage 14070500) below Bend. If flow in the Deschutes River upstream of Bend (Hydromet Station BENO) is less than 250 cfs, the three DBBC Districts will not conduct stock water diversions or other diversions of live flow from the Deschutes River, but they also will have no obligation to release storage beyond the requirements of Conservation Measure WR-1, or otherwise augment flow, in order to provide 250 cfs at DEBO.

AID, COID and SID shall have no obligation to reduce diversions to account for simultaneous diversions by other parties between BENO and DEBO. If the flow at BENO minus the combined diversions by AID, COID and SID is ≥ 250 cfs, but the flow at DEBO is < 250 cfs due to simultaneous diversion or retention of water by another party, AID, COID and SID shall be considered in compliance with this measure. In addition, none of the three Districts shall be found out of compliance with this measure during any time they are not actively diverting water from the Deschutes River.

6.2.10 Rationale for Conservation Measure DR-1

6.2.10.1 Overview

AID, COID and SID conduct stock water diversions from the Deschutes River throughout the winter (November through March). All three Districts divert the water at their primary diversion facilities within Bend. Flows in the Deschutes River immediately upstream of Bend rarely drop below 300 cfs during the winter, but flows downstream of Bend have dropped to less than 250 cfs have on several occasions. The potential for low flows will be reduced in the future because of increased flow out of Wickiup Reservoir during the winter (see Measure WR-1). Nevertheless, a lack of coordination between the Districts could still result in flows of less than 250 cfs downstream of Bend during stock runs. To remedy this, Measure DR-1 will require the coordination of stock runs. The targeted minimum flow in Measure DR-1 is based on the ODFW Application for Instream Water Right of 250 cfs to support salmonid and smallmouth bass migration, spawning, egg incubation, fry emergence and juvenile rearing from North Canal Dam (RM 165) to Round Butte Reservoir (RM 119.5).

Conservation Measure DR-1 clarifies that the three Permittees (AID, COID and SID) shall not be responsible for preventing or mitigating the impacts of other diverters along the Deschutes

River during the winter. At times when the Permittees are not diverting water, and thus not influencing flow in the Middle Deschutes River, they will not be obligated to take corrective actions for the effects of others. The minimum flows required at WICO under Measure WR-1, combined with natural inflow from surface tributaries and springs between Wickiup Dam and Bend, will always result in flows of at least 250 cfs reaching Bend. If the Permittees are not diverting stock water and the flow downstream of Bend is less than 250 cfs, this is a result diversion by other parties (or extreme natural conditions) that will not require action by the Permittees. However, the Permittees may only divert stock water when at least 250 cfs is passing their diversions, regardless of the rate of flow reaching the diversions. This will ensure the Permittees never cause the flow at DEBO to drop below 250 cfs.

6.2.10.2 Effects of Historical Stock Water Diversions

From 1981 through 2018, daily average flow in the Deschutes River upstream of Bend at Benham Falls (Hydromet Station BENO) never dropped below 330 cfs in November through March (OWRD 2020c). During those same months, Deschutes River flow at Hydromet Station DEBO downstream of Bend dropped below 250 cfs for a total of 291 days (5.2 percent of the time), and reached as low as 21 cfs in December 1980 (Table 6-3).

Table 6-3. Reported days with average flow of less than 250 cfs at Hydromet Station DEBO (OWRD Gage 14070500) on the Deschutes River downstream of Bend from 1981 through 2018.

Month	Number of Days with Daily Average Flow less than 250 cfs	Minimum Daily Average Flow (cfs)
November	113	22
December	57	21
January	59	102
February	34	90
March	28	60
TOTAL	**291**	–

Source: OWRD 2020d

6.2.10.3 Effects of DBHCP Measure DR-1 on the Hydrology of the Middle Deschutes River

Coordination between the three Permittees involved in Deschutes River winter stock runs will prevent stock runs from resulting in daily average flows of less than 250 cfs downstream of Bend. As long as the flow is at least 250 cfs upstream of Bend between November 1 and March 31, the flow will also be at least 250 cfs downstream of Bend. Historical records for the 38-year period from 1981 through 2018 show the flow upstream of Bend at Benham Falls never dropped below 350 cfs during the winter, while the flow downstream of Bend reached as low as 99 cfs (Figure 6-24). Under the DBHCP, increases in minimum flows below Wickiup Dam (Measure WR-1) and Crescent Dam (Measure CC-1) will make it even less likely the total combined flow at Bend would be as low as 250 cfs. With Conservation Measure DR-1 in place, at least 250 cfs of the flow reaching Bend during the winter will always continue to flow past Bend.

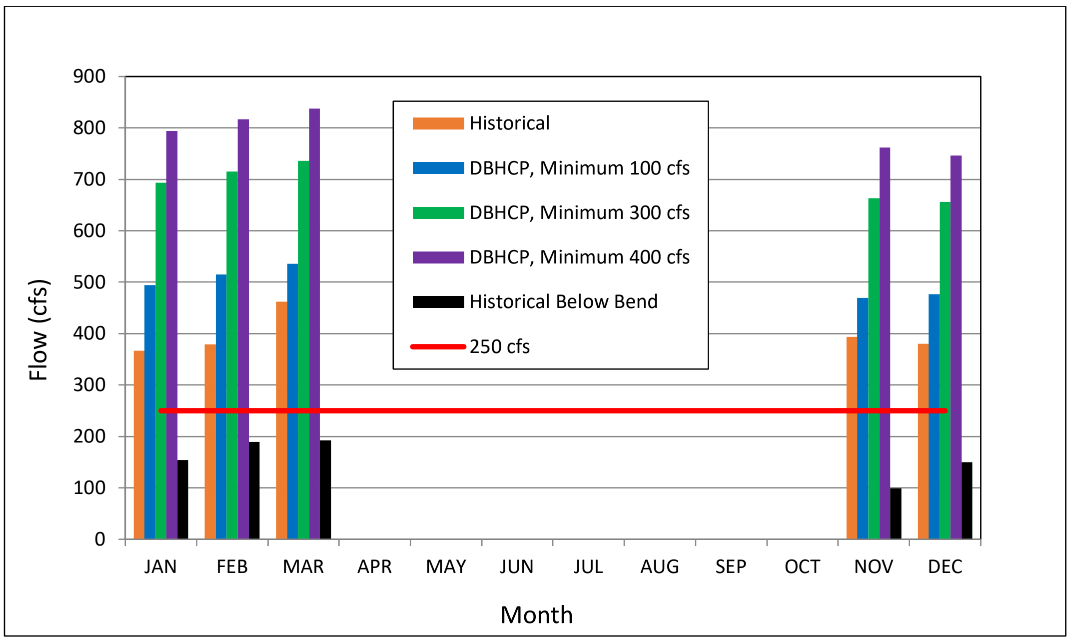

Figure 6-24. Monthly minimums of daily average flows in the Deschutes River at Benham Falls (Hydromet Station BENO) during the winter for historical and DBHCP projected conditions. Sources: OWRD 2020c, Reclamation 2020a.

6.3 Crescent Creek and Little Deschutes River

6.3.1 Conservation Goals and Objective for Crescent Creek and Little Deschutes River

6.3.1.1 Crescent Creek Goal No. 1

Manage flows in Crescent Creek downstream of Crescent Dam to support riverine and wetland habitats in lower Crescent Creek and lower Little Deschutes River (downstream of the confluence with Crescent Creek) for all life stages of the Oregon spotted frog at levels capable of sustaining the species over the long term.

6.3.1.2 Measurable Resource Objectives for Crescent Creek Goal No. 1

Crescent Creek Objective 1-A: Maintain flows in Crescent Creek below Crescent Dam within the natural range during the storage season, while avoiding extremely low flows, to support Oregon spotted frog overwintering and seasonal movements in lower Crescent Creek and lower Little Deschutes River.

Crescent Creek Objective 1-B: Manage the release of irrigation storage from Crescent Lake Reservoir to support sustainable Oregon spotted frog breeding/rearing/nonbreeding habitat and fall movements to overwintering habitat in lower Crescent Creek and lower Little Deschutes River.

Crescent Creek Objective 1-C: Regulate the rate of change in flow below Crescent Dam to reduce the potential for flushing and stranding of frogs

6.3.1.3 Rationale for Crescent Creek Goal No. 1

Tumalo Irrigation District (TID) owns and operates Crescent Lake Reservoir at RM 29 on Crescent Creek (Figure 6-25). This reservoir is the only DBHCP covered activity in the Little Deschutes subbasin, and water released from the reservoir is not diverted until it reaches Bend in the Deschutes River. Operation of the reservoir influences the timing and magnitude of streamflow in the lower 29 miles of Crescent Creek, the lower 57 miles of the Little Deschutes River, and 193 miles of the Deschutes River from its confluence with the Little Deschutes River to the Columbia River. The effects of operation are most apparent in Crescent Creek and the Little Deschutes River and are very small in the Deschutes River because the upper Crescent Creek watershed, with an area of 57 square miles, contributes only 3.2 percent of the water in the Deschutes Basin at Benham Falls. Consequently, the management of Crescent Lake Reservoir under the DBHCP focuses on Crescent Creek and the Little Deschutes River.

Oregon spotted frogs are present in lower Crescent Creek (downstream of Big Marsh Creek) and in the Little Deschutes River upstream and downstream of the confluence with Crescent Creek. Historical operation of Crescent Lake Reservoir has reduced flows in the affected portions of Crescent Creek and Little Deschutes River during TID's storage season (typically October through May) and increased flows in these same waters during their peak irrigation season (July through September). The reservoir has also moderated natural short-term fluctuations in flow by buffering the effects on storm events and snowmelt pulses originating upstream of the dam.

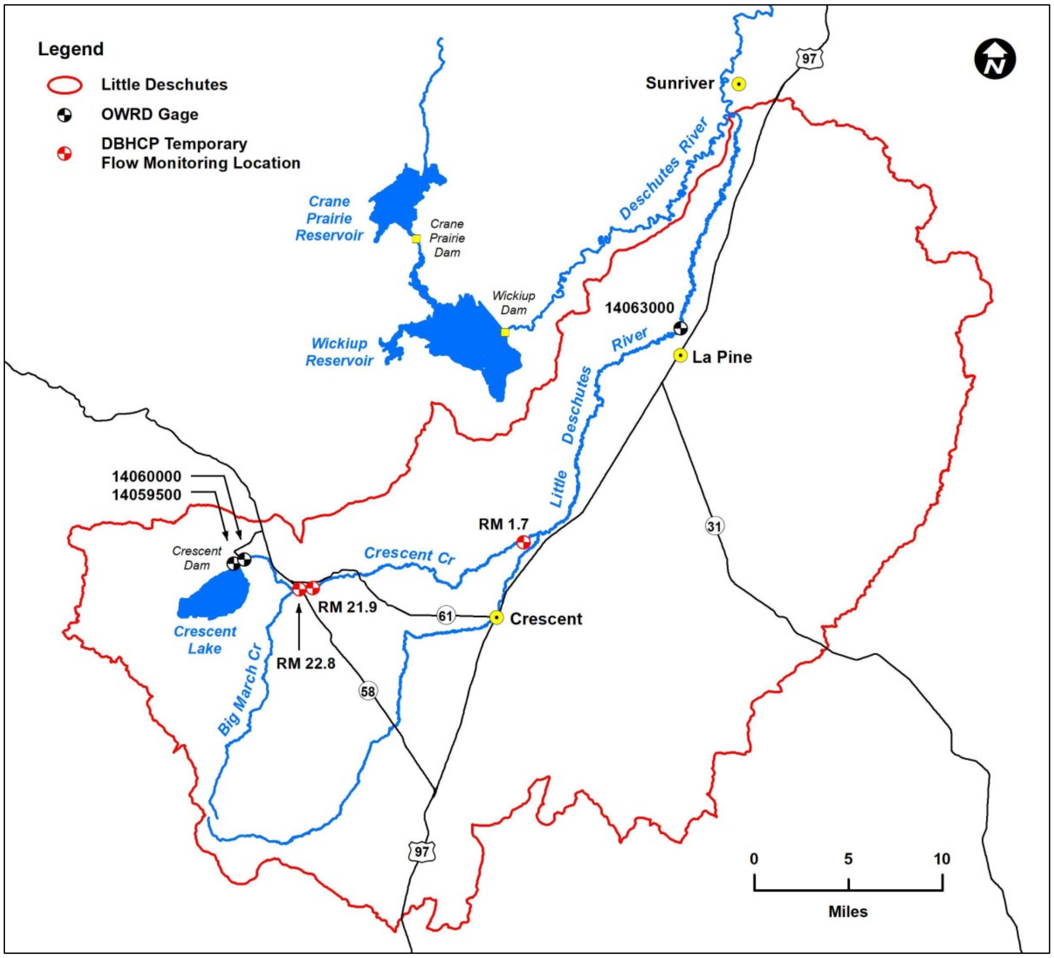

Figure 6-25. Map of the Little Deschutes River subbasin showing Crescent Creek and Crescent Lake Reservoir.

These historical changes in hydrology have had both positive and negative effects on Oregon spotted frogs. The positive effects have been increased availability of wetland habitat in the late summer when natural flows in Crescent Creek and the Little Deschutes River would otherwise be quite low, and reduction in the potential for egg mass stranding during the breeding season by reducing the magnitude of short-term fluctuations in water depth. The negative effects have been unnaturally low flows in portions of Crescent Creek during the storage season and rapid changes in flow (and water depth) from operational changes in reservoir releases during and at the end of the irrigation season. The goal of the DBHCP is to reduce or eliminate the negative effects of reservoir operation without inadvertently reducing the historical benefits.

There are three measurable resource objectives related to Crescent Creek Goal No. 1. Crescent Creek Objective 1-A addresses the effects of reservoir operation on creek flows during the storage season (fall, winter and spring), Objective 1-B addresses the effects of reservoir operation on creek flows during the irrigation season (summer), and Objective 1-C addresses the rate at which creek flows are allowed to change when TID is transitioning between seasons.

6.3.2 Conservation Measures for Crescent Creek and the Little Deschutes River

Conservation Measure CC – 1: Crescent Creek Flow Management *

During the term of the DBHCP the storage volumes shown in Table CC-1 shall be made available for Oregon spotted frog conservation in Crescent Creek. The volumes in Table CC-1 include Crescent Creek instream and storage rights for fish and wildlife use that have already been created through TID conserved water projects, as well as water rights that will result from future TID conserved water projects. The volume of water available each year shall be determined on July 1 based on total storage volume in Crescent Lake Reservoir on that date. This water will be available for release over the subsequent (first) water year (October 1 – September 30), after coordination with USFWS and ODFW to maximize benefits to fish and wildlife, and may not be carried over in whole or in part into the second water year. The rate of release of this stored water from Crescent Lake Reservoir may be adjusted up to two times per month. A portion of the water shall be used each year to maintain the storage season minimum instream flows specified in Table CC-2. The remaining water may be used to: a) increase the storage season minimum flows above the levels specified in Table CC-2, b) increase instream flow prior to the ramping up of irrigation releases from Crescent Lake Reservoir in late spring or early summer, or c) delay the ramping down of irrigation releases from the reservoir at the end of the irrigation season. If TID conserved water projects result in Crescent Creek rights for fish and wildlife use that exceed the amounts specified in Table CC-1 for the respective years of DBHCP implementation, the higher storage rights will become the requirement under this conservation measure when the conservation projects are complete.

Table CC-1. Volumes of storage in Crescent Lake Reservoir to be made available for Oregon spotted frog conservation under the DBHCP.

DBHCP Implementation Years	Volume of Crescent Lake Reservoir Storage (acre-feet) to be Available for Oregon Spotted Frog Conservation[1,2]		
	When Total Storage Volume[2] on July 1 is < 45,000 acre-feet	When Total Storage Volume[2] on July 1 is 45,000 – 75,000 acre-feet	When Total Storage Volume[3] on July 1 is > 75,000 acre-feet
1-10	5,264	7,264	8,764
11-15	6,464	8,464	9,964
16-20	7,664	9,664	11,164
21-30	8,864	10,864	12,364

Notes:

1 Total volume of water available for Oregon spotted frog conservation under this measure includes, and is not in addition to, Crescent Lake Reservoir storage allocated for fish and wildlife use under Oregon water law.

[2] The water made available each year can only be used during the subsequent (first) water year, and may not be carried over in whole or in part into the second water year.
[3] Total storage volume will be measured at Hydromet Station CRE (OWRD Gage 14059500) as the 3-day average for June 29 – July 1 to reduce the effects of wind-induced fluctuations in storage volume readings at the gage.

Table CC-2. Minimum flows at Hydromet Station CREO (OWRD Gage 1406000) under the DBHCP.

DBHCP Implementation Years	Storage Season Minimum Flow (cfs) [1] (Oct 1 – Jun 30)	Irrigation Season Minimum Flow (cfs) [2, 3] (Jul 1 – Sep 30)
1-10	10 (±1) cfs	50 (±5) cfs
11-15	10 (±1) cfs	50 (±5) cfs
16-20	11 (±1) cfs	50 (±5) cfs
21-30	12 (±1) cfs	50 (±5) cfs

Notes:
[1] Allowances of ± 1 cfs are for compliance purposes to allow for inaccuracies in gage measurements and limitations in the precision of dam operation.
[2] Allowances of ± 5 cfs are for compliance purposes to allow for inaccuracies in gage measurements and limitations in the precision of dam operation.
[3] Instream flow may be less than 50 cfs if low storage volume in Crescent Lake Reservoir makes passive release of water impossible.

The flow at CREO may be less than the minimums specified in Table CC-2 during gate tests, gallery/conduit inspections, dam maintenance, and minor repairs. Flow changes to accommodate these actions will be done in coordination with USFWS.

- Gate tests and gallery/conduit inspections will be conducted between October 1 and November 31 and will last no more than 8 hours each. During gate tests and gallery/conduit inspections TID will utilize the existing bypass (estimated to be 5 cfs) to maintain a flow downstream of the dam.
- Maintenance involving removal of rock from the ramp flume will not cause cessation of flows for more than 2 hours. The timing of these maintenance activities will be coordinated in advance with USFWS.
- Minor repairs will not result in complete cessation of flows for more than 4 hours, flows below 10 cfs for more than 8 consecutive hours, or flows of less than 10 cfs for more than 24 hours cumulatively in a one-week period. The timing of minor repairs will be

coordinated in advance with USFWS.

* *USFWS is not a water manager. All references here and elsewhere in this DBHCP regarding USFWS involvement in water management decisions are intended to define where USFWS technical assistance will be sought to remain in compliance with the Conservation Measures.*

Conservation Measure CC – 2: Crescent Dam Ramping Rates

Tumalo Irrigation District will not increase in the flow below Crescent Dam (as measured at OWRD Gage 14060000) more than 30 (±2) cfs per 24-hour period or decrease the flow more than 20 (±2) cfs per 48-hour period, except under emergency conditions.

Conservation Measure CC – 3: Crescent Lake Reservoir Irrigation Release Season

Annual transition from irrigation season flows (≥ 50 cfs) to storage season flows (≥ 10 cfs) at Hydromet Station CREO below Crescent Dam will end no later than October 31 of each year.

6.3.3 Rationale for Conservation Measure CC-1

6.3.3.1 Overview

Conservation Measure CC-1 will dedicate a portion of the storage in Crescent Lake Reservoir each year for Oregon spotted frog habitat management (hereinafter referred to as "OSF storage"). The OSF storage will be released after coordination with USFWS to increase flows in lower Crescent Creek and lower Little Deschutes River at times when flows would otherwise be insufficient to support Oregon spotted frog habitats. The amount of water available for this purpose will vary depending on the total storage available in the reservoir, and it will increase over the term of the DBHCP as TID completes water conservation projects and reduces its need for Crescent Lake storage (Table 6-4). A certain amount of the OSF storage will be dedicated for use during the storage season (October 1 through June 30) to provide a minimum flow at Hydromet Station CREO below Crescent Dam of 10 cfs in Years 1 through 15 of DBHCP implementation, 11 cfs in Years 16 through 20, and 12 cfs in Years 21-30. The remaining OSF storage may be used to increase the storage season flow at CREO even further, or it may be used to increase flows in the spring and fall when TID is releasing little or no storage for irrigation use. These "shoulder seasons" before and after irrigation releases have been identified by USFWS as important periods in the life cycle of the Oregon spotted frog. The release of OSF storage during the shoulder seasons can offset naturally low flows in Crescent Creek and Little Deschutes River and support riparian wetlands used by the frogs for breeding, summer rearing/foraging and transitioning to overwintering.

If TID begins to release storage for irrigation prior to July 1 or continues to release storage for irrigation after October 1, the irrigation releases will count in lieu of using OSF storage toward maintaining the minimum flows indicated in Table CC-2. When this occurs, the amount of OSF storage available for use at other times of year will show a corresponding increase.

Table 6-4. Volumes of storage in Crescent Lake Reservoir to be made available for Oregon spotted frog conservation under the DBHCP.

DBHCP Years	Minimum Flow at CREO Oct 1 – Jun 30 (cfs)	Maximum Volume of OSF Storage Required to Provide Minimum Flow at CREO Oct 1 – Jun 30 (acre-feet)	OSF Storage Available for Uses Other than Providing Minimum Flow at CREO (acre-feet) [1]		
			When Total Storage Volume on July 1 is < 45,000 acre-feet	When Total Storage Volume on July 1 is 45,000 - 75,000 acre-feet	When Total Storage Volume on July 1 is > 75,000 acre-feet
1-10	10	2,174	3,090	5,090	6,590
11-15	10	2,174	4,290	6,290	7,790
16-20	11	2,717	4,947	6,947	8,447
21-30	12	3,261	5,603	7,603	9,103

Note:

1 Volumes of water available are calculated based on the maximum volume of water needed for storage season flows from October 1 through June 30. If TID begins releasing water for irrigation from Crescent Lake Reservoir prior to July 1 in a given year, the irrigation release will contribute toward meeting the minimum flow, and the volume of water required from this conservation measure to provide the minimum flow will decrease. When this happens there will be a corresponding increase in the volume of water available for other uses to benefit Oregon spotted frogs.

Natural flows in lower Crescent Creek are variable throughout the year, but historical operation of Crescent Lake Reservoir has held flows downstream of the dam consistently at the low end of the natural range during the storage season (October through May). Prior to the beginning of the 21st Century there was no required minimum flow in Crescent Creek. As recently as 2005, OWRD (2020e) reported a flow of less than 1 cfs below Crescent Dam for several consecutive days in October. Low flows in the fall can interfere with seasonal movements by Oregon spotted frogs between summer and winter habitats. Low flows during the winter can reduce the total area of inundated wetland available for overwintering and increase the potential for the formation of anchor ice in occupied wetlands. Low flows in the spring can reduce the total area of inundated wetlands available for breeding and larval development. Conservation Measure CC-1 will increase the base (minimum) flow below Crescent Dam throughout the storage season and make additional water available for release in the spring and fall to improve wetland habitat conditions and reduce the potential for adverse impacts of reservoir operation on Oregon spotted frogs.

Water stored in Crescent Lake Reservoir comes from moderate to low inflow throughout the winter, followed by snowmelt and precipitation runoff late in the storage season. Small increases in the base flow below the dam during the storage season will cause reductions to storage, but they will have substantial benefits to downstream wetland habitats. Irrigation storage will continue to occur under the DBHCP, but the minimum flow during the storage season will be increased to avoid extremely low flows. The minimum flow of 10 cfs in Years 1 through 15 under Conservation Measure CC-1 represents a natural flow exceedance level of 65 to 75 percent during the months of October through March. This means the flow below Crescent Dam during the fall and winter will be managed at or above the 75 percent exceedance level (25th percentile) for natural flows, thereby preventing flows from getting as low as they did historically or as low as they would naturally. When the minimum flow reaches 12 cfs in Year 21, this will represent at least the 27th percentile of natural flow during the fall and winter.

The minimum flow of 10 cfs specified in Conservation Measure CC-1 during the storage season was selected to balance the desire to increase winter flows with the need to continue storing water for release in the spring, summer and fall when it is most beneficial to Oregon spotted frogs. Summer releases for irrigation occur at a time when Crescent Creek and the Little Deschutes River would otherwise be at their lowest flows of the year. Releases of OSF storage before and after irrigation releases can extend the benefits of the irrigation releases into the remaining dry months of the year. These increases help support riparian wetland conditions that would otherwise not occur. Water is stored in Crescent Lake Reservoir over 9 months, and will be released under the DBHCP primarily over 3 to 5 months. Consequently, small increases in flow during the winter have the potential to cause much larger reductions in flow during the spring, summer and fall. This situation will be avoided by maintaining only modest flows of 10 to 12 cfs during the winter. To further protect the beneficial increases in summer flows that occurred historically, Conservation Measure CC-1 also requires a minimum flow of 50 cfs from July 1 through September 30.

In addition to seasonal changes in flow, reservoir operation (which involves the release of water at a constant rate) moderates natural fluctuations in flow that occur on a daily or weekly basis due to precipitation events and snowmelt. Natural fluctuations during the Oregon spotted frog breeding season can harm eggs and young tadpoles; moderation of the fluctuations will be a benefit to the frogs.

6.3.3.2 Effects of Historical Crescent Lake Reservoir Operation on Flow

Upper Crescent Creek basin (above Crescent Dam) provides about 40 percent of the average annual flow in Crescent Creek (Table 6-5). Big Marsh Creek, the largest tributary to Crescent Creek, enters about 6 miles downstream of Crescent Dam at RM 23 and contributes another 26 percent to average annual flow (see Figure 6-25). Much of the remaining 36 percent of the annual flow in Crescent Creek enters between Crescent Dam and Big Marsh Creek (Gannett et al. 2001). The relative contributions of upper Crescent Creek and Big Marsh Creek to Little Deschutes River flows are 13 and 8 percent, respectively. The upstream limit of known Oregon spotted frog distribution in Crescent Creek is at RM 22.8 (downstream of Big Marsh Creek), where reservoir operation influences only about 40 to 50 percent of the total flow on an annual basis.

Table 6-5. Percentage of average annual precipitation volume in subbasins of the Little Deschutes River at La Pine, and in Crescent Creek at mouth

	Little Deschutes River Total	Little Deschutes River above La Pine	Crescent Creek Total	Crescent Creek Above Crescent Dam	Big Marsh Creek
Drainage Area	1,050 mi^2	859 mi^2	186 mi^2	57 mi^2	49 mi^2
Percent of Average Annual Precipitation Volume in Little Deschutes Basin at La Pine	-	100	31	13	8
Percent of Average Annual Precipitation Volume in Crescent Creek Basin at Mouth	-	-	100	40	26

Source: R2 and Biota Pacific 2016.

The effects of Crescent Lake Reservoir operation on downstream hydrology can be seen by comparing historical flows with unregulated flows (those that would have occurred without the reservoir). Historical flows for the period of 1983 through 2015 at Hydromet Stations CREO (OWRD Gage 14060000) and LAPO (OWRD Gage 14063000) were obtained from OWRD (2020e, 2020f). Unregulated flows at both locations were estimated for the same period from historical flows and corresponding changes in daily storage volume of the reservoir (R2 and Biota Pacific 2016), based on the assumption that a change in storage volume of 1 acre-foot over a 24-hour period corresponds to a continuous flow of 0.5042 cfs. If reservoir volume increased over a 24-hour period, the corresponding volume of water was converted to a daily average flow and added to historical flow to produce an estimate of unregulated flow for that day. If reservoir volume decreased, the corresponding amount of water was subtracted from historical flow to estimate unregulated flow. (Note that the analysis period of 1983-2015 is shorter than the analysis period of 1981-2018 utilized for the Deschutes River and other covered waters. This is due to limited availability of unregulated flow data before 1983 and after 2015 for Crescent Creek.)

Historical and unregulated daily average flows were also estimated at two locations in lower Crescent Creek (RM 22.8 and RM 1.7) by: a) developing rating curves for both locations (Figures 6-26 and 6-27), b) collecting water depth data for one full year (2015), c) correlating 2015 flows at the two locations with reported flows at CREO (Figures 6-28 and 6-29) and d) using those correlations to generate estimated flows for the period of 1983 through 2015. While the rating curves shown in Figures 6-26 and 6-27 are based on a limited number of measurements and do not achieve the level of precision typically needed to determine absolute flow, they do provide relative estimates of water surface elevation and flow that can be used to characterize the relationship between the two in Crescent Creek.

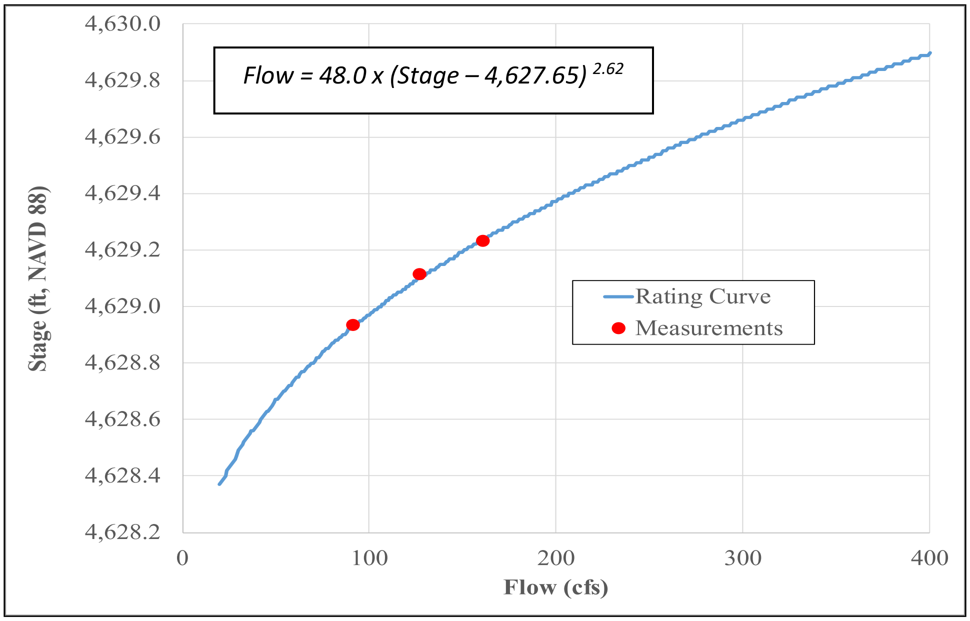

Figure 6-26. Stage/discharge rating curve for Crescent Creek below Big Marsh Creek (RM 22.8). Source: R2 and Biota Pacific 2016.

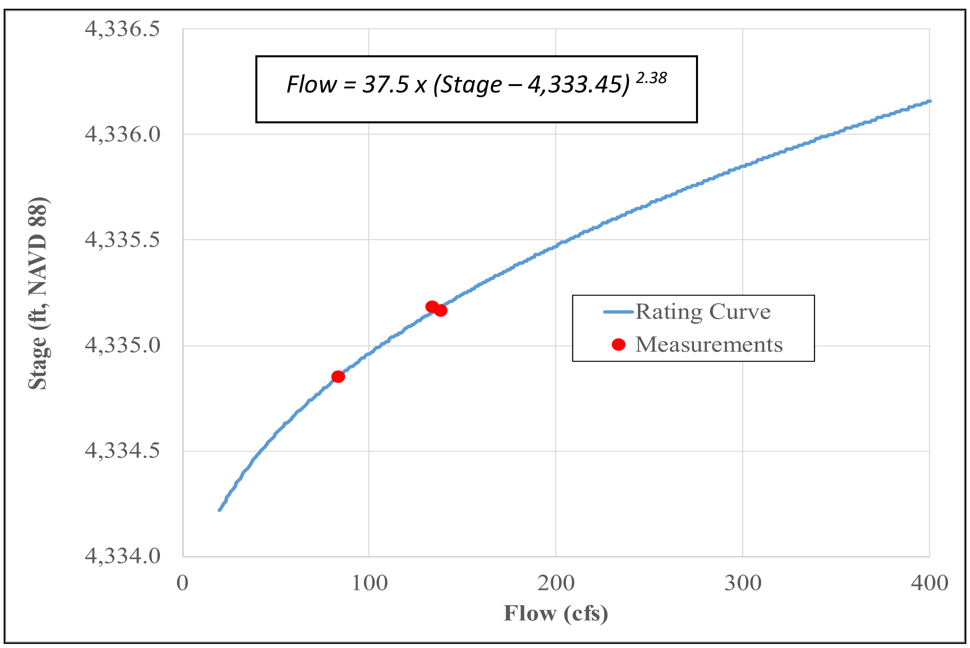

Figure 6-27. Stage/discharge rating curve for Crescent Creek near confluence with Little Deschutes River (RM 1.7). Source: R2 and Biota Pacific 2016.

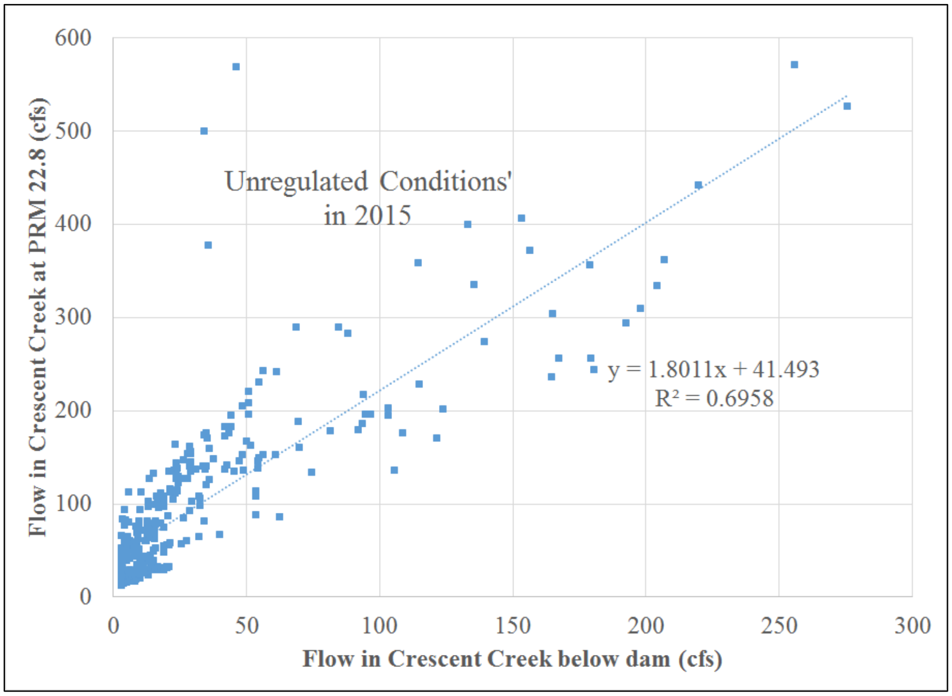

Figure 6-28. Relationship between Crescent Creek flows below Crescent Dam (OWRD Gage 14060000) and below Big Marsh Creek (RM 22.8) in 2015. Source: R2 and Biota Pacific 2016.

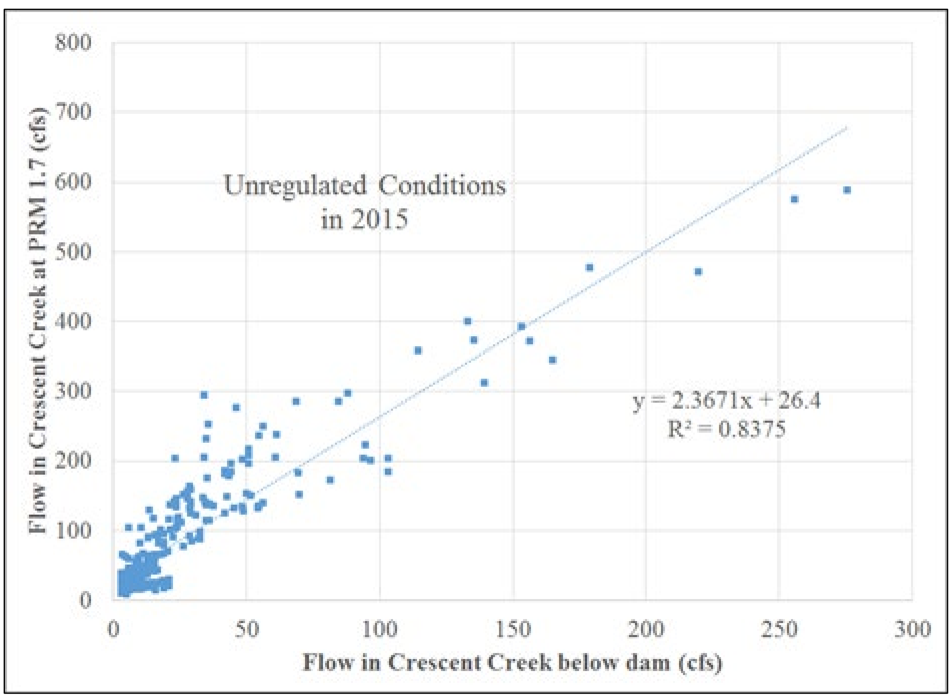

Figure 6-29. Relationship between Crescent Creek flows below Crescent Dam (OWRD Gage 14060000) and at RM 1.7 in 2015. Source: R2 and Biota Pacific 2016.

The comparison of historical to unregulated flows based on the period from 1983 to 2015 shows that unregulated flows fluctuate considerably on an annual, seasonal and daily basis in response to rain and snowmelt (Figures 6-30 through 6-33). Unregulated flows consistently reach their annual high during peak snowmelt in April through June and annual low from July through October. For May (the wettest month in upper Crescent Creek) the median of unregulated daily average flows at Crescent Dam is 78 cfs, while the 80 percent exceedance flow is 29 cfs and the 20 percent exceedance flow is 136 cfs (Figure 6-30). The driest month in upper Crescent Creek is September, when the median of daily average flows is 16 cfs, the 80 percent exceedance flow is 4 cfs, and the 20 percent exceedance flow is 44 cfs. The Little Deschutes River shows similar trends (Figure 6-33). The median for unregulated flow on the Little Deschutes River at La Pine in May (the wettest month) is 330 cfs, the 80 percent exceedance flow is 166 cfs and 20 percent exceedance flow is 556 cfs. The median for unregulated flow in the Little Deschutes River in August (the driest month) is 19 cfs, the 80 percent exceedance flow is 9 cfs and 20 percent exceedance flow is 66 cfs.

Unregulated flows for RM 22.8 (Figure 6-31) and RM 1.7 (Figure 6-32) show seasonal trends similar to unregulated flows at Crescent Dam, but total flow is greater in all months at RM 22.8 and RM 1.7 due to inflow from surface tributaries (primarily Big Marsh Creek) and groundwater discharge. Unregulated median flows at the two downstream locations are roughly 2.5 to 4 times the corresponding medians immediately below the dam. These differences are greatest during late summer (July - September) when unregulated flow below the dam is particularly low.

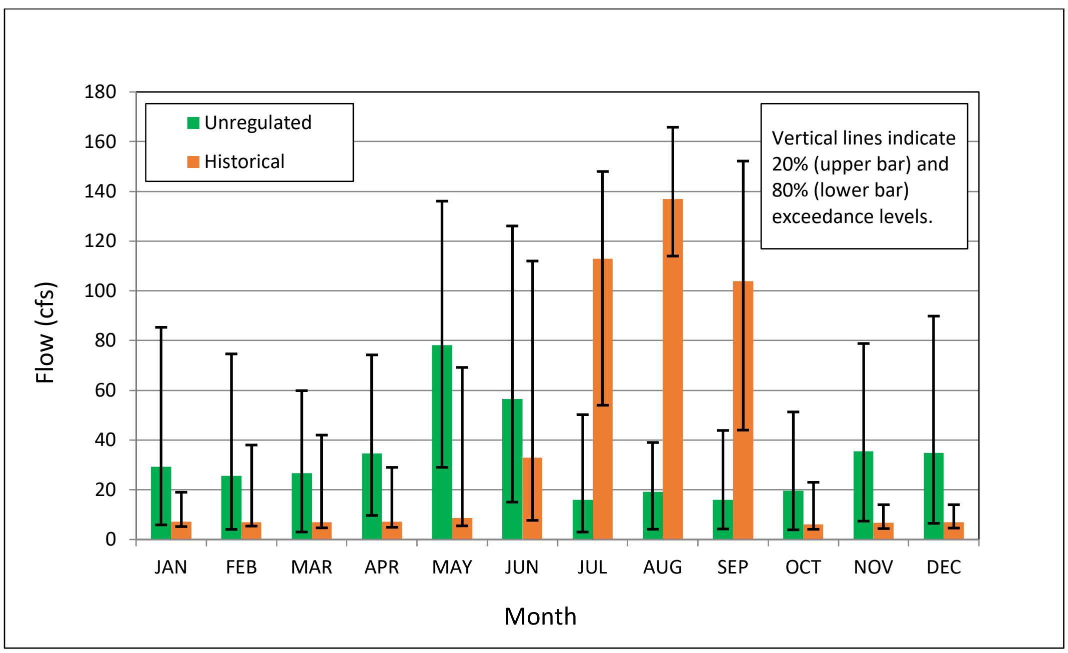

Figure 6-30. Monthly medians of daily average flows in Crescent Creek below Crescent Dam at RM 29 (Hydromet Station CREO) for historical and unregulated conditions.
Sources: OWRD 2020e, R2 and Biota Pacific 2016.

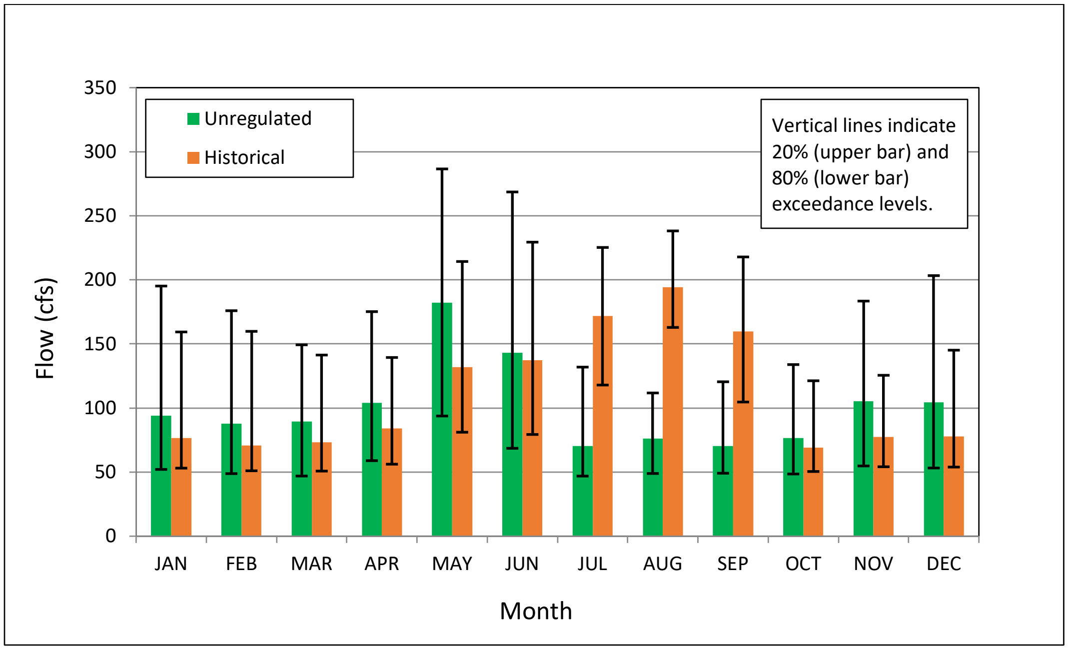

Figure 6-31. Monthly medians of daily average flows in Crescent Creek at RM 22.8 for historical and unregulated conditions. Source: R2 and Biota Pacific 2016.

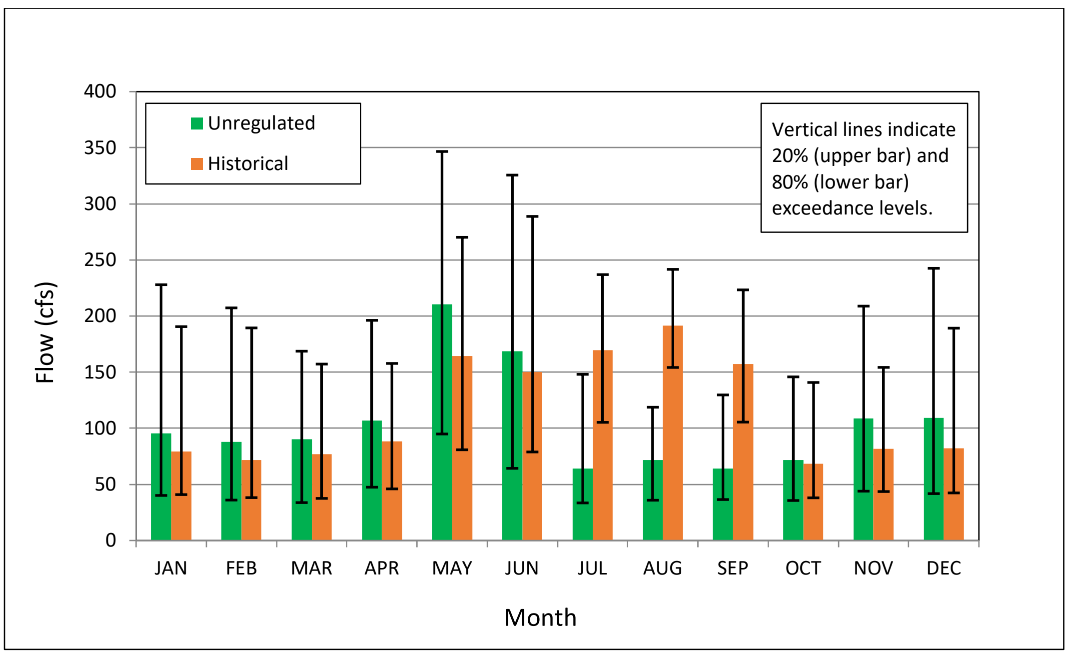

Figure 6-32. Monthly medians of daily average flows in Crescent Creek at RM 1.7 for historical and unregulated conditions. Source: R2 and Biota Pacific 2016.

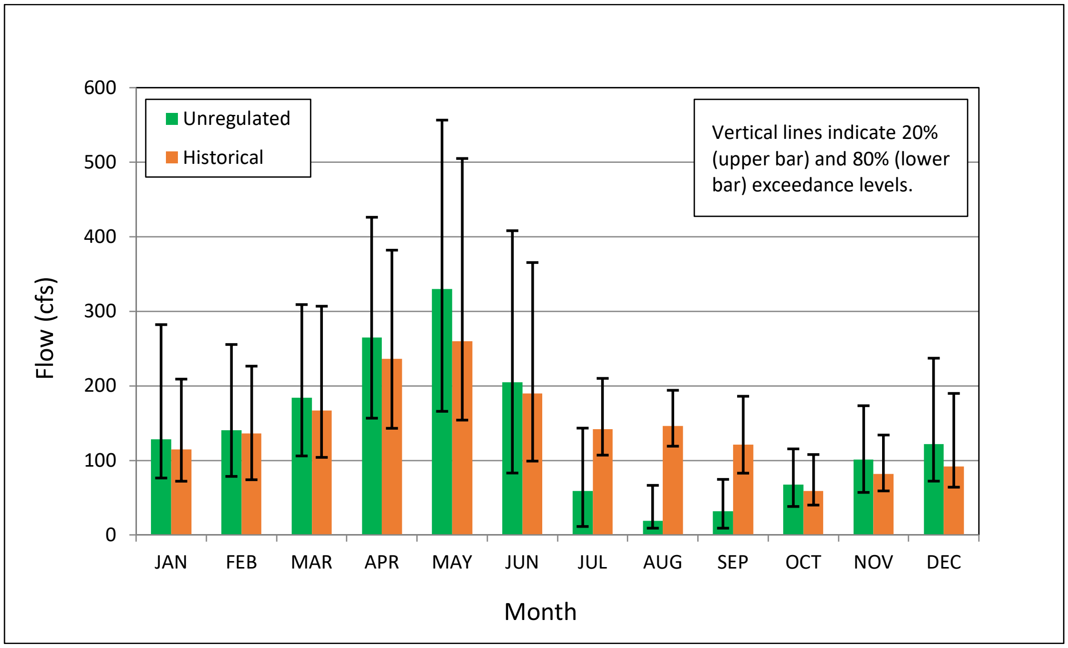

Figure 6-33. Monthly medians of daily average flows in Little Deschutes River near La Pine (Hydromet Station LAPO) for historical and unregulated conditions. Sources: OWRD 2020f, R2 and Biota Pacific 2016.

Within a single season, unregulated flows in Crescent Creek and the Little Deschutes River can fluctuate considerably over a matter of days due to storm events and snowmelt. In 2015, unregulated flows below Crescent Dam peaked rapidly to 100 cfs or more on several occasions; each time followed by an equally rapid drop in flow (Figure 6-34). The unregulated flow at this location went from 24 cfs on January 30 to 276 cfs on February 6, and back to 6 cfs by February 23. The unregulated flow peaked multiple times between March 12 and March 28 (the beginning of Oregon spotted frog breeding), at times increasing as much as 47 cfs and decreasing as much as 79 cfs in a single day. Similar trends occurred for unregulated flows in Crescent Creek at RM 22.8 (Figure 6-35) and RM 1.7 (Figure 6-36), as well as in the Little Deschutes River at La Pine (Figure 6-37). The magnitude of fluctuation increased with downstream distance from Crescent Dam due to tributary inflow.

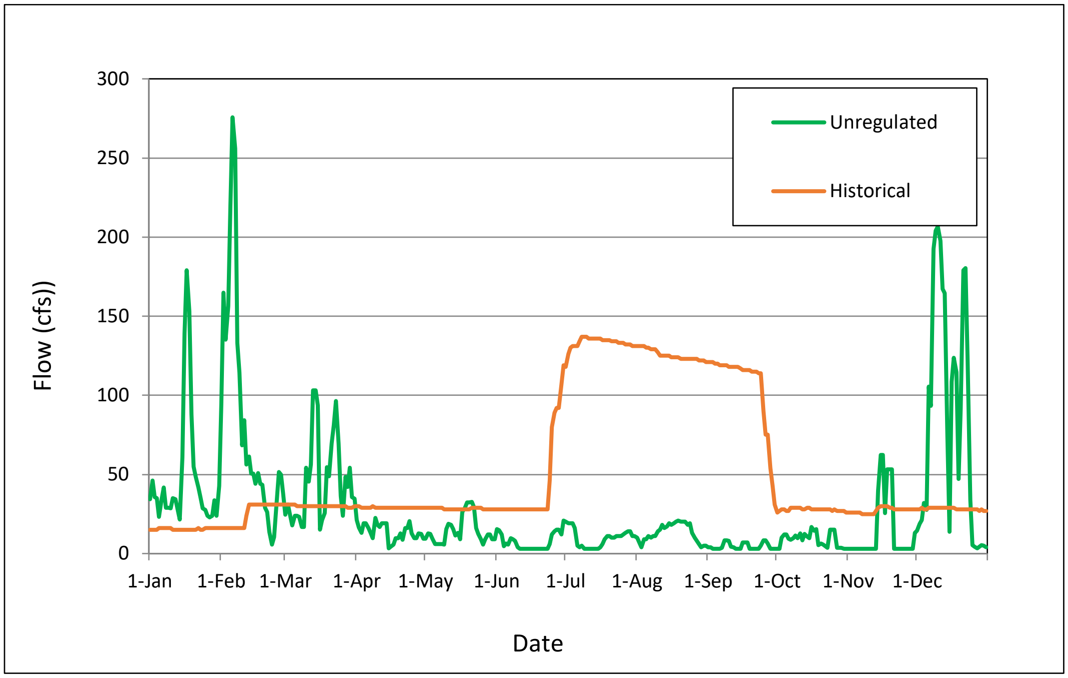

Figure 6-34. Daily average flows in Crescent Creek below Crescent Dam (Hydromet Station CREO) for historical and unregulated conditions in 2015. Source: R2 and Biota Pacific 2016.

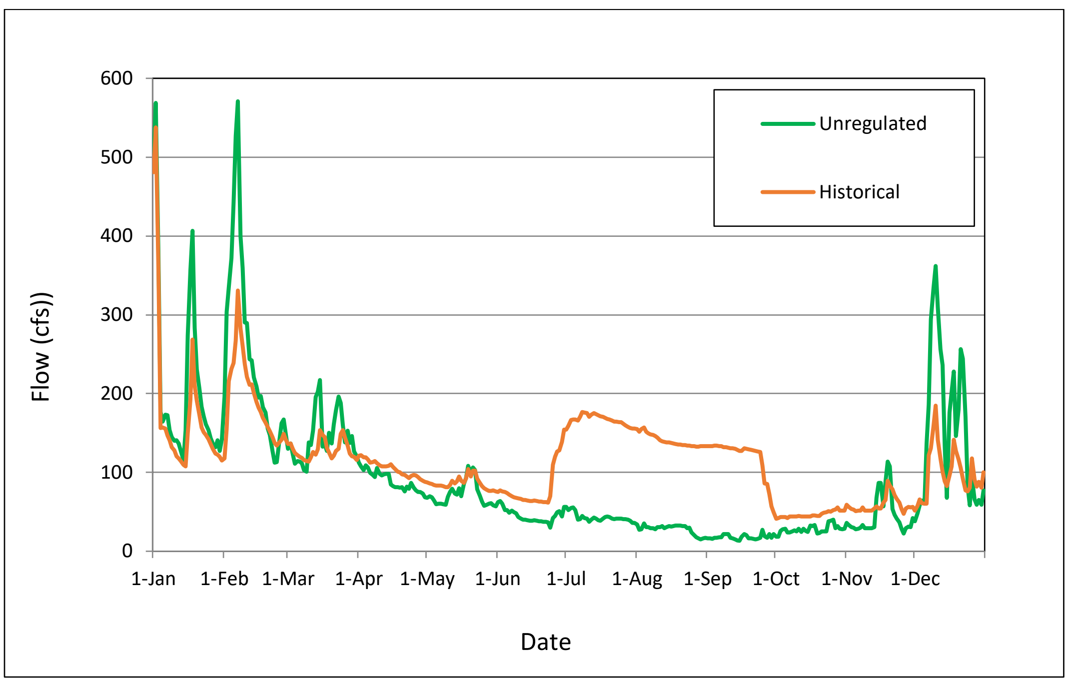

Figure 6-35. Daily average flows in Crescent Creek at River Mile 22.8 for historical and unregulated conditions in 2015. Source: R2 and Biota Pacific 2016.

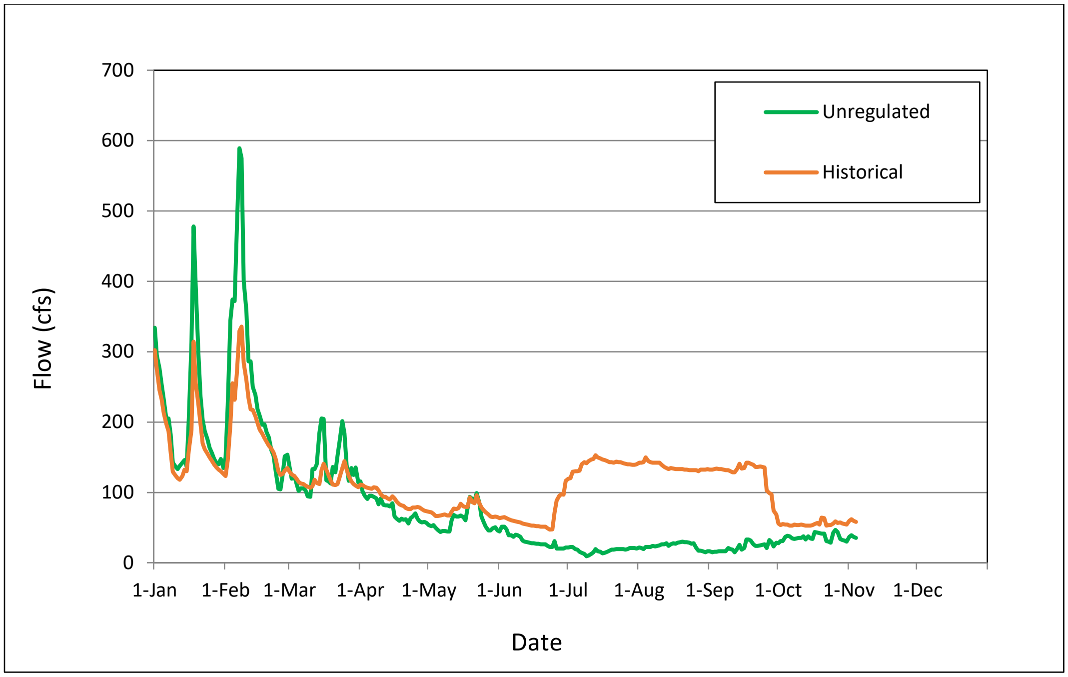

Figure 6-36. Daily average flows in Crescent Creek at River Mile 1.7 for historical and unregulated conditions in 2015. Source: R2 and Biota Pacific 2016.

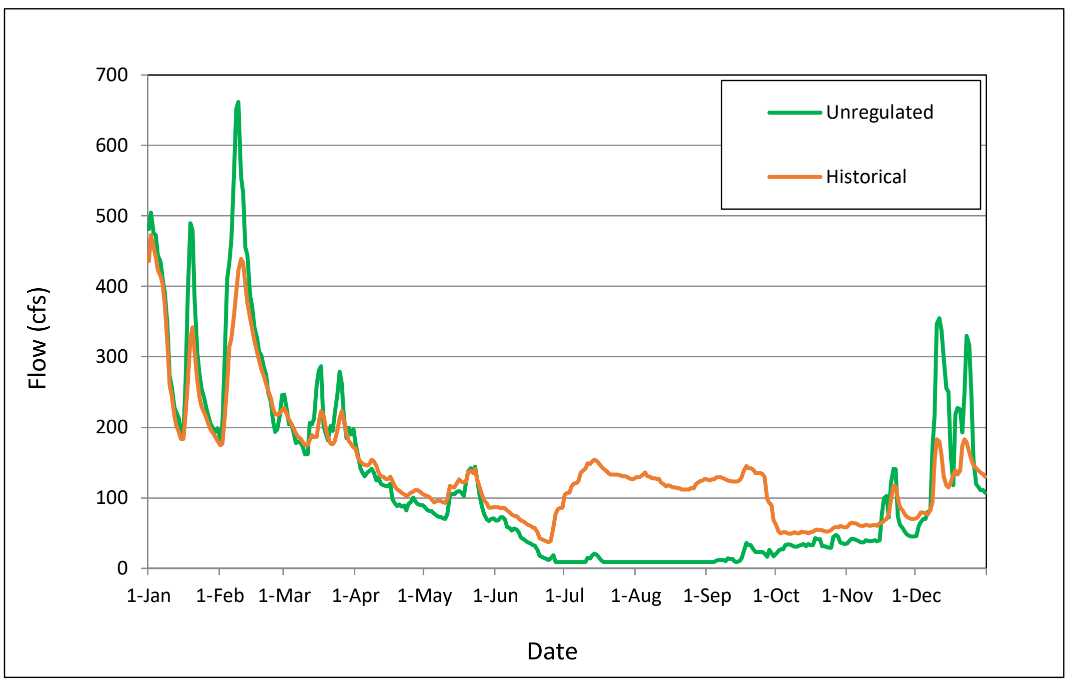

Figure 6-37. Daily average flows in Little Deschutes River at La Pine (Hydromet Station LAPO) for historical and unregulated conditions in 2015. Source: R2 and Biota Pacific 2016.

The effects of Crescent Lake Reservoir operation on the hydrology of lower Crescent Creek and Little Deschutes River on both an annual and a multi-year basis are illustrated by comparing unregulated and regulated (historical) flows (Figures 6-30 through 6-37). Historical operation of the reservoir produced shifts in the seasonal hydrographs of lower Crescent Creek and the Little Deschutes River. Immediately downstream of Crescent Dam (Figure 6-30) the historical flow was generally lower than the unregulated flow from October through June (the storage season for Crescent Lake Reservoir) and higher than the unregulated flow from July through September. The effects of reservoir operation were similar at Crescent Creek RM 22.8 (Figure 6-31), Crescent Creek RM 1.7 (Figure 6-32) and the Little Deschutes River at La Pine (Figure 6-43). The relative differences between unregulated and historical flows during the storage season were more subtle at the three downstream locations due to contributions to flow from surface tributaries, groundwater discharge and local runoff that decreased the relative importance of upper Crescent Creek to total flow.

The most notable effect of reservoir operation on hydrology was an increase of 160 to 600 percent in median flow from July through September, in contrast to a decrease in median flow of 28 percent or less during the other 9 months. This seasonal difference in magnitude of effect was due to two factors. First, storage of irrigation water occurred over most of 9 months while the release of that water occurred primarily during 3 months. Consequently, water was released at roughly three times the rate it was stored. Second, most of the stored water came from peak runoff periods (high flows) during the winter and spring, rather than from base flows. This is best illustrated by Figure 6-30, which shows that from October through June the difference between unregulated and historical flows below Crescent Dam was greater at the 20 percent exceedance level than at the median flows. In other words, reservoir operation has historically had a greater effect on high flows than it has on median or average flows.

Reservoir operation also reduced the variation in daily average flow during the storage season while increasing it during the irrigation season. This is because releases from Crescent Lake Reservoir have been held relatively constant during the storage season, thereby buffering the effects of storms and runoff events, but releases during the irrigation season have fluctuated in response to irrigation demand. This is illustrated by the differences in exceedance values for unregulated and historical data, as well as in daily average flow data for 2015 (Figures 6-34 through 6-37). It should be noted that the 2015 historical data in these figures included the experimental release of 20 to 30 cfs at Crescent Dam as a test of potential DBHCP options. Without this experimental release the historical flow in 2015 would have been considerably lower during the storage season of October through June.

The effects of inflow between Crescent Dam and RM 22.8 can also be seen in Figures 6-34 through 6-37. Flows immediately below the dam (Figure 6-34) showed a large proportional decrease during the storage season of 2015, and a large increase during the irrigation season. At RM 22.8 (Figure 6-35) the proportional effect of irrigation storage was much reduced due to inflow from tributaries (primarily Big Marsh Creek), groundwater discharge and local runoff. Historical flows at RM 22.8 were 90 percent or more of unregulated flows throughout the storage season, except during peak flow events. Short-term spikes in flow occurred under reservoir operation, but the spikes were reduced compared to unregulated flows. In a similar fashion, the net increase in flow from July through September at RM 22.8 was less pronounced than directly below Crescent Dam, although it was still substantial. Flows at RM 1.7 (Figure 6-36) were very similar in magnitude and pattern to flows at RM 22.8 in 2015, which also indicates that Crescent Creek does not gain or lose appreciable flow between RM 22.8 and the mouth.

Comparison of unregulated and historical flows in the Little Deschutes River at La Pine (Figure 6-37) shows continued diminishment of the effects of reservoir operation. These data represent a single year (2015), which was also a relatively dry year for Crescent Creek, and the difference between historical and unregulated flows during the storage season would likely be greater in average and wet years. Nevertheless, the relative reduction in reservoir effects downstream of Big Marsh Creek would occur in all years.

6.3.3.3 Effects of Historical Crescent Lake Reservoir Operation on Water Surface Elevation

Water surface elevation provides a more precise measurement of reservoir operation effects on Oregon spotted frogs than is provided by flow because the frogs inhabit the calm, shallow waters of riparian wetlands where water depth is the primary hydraulic factor influencing habitat. The analysis of water surface elevation focuses on wetlands known to be occupied by Oregon spotted frogs at RM 22.8 and RM 1.7 on Crescent Creek. These wetlands represent the range of hydrologic conditions in the occupied reach of Crescent Creek. They also represent the extreme situation likely to be encountered in the Little Deschutes River because of the overall diminished effects of reservoir operation with downstream distance from the dam.

Unregulated and historical flows for 1983-2015 on Crescent Creek at RM 22.8 and RM 1.7 were converted to water surface elevations (feet) using the stage/discharge rating curves shown in Figures 6-26 and 6-27. Monthly medians of the daily average water surface elevations were calculated, and the differences between unregulated and historical monthly medians are used to summarize the effects of reservoir operation.

The effects were similar at RM 22.8 and RM 1.7, which is to be expected given that flows do not vary appreciable within lower Crescent Creek. At both locations, historical reservoir operation reduced the monthly median water surface elevations by approximately 0.03 to 0.21 foot (0.3 to 2.5 inches) from October through June and increased median water surface elevation 0.42 to 0.66 foot (5.0 to 7.9 inches) from July through September (Figures 6-38 and 6-39). The greatest decrease in monthly median water surface elevation has been in May, when unregulated flows would otherwise be at their annual peak. The effect of the decrease has been to bring the May median water surface elevation closer to the annual average.

In addition to affecting monthly median water surface elevation, reservoir operation has influenced the magnitude of within-month fluctuation as well. Unregulated and historical water surface elevations for 2015 (Figures 6-40 and 6-41) show that the presence of Crescent Lake Reservoir reduced the short-term effects of winter storms and spring snowmelt at RM 22.8 and RM 1.7. Unregulated water surface elevations in Crescent Creek spiked quickly multiple times between January 1 and May 31, and again in November and December. Unregulated spikes ranged in magnitude from 0.23 foot (2.8 inches) in late February to over 1.0 foot (12 inches) in early February. In all cases the historical water surface elevations, which were influenced by the storage of water in Crescent Lake Reservoir, showed less fluctuation than unregulated elevations. In 2015, unregulated water surface elevations spiked twice in late March, with fluctuations of up to 5.4 inches over the course of a week. Historical water surface elevations at the same time showed less than half the fluctuation of unregulated elevations. While the timing and magnitude of flows and water surface elevations can be expected to vary from year to year, the dampening effect observed in 2015 will occur in all years because the reservoir reduces the magnitude of flow fluctuations originating in upper Crescent Creek. This is illustrated by the reductions in the 20 percent exceedance levels and increases in the 80 percent exceedance levels for all months under reservoir operation (historical conditions in Figures 6-38 and 6-39). In other words, extremely high and extremely low water depths have been eliminated by reservoir operation.

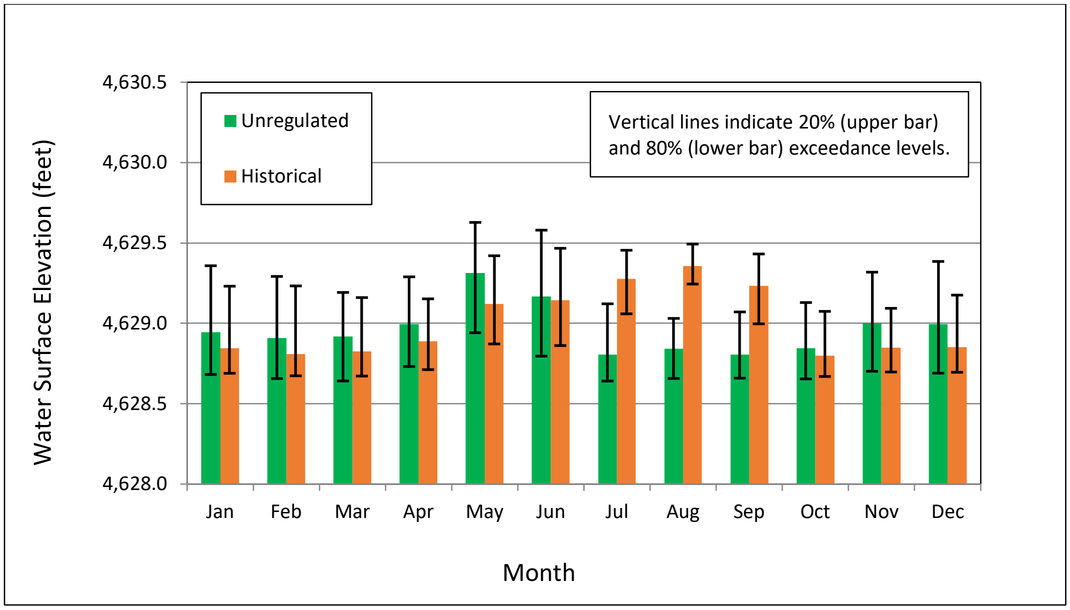

Figure 6-38. Monthly medians of daily water surface elevations in Crescent Creek at RM 22.8 for historical and unregulated conditions. Source: R2 and Biota Pacific 2016**.**

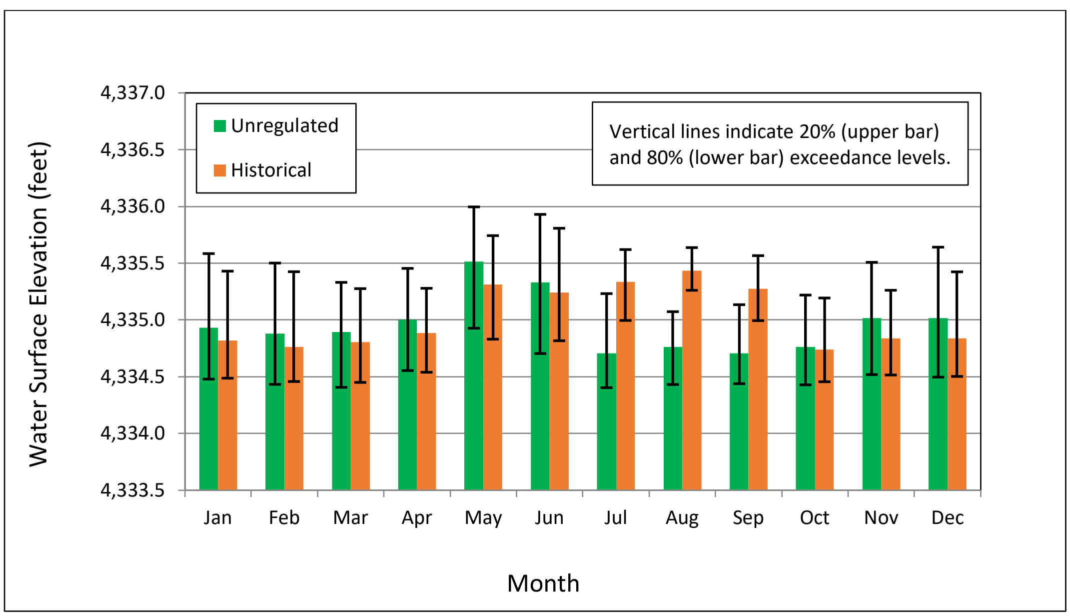

Figure 6-39. Monthly medians of daily water surface elevations in Crescent Creek at RM 1.7 for historical and unregulated conditions. Source: R2 and Biota Pacific 2016.

Figure 6-40. Daily average water surface elevation in Crescent Creek at River Mile 22.8 for historical and unregulated conditions in 2015. Source: R2 and Biota Pacific 2016.

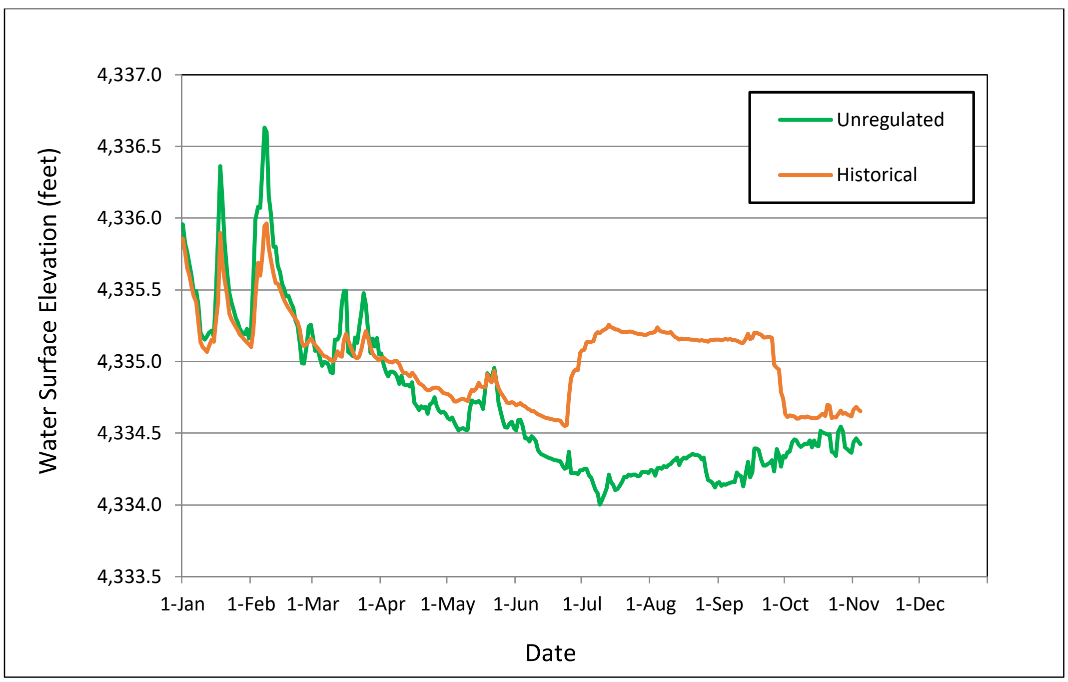

Figure 6-41. Daily average water surface elevation in Crescent Creek at River Mile 1.7 for historical and unregulated conditions in 2015. Source: R2 and Biota Pacific 2016.

6.3.3.4 Effects of DBHCP Measure CC-1 on Flow and Water Surface Elevation

The minimum flow below Crescent Dam in recent years (prior to 2015) has been 6 cfs. Under the DBHCP, the minimum flow below Crescent Dam from October 1 through June 30 will be 10 cfs during the first 15 years of implementation, and it will increase after Year 15 until it reaches 12 cfs in Year 21. Water from OSF storage can be used during any month and any year of DBHCP implementation to increase the minimum flow above these amounts if habitat monitoring indicates a potential benefit to Oregon spotted frogs. The minimum flow from July 1 through September 30 will be 50 cfs during all years of DBHCP implementation, and this too can be increased through use of the OSF storage.

The minimum flows required under Measure CC-1 will increase monthly median flows from historical conditions throughout most of the storage season in lower Crescent Creek and lower Little Deschutes River (Figures 6-42 through 6-45). Measure CC-1 will also increase monthly low (80% exceedance) flows during the storage season in Crescent Creek and the Little Deschutes River relative to both historical and unregulated conditions. This is because the flow below Crescent Dam will be managed at or above 10 cfs at all times, whereas unregulated flows can go as low as 3 cfs. High (20% exceedance) flows during the storage season may be higher under the DBHCP than under historical and unregulated conditions as efforts to carry more storage (for both irrigation and OSF storage) into the spring may increase the need to spill water during flood events that originate above Crescent Dam. Historically, there have been occasions when it was necessary to release additional water from Crescent Lake Reservoir during high-flow events in the storage season to avoid over-topping the spillway. The frequency of such events could increase under the DBHCP.

Inflow to Crescent Lake Reservoir is cyclical, alternating between successive years of high inflow and successive years of low inflow. Historically, the reservoir was operated to capture and store water during periods of high inflow and utilize it when TID's other sources of water (primarily Tumalo Creek) were not sufficient. This resulted in considerable year-to-year variation in reservoir storage volume, and occasionally in the complete draining of the reservoir followed by very low flows in the lower reaches of the creek. Under the DBHCP, Crescent Lake Reservoir will be operated more to balance average annual inflow with average annual release in an attempt to avoid complete draining of the active storage. An initial increase of 4 cfs (from 6 cfs to 10 cfs) in the median flow below Crescent Dam during the 9-month storage season will therefore produce a corresponding decrease in the amount of water that could otherwise be released during the irrigation season. The anticipated effects of this decrease in flow can be seen in July, August and September at all three locations on Crescent Creek that were modeled (Figures 6-42 through 6-44). As noted above, flow predictions at CREO (Figure 6-43) were developed with the RiverWare model (Reclamation 2020a). Flow predictions for RM 22.8 (Figure 6-43) and RM 1.7 (Figure 6-44) were developed by applying the relationships in Figures 6-28 and 6-29, respectively, to the RiverWare results for CREO.

The RiverWare modeling depicted in Figures 6-42 through 6-45 included an assumption that water from the OSF storage account would be used to increase flows in June prior to the release of irrigation storage from Crescent Lake Reservoir. June has been identified as a potential month to use the OSF storage if flows in lower Crescent Creek and lower Little Deschutes River are otherwise too low to sustain wetlands used by breeding and rearing Oregon spotted frogs, but this is just one potential use of the water. Alternately, or additionally, OSF storage could be used to increase flows in late September and October if monitoring indicates the need to keep wetlands inundated after the end of the irrigation season. The modeling depicted in Figures 6-42 through 6-45 addressed one potential use of the OSF storage primarily to evaluate the effect of using the storage each year on subsequent reservoir volumes and the associated ability to sustain desired minimum flows. The modeling does not restrict the use of the OSF storage, but it successfully demonstrates that the full available amount can be utilized each year without impacting TID's ability to maintain the required minimum flows.

In most years, irrigation demand in September will keep flows higher than the required minimum of 50 cfs through the middle of the month, but by late September a decrease in irrigation demand could reduce the flow to 50 cfs. As required by Conservation Measures CC-2 and CC-3, this transition must be gradual and it must be completed by the end of October. This is reflected in the predicted monthly median flow for September of 93 cfs.

The RiverWare model results for the Little Deschutes River at LAPO (Figure 6-45) show DBHCP median monthly flows increasing from historical flows in July through September, which is counterintuitive given the flow reductions that will occur upstream in Crescent Creek. The predicted DBHCP flows are based on proposed management of Crescent Lake Reservoir and established diversion rights between the dam and LAPO gage. The apparent increases from historical to DBHCP flows could be the result of artificially low historical flows at LAPO caused by irrigation diversions between CREO and LAPO that exceeded established water rights, or alternately from inflated DBHCP flows at LAPO caused by the challenges of accurately modeling unregulated flows and future diversions. In either case, it is reasonable to assume flows at LAPO under the DBHCP in July through September will actually be lower than historical levels, particularly if diversions in this reach continue to follow their historical patterns.

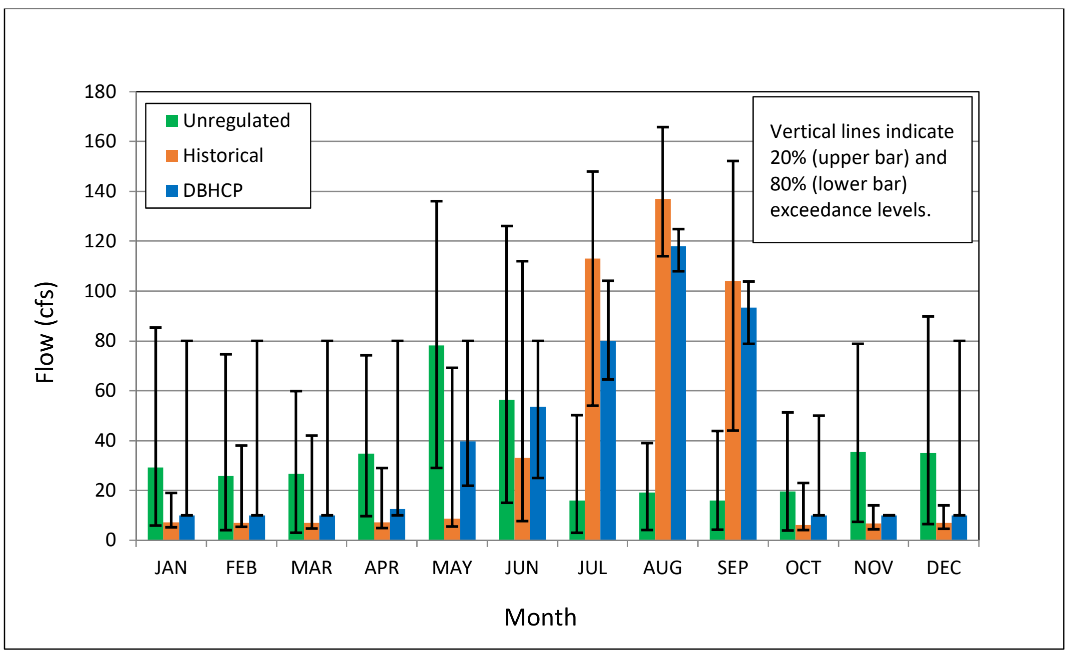

Figure 6-42. Monthly medians of daily average flows in Crescent Creek below Crescent Dam (Hydromet Station CREO) for unregulated, historical and DBHCP projected conditions. Sources: R2 and Biota Pacific 2016, Reclamation 2020a.

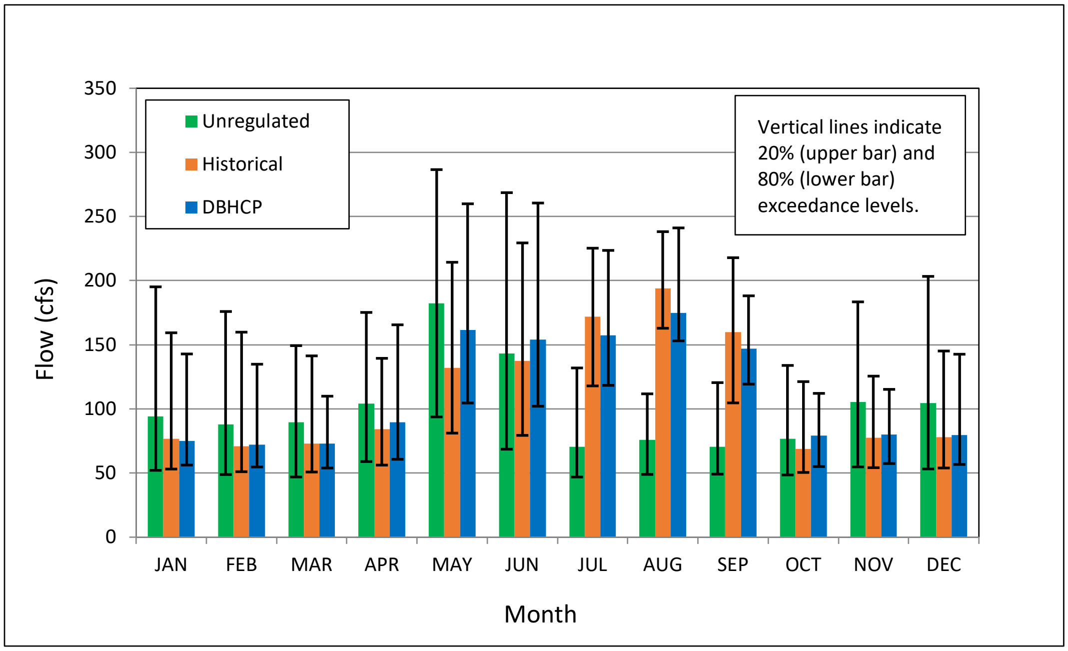

Figure 6-43. Monthly medians of daily average flows in Crescent Creek at River Mile 22.8 for unregulated, historical and DBHCP projected conditions. Sources: R2 and Biota Pacific 2016, Reclamation 2020a.

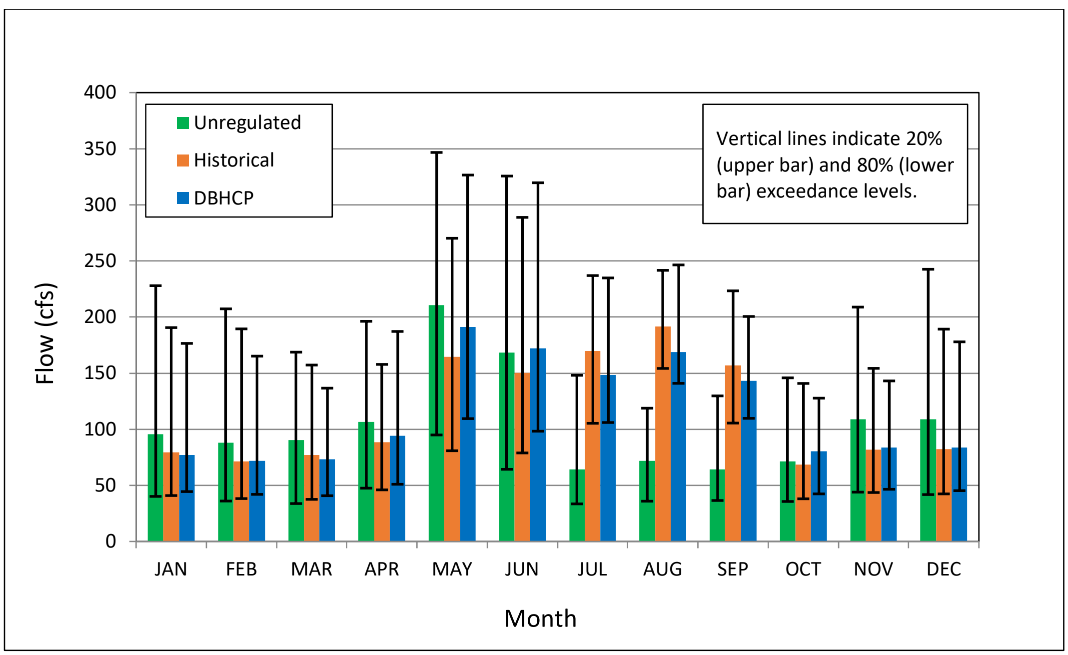

Figure 6-44. Monthly medians of daily average flows in Crescent Creek at River Mile 1.7 for unregulated, historical and DBHCP projected conditions. Sources: R2 and Biota Pacific 2016, Reclamation 2020a.

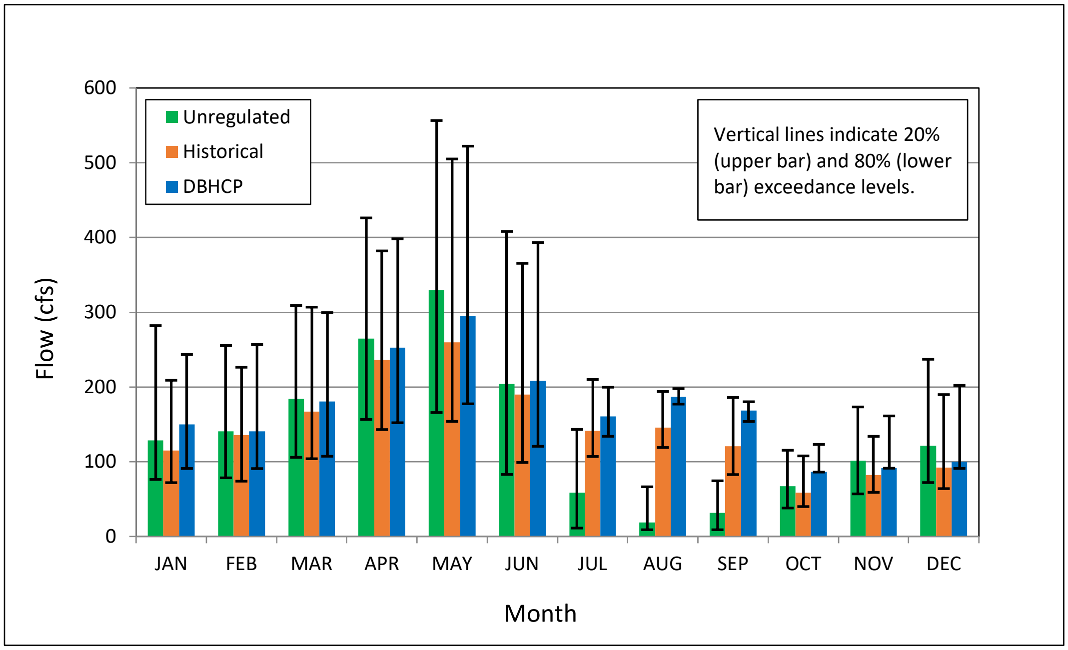

Figure 6-45. Monthly medians of daily average flows in Little Deschutes River at La Pine (Hydromet Station LAPO) for unregulated, historical and DBHCP projected conditions. Sources: R2 and Biota Pacific 2016, Reclamation 2020a.

Changes in water surface elevation under the DBHCP will be similar to the changes in flow. At RM 22.8 (Figure 6-47) and RM 1.7 (Figure 6-48) median water surface elevations will be at least comparable to historical conditions during most of the storage season and lower during the peak of the irrigation season, although all elevations can be increased, if desired, by release of OSF storage. From October through June median water surface elevations under the DBHCP will be from 0.03 foot (0.3 inch) lower to 0.15 foot (1.8 inches) higher than historical conditions. More importantly, the 80 percent exceedance levels under the DBHCP will be up to 0.18 foot (2.1 inches) higher than historical levels. This means that extremely low water levels that historically occurred in the streams and associated wetlands during the winter will no longer occur. In July, August and September median water surface elevations under the DBHCP will be 0.05 to 0.10 foot (0.6 to 1.3 inches) lower than they were historically.

While the DBHCP will continue to reduce median water surface elevations in the creek up to 2 inches from unregulated conditions during the storage season, it will simultaneously prevent the extremely low flows that would occur without the presence of the reservoir. From October through April, a flow of 10 cfs below Crescent Dam represents a monthly unregulated exceedance level of 65 to 79 percent. In other words, the unregulated flow below Crescent Dam from October through April would only exceed 10 cfs from 65 to 79 percent of the time, depending on the month. Conversely, from 21 to 35 percent of the time the unregulated flow would be less than 10 cfs. Under the DBHCP, however, the flow below Crescent Dam will never be allowed to drop below 10 cfs unless extended drought eliminates all storage in the reservoir. In addition to this, OSF storage could be used to increase the minimum flow above these levels, if warranted, to benefit Oregon spotted frogs.

Brief interruptions in flow below Crescent Dam will occur at infrequent intervals under the DBHCP for inspection, maintenance and repair of the dam. These activities have occurred historically, but they are not reflected in historical records because the events typically last less than 24 hours and historical records are based on daily average flows. Gate tests will be conducted every year and gallery/conduit inspections will occur every 5 years, both between October 1 and November 30. Gate tests will result in flow fluctuations of up to 40 cfs over a period of up to 8 hours (most will be less than 4 hours), during which time the minimum flow will be about 5 cfs. Gallery/conduit inspections will cause a minimum flow of about 5 cfs that will also last 4 to 8 hours. In both cases, the minimum flow below the dam will be provided by a bypass pipe. The effects of these temporary flow modifications will be most apparent for about 6 miles downstream to the confluence with Big Marsh Creek.

Maintenance activities that will require flow reductions will occur every 3 to 10 years. Removal of rock from the ramp flume is required about every 3 years and requires the complete cessation of flow, including bypass flow, for about 2 hours. Removal of rock from the tailrace is less frequent (about every 10 years), lasts about 4 hours, and can be done while a bypass flow of 5 cfs is maintained. These activities will be scheduled in advanced with USFWS to select a time with the least potential to impact Oregon spotted frogs.

Repair activities will occur as needed. The frequency and duration of flow reductions associated with dam repairs cannot be predicted in advance, but historical operation of the dam suggests these will occur at intervals of 5 years or longer. Minor repairs, which are covered by the DBHCP, will result in complete cessation of flow (no bypass flow) for no more than 4 hours and flows of less than 10 cfs for no more than 8 consecutive hours and no more than 24 cumulative hours in 1 week. When the need for non-emergency repairs arises, TID will coordinate the timing of flow reductions with USFWS in the same manner as maintenance activities. When the need for emergency repairs arises, TID will make the repairs and notify USFWS within 48 hours.

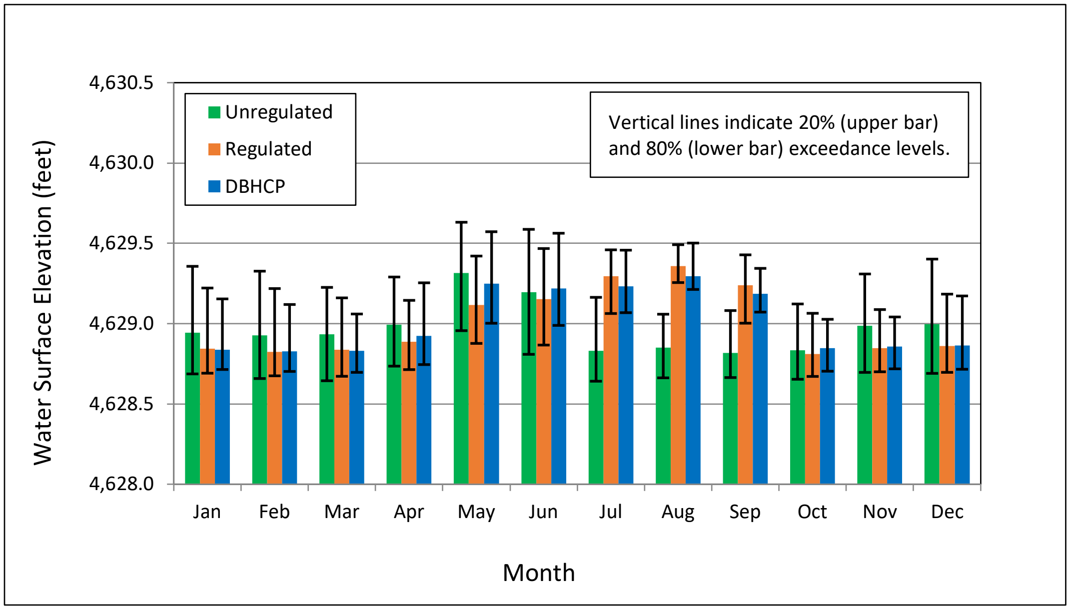

Figure 6-46. Monthly medians of daily water surface elevations in Crescent Creek at River Mile 22.8 for unregulated, historical and DBHCP conditions. Sources: R2 and Biota Pacific 2016, Reclamation 2020a.

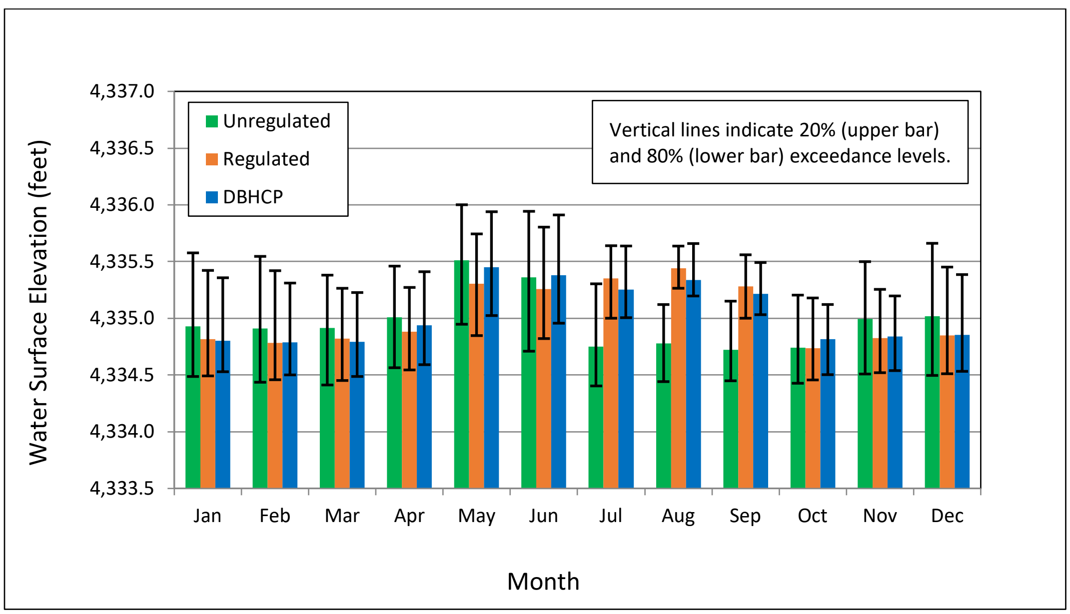

Figure 6-47. Monthly medians of daily water surface elevations in Crescent Creek at River Mile 1.7 for unregulated, historical and DBHCP conditions. Sources: R2 and Biota Pacific 2016, Reclamation 2020a**.**

6.3.4 Rationale for Conservation Measure CC-2

6.3.4.1 Overview

TID adjusts the outflow from Crescent Lake Reservoir in response to irrigation demands and natural runoff events. Outflow is increased to meet irrigation demand during the spring and summer, and decreased to facilitate the storage of water in the fall. The onset of irrigation releases can begin with small increases in flow as early as April in some years, but the largest increases typically occur in early July when the flow below Crescent Dam can go from the allowable minimum (previously 6 cfs) to over 100 cfs. Similarly, outflow can be decreased in small increments during the irrigation season, but the largest decreases occur in late September or early October when the flow below Crescent Dam is returned to the allowable minimum. Under the DBHCP, the minimum flow below Crescent Dam will be 10 cfs from September through May and 50 cfs from June through August. There will be no limit on the maximum flow, but for practical reasons it will rarely exceed the recent historical (1983-2015) maximum of 250 cfs.

On occasion, TID also finds it necessary to release more than the allowable minimum flow during the storage season to protect homes along the reservoir from flooding and avoid overtopping the spillway at Crescent Dam. From 1983 through 2015, releases of water to protect property in this way were required at least seven times, with resulting flows below Crescent Dam of 200 cfs or more. The frequency of storage season releases from Crescent Lake Reservoir may change under the DBHCP, but the need for storage season releases will not go away.

Oregon spotted frog eggs and tadpoles are highly aquatic and can be affected by sudden or rapid changes in water levels. If water levels drop several inches in occupied wetlands during egg development (March and April in the Deschutes Basin), eggs can become desiccated and fail to develop. If water levels drop comparable amounts during the spring and summer, tadpoles must move with receding waters or they will perish. Juveniles and adult Oregon spotted frogs are more mobile than tadpoles and are capable of moving across open ground, but numerous studies have shown they typically move along aquatic corridors if they are available (Licht 1986a and 1986b; Watson et al. 2003; Pearl et al. 2005; Chelgren et al. 2007; USFWS 2014). Juveniles and adults have been observed moving several yards between water bodies in the Deschutes Basin (Bowerman pers. comm.; Diller pers. comm.), but the diurnal patterns, maximum distances and mortality rates associated with overland travel are not fully understood.

Rising water levels can also affect Oregon spotted frogs, but in most wetlands the potential for adverse impacts is less than when water levels decrease. Increasing water levels in occupied wetlands may cause frogs to relocate within the wetlands to find preferred water depths and avoid predators. Mobile life stages (large tadpoles, juveniles and adults) can accomplish this with little effort, but eggs and young tadpoles lack the mobility to stay within preferred depths when water levels change. Increases in flow can also increase the velocity of waters in wetlands closely associated with main stream channels, exposing Oregon spotted frogs of all life stages to the potential for being swept downstream. The less mobile life stages (eggs and young tadpoles) are most vulnerable to being moved involuntarily by high flows.

Natural (unregulated) water levels in Crescent Creek and Little Deschutes River fluctuate several inches per week without the influence of Crescent Lake Reservoir, primarily during spring runoff (March – May) and winter storms (December – February) (see Figures 6-34 through 6-37). The intent of the DBHCP is to reduce the magnitude of reservoir contributions to natural fluctuations by limiting the daily rate of change in flow below Crescent Dam.

6.3.4.2 Effects of Historical Crescent Lake Reservoir Operation on Daily Changes in Flow

Daily increases in historical flow below Crescent Dam between 1983 and 2015 were as much as 81 cfs in late June, and daily decreases in historical flow were as much as 109 cfs in late September (OWRD 2020e). These were extremes during the 33-year period; most daily increases and decreases at Crescent Dam were less than 50 cfs. An increase in flow of 81 cfs over 24 hours at Crescent Dam would translate to an increase in water surface elevation in lower Crescent Creek and lower Little Deschutes River of about 0.5 foot (6 inches) per day (see Figures 6-26 and 6-27) if all other sources of flow affecting the downstream waters were held constant. In a similar manner, a decrease in flow of 109 cfs at Crescent Dam would result in a decrease in water surface elevation in downstream waters of about 0.75 foot (9 inches) per day if all other sources of flow were constant. However, water surface elevations in the occupied reaches of Crescent Creek and Little Deschutes River are also influenced by flows from unregulated tributaries like Big Marsh Creek and upper Little Deschutes River that experience large natural fluctuations in flow. These unregulated sources account for the majority of the daily fluctuations in flow downstream in the occupied reaches. For example, daily changes (increases and decreases) in flow at RM 1.7 on Crescent Creek were more than 100 cfs on multiple occasions between 1983 and 2015, with much of this variation being unrelated to operation of the reservoir. In several months, daily changes in flow were as much as 300 cfs, which would translate to daily changes in water surface elevation of over 1 foot. Unregulated flows during the same 27 years would have increased and decreased even more than recorded flows because the reservoir would not have reduced the effects of high and low flow events originating in upper Crescent Creek.

6.3.4.3 Effects of DBHCP Measure CC-2 on Daily Changes in Flow and Water Surface Elevation

Conservation Measure CC-2 will limit the rate of increase in flow at Crescent Dam to 30 (±2) cfs per 24-hour period. This translates to a maximum daily increase of roughly 2.5 inches in water depth attributable to operation of the reservoir. Conservation Measure CC-2 will also limit the rate of decrease to 20 (±2) cfs (roughly 2 inches) per 48-hour period. Actual flows in occupied reaches of lower Crescent Creek and lower Little Deschutes River will continue to be influenced by the unregulated portions of the upper basin, and total daily fluctuations will be greater than those caused by changes in flow at Crescent Dam alone. Daily changes in downstream water depth, particularly daily increases, could still be 1 foot or more during high runoff events. The benefit of Measure CC-2 is that it will reduce fluctuations in daily flow (and water depth) in occupied reaches of Crescent Creek and Little Deschutes River compared to both unregulated and historical regulated conditions.

For much of the year, releases from Crescent Lake Reservoir will be constant (e.g., 10 cfs during the storage season) while inflow to the reservoir will fluctuate. At these times, the reservoir will prevent fluctuations originating in upper Crescent Creek from perpetuating downstream of Crescent Dam. During the brief periods when flows below Crescent Dam are in transition, such as at the beginning of the irrigation season, the end of the irrigation season, and during flood events, the rate of change in flow will be held to less than half the maximum rates that were recorded historically or would occur in the absence of the reservoir.

6.3.5 Rationale for Conservation Measure CC-3

6.3.5.1 Overview

Unregulated (natural) flows in Crescent Creek and Little Deschutes River decline substantially from May through August as snowmelt ends. The historical release of irrigation water from Crescent Lake Reservoir has counteracted this natural decline and maintained downstream flows (and water surface elevations) at high levels throughout the summer (see Figures 6-30 through 6-33). These high water levels are believed to be contributing to the maintenance of Oregon spotted frog summer rearing and foraging habitat in lower Crescent Creek and lower Little Deschutes River that would not otherwise persist through the summer. At the end of the irrigation season, releases from Crescent Lake Reservoir have historically been ramped down over a period of a few days to initiate winter storage. While the rate of ramp-down may have historically been too rapid, the completion of ramp-down by mid- to late October has caused winter water levels in occupied wetlands to be established before Oregon spotted frog juveniles and adults settled into overwintering sites. Decreases in flow and water depth after the onset of overwintering could expose frogs to freezing temperatures and/or force them to relocate during less than favorable weather conditions.

The DBHCP will change operation of Crescent Lake Reservoir from recent historical practices by dedicating a portion of the storage for Oregon spotted frog habitat management. A portion of the OSF storage will be used to increase the minimum flow below Crescent Dam from 6 cfs to 10 cfs during the storage season. This increase in flow will decrease average annual storage in the reservoir, which will in turn decrease the average amount of stored water available for release during the summer. This is an unavoidable consequence of increasing the minimum flow below Crescent Dam during the storage season. TID will need to modify its summer operation of the reservoir over the term of the DBHCP to accommodate the reduction in available storage. Conservation Measures CC-1, CC-2 and CC-3 are all designed to keep the modified reservoir operation from adversely affecting Oregon spotted frogs. Measure CC-1 will provide a flow of at least 50 cfs below Crescent Dam through August and additional water (OSF storage) that can be used to increase flows above this level. Measure CC-2 will require a gradual ramp-down to winter flow (≥ 10 cfs). Measure CC-3 places an additional constraint by requiring the ramp-down to be completed before Oregon spotted frogs typically selected overwintering sites.

6.3.5.2 Effects of Historical Crescent Lake Reservoir Operation on Late Summer Hydrology

Median water surface elevations in lower Crescent Creek and lower Little Deschutes River have historically been up to 0.7 foot (8 inches) higher than unregulated elevations from July through September (see Figures 6-46 and 6-47). While unregulated flows and water surface elevations would have decreased steadily from May through July and stayed low until late autumn, they have instead remained high from May through September as a result of irrigation releases. In some years, such as in 2015 (see Figures 6-39 and 6-41) water levels started to decrease in June and then increased again in July when irrigation releases began. At the end of the irrigation season in late September, releases from Crescent Lake Reservoir have historically been ramped down quickly over a period of a few days and median water surface elevations in lower Crescent Creek and lower Little Deschutes River have been comparable to or slightly less than unregulated elevations.

6.3.5.3 Effects of DBHCP Measure CC-3 on Late Summer Hydrology

The minimum flow below Crescent Dam during the irrigation season will be 50 cfs (see Measure CC-1), although actual flow will be considerably higher at most times to meet irrigation demand. OSF storage will also be available to maintain certain flows when irrigation demand is low. Once the release of irrigation season and OSF storage ceases in the fall, however, TID will endeavor to ramp releases from Crescent Lake Reservoir down to the allowable minimum as quickly as possible to conserve the remaining storage. Measure CC-2 will set a limit on how quickly ramp-down may occur to facilitate frog movements, but it does not require ramp-down to be completed by any set date. Measure CC-3 will therefore require that ramp-down be completed no later than October 31 so that winter water surface elevations in occupied wetlands are established prior to the onset of overwintering by Oregon spotted frogs.

6.4 Whychus Creek

6.4.1 Conservation Goal and Objectives for Whychus Creek

6.4.1.1 Whychus Creek Goal No. 1

Support the use of Whychus Creek by salmonid fishes.

6.4.1.2 Measurable Resource Objectives for Whychus Creek Goal No. 1

Whychus Creek Objective 1-A: Maintain increased instream flows in Whychus Creek during the irrigation season above historical (pre 2010) levels.

Whychus Creek Objective 1-B: Eliminate impediments to safe upstream and downstream movement of fish caused by the TSID diversion.

Whychus Creek Objective 1-C: Support efforts to increase summer instream flows, decrease peak summer temperatures and enhance habitats for covered species in lower Whychus Creek.

6.4.1.3 Rationale for Whychus Creek Goal No. 1

Whychus Creek provides habitat for resident redband trout and adfluvial bull trout. Efforts are currently underway to reintroduce anadromous trout (steelhead) above the Pelton Round Butte Project, and if the reintroductions are successful steelhead are expected to spawn and rear in Whychus Creek. Irrigation activities on Whychus Creek have historically had negative effects on salmonid fishes in two ways: summertime diversions of water for irrigation have resulted in extremely low instream flows, and diversions structures have interfered with upstream and downstream fish movement. The goal of the DBHCP for Whychus Creek is to reduce the negative effects of TSID activities on salmonid habitats in Whychus Creek and support the ongoing reintroductions.

There are three resource objectives related to Whychus Creek Goal No. 1. Objective 1-A addresses the need to maintain increased irrigation season flows in Whychus Creek that have resulted from recent conservation actions by TSID. Objective 1-B concerns the historical potential for entrainment and blockage to fish passage at the TSID diversion on Whychus Creek. Objective 1-C acknowledges the ongoing efforts by the Upper Deschutes Watershed Council (UDWC), Deschutes River Conservancy (DRC) and others to improve overall habitat conditions for salmonids in Whychus Creek. A key limiting factor for anadromous salmonids in Whychus Creek is peak summer water temperature. Objective 1-C directs TSID to support ongoing efforts by UDWC, DRC and others to reduce peak temperatures (as indicated by maximum 7-DADM of ≤20°C at RM 6.0) by increasing instream flows and improving physical and biological habitat conditions.

6.4.2 Conservation Measures for Whychus Creek

The DBHCP contains seven conservation measures for Whychus Creek. Four of the measures (WC-1, WC-2, WC-4 and WC-5) address instream flow in Whychus Creek during the irrigation season (Whychus Creek Objective 1-A). Two other measures (WC-3 and WC-7) involve removal of impediments to safe fish passage in the creek and maintenance of those safe conditions.

Measure WC-6 creates a habitat conservation fund to support ongoing efforts in support of the steelhead reintroduction.

Conservation Measure WC – 1: Whychus Creek Instream Flows

For the full term of the DBHCP, and subject to the last paragraph of this conservation measure, Three Sisters Irrigation District (TSID) will pass all water the District has converted to permanent instream water rights on Whychus Creek (currently 31.18 cfs) at its diversion. In addition, TSID will pass all water required under Oregon water law to senior water right holders downstream of the TSID diversion (currently 3 cfs), for a combined minimum flow past the TSID diversion of 34.18 cfs. All future additional conversions of senior water rights to permanent instream flow use will be added to this minimum flow as such rights are converted.

TSID will monitor flow in Whychus Creek at OWRD Gage 14076020 whenever TSID is diverting water, and will adjust its diversions as necessary to pass required minimum instream flows on an hourly basis when the flow reaching the TSID diversion is 60 cfs or less. Instream flows when TSID is diverting will be determined by using the proportionality calculator developed by TSID and the Deschutes River Conservancy in 2019. Any updates to the proportionality calculator during the term of the DBHCP that affect flow in Whychus Creek shall be approved in advance of use by the Services.

For TSID irrigation rights with priority dates equal to instream rights, water will be shared proportionally between irrigation and instream rights whenever there is insufficient natural flow above the TSID diversion to meet all of the rights. However, TSID will reduce diversions disproportionately if necessary to ensure the instream flow at Gage 14076020 does not drop below 20 cfs (averaged over no more than 60 minutes) while TSID is diverting. This 20 cfs minimum does not include the 3 cfs of senior water that TSID will pass below the TSID diversion, or any future additional conversions of senior water rights to permanent instream use. To help minimize the amount of time when the flow at Gage 14076020 is less than the full instream water right, TSID will continue to manage water “on-demand,” whereby TSID will only divert and deliver to its patrons when specifically requested by its patrons.

Conservation Measure WC – 2: Whychus Creek Temporary Instream Leasing

Within 6 months after issuance of the Incidental Take Permits, and no later than March 1 of each year thereafter for the term of the Permits, TSID will provide $6,000 each year for the Whychus Creek temporary In-stream Leasing Fund. This amount will be adjusted annually for inflation in direct proportion to the change in annual average Consumer Price Index for all urban consumers (CPI-U), West Region, all items, Base Period 1982-84=100, published by the Bureau of Labor Statistics. The fund shall be held, managed and distributed by a third-party designated by USFWS and NMFS. The funds will be distributed to secure temporary instream leases and/or improve or enhance habitat in Whychus Creek.

Conservation Measure WC – 3: Whychus Creek Diversion Fish Screens and Fish Passage

Over the term of the DBHCP, TSID will maintain and operate fish screens at its Whychus Creek diversion to ensure they function according to the NMFS downstream migrant fish screen criteria they were designed to meet.

Over the term of the DBHCP, TSID will maintain and operate its diversion structure to ensure it continues to function without interference to the upstream migration of anadromous fish.

Annual turn-off of the TSID diversion will be done in accordance with the TSID Diversion Screen Maintenance Plan (Appendix C) to minimize impacts to covered species and resident fish.

Conservation Measure WC – 4: Piping of Patron Laterals

TSID will assist with the piping of patron-owned canals (patron laterals) within TSID. The goal of this measure will be to pipe all patron laterals in TSID (remaining 5 miles) within 5 years of issuance of the Incidental Take Permits, subject to patron willingness and funding. TSID will assist with project design, application for funding, and pipe installation.

Conservation Measure WC – 5: Whychus Creek Diversion Ramping Rate

When the flow in Whychus Creek downstream of TSID's diversion (measured at OWRD Gage 14076020) is 30 cfs or less, the amount of water being diverted will not be increased or decreased more than 5 cfs/hour. When the flow at OWRD Gage 14076020 is between 30 and 50 cfs, the amount of water being diverted will not be increased or decreased more than 10 cfs/hour. TSID may reduce diversions faster than these rates during emergency conditions to maintain human safety and/or protect infrastructure.

Conservation Measure WC – 6: Whychus Creek Habitat Conservation Fund

For the full term of the DBHCP, TSID will provide $10,000 each year in funding, in-kind services, or a combination of funding and in-kind services to support the restoration and enhancement of aquatic and riparian habitats in Whychus Creek. This amount will be adjusted annually for inflation in direct proportion to the change in annual average Consumer Price Index for all urban consumers (CPI-U), West Region, all items, Base Period 1982-84=100, published by the Bureau of Labor Statistics. The use of the funds and/or in-kind services will be directed by an entity acceptable to USFWS and NMFS.

Conservation Measure WC – 7: Plainview Dam Removal

No later than Year 1 of DBHCP implementation, TSID will provide in-kind services for the removal of the Plainview Dam, restoration of the associated reach of Whychus Creek, and installation of a fish screen at the Runco diversion.

6.4.3 Rationale for Conservation Measure WC-1

6.4.3.1 Overview

TSID diverts water from Whychus Creek at RM 24.2, upstream of the City of Sisters. The District is the largest of several parties diverting water from Whychus Creek, and it holds about 78 percent of the water rights for the creek. TSID does not store water within the creek channel or return tailwater to the creek; the District's only effects on Whychus Creek result from the diversion of water. Irrigation diversions occur primarily from April through October and stock water diversions occur in November and March. TSID delivers stock water to patrons in December through February as well, but this is done with water stored in the District's reregulating reservoirs in November and does not involve diverting additional water from the creek during the winter. Historically, irrigators on Whychus Creek collectively had the ability to dry up portions of the creek during the summer. In recent years TSID has made substantial improvements in its infrastructure to reduce its diversions and converted portions of its irrigation rights to instream rights in Whychus Creek. The DBHCP represents the culmination of that multi-year effort.

6.4.3.2 Effects of Historical Diversions on Whychus Creek Hydrology

The recent historical effects of irrigation diversions on the hydrology of Whychus Creek are illustrated by comparing unregulated flows to historical flows for the years 2001 through 2018 (Figures 6-48 and 6-49). The difference between unregulated and historical daily average flows reflects diversions by TSID as well as a small number of additional diversions by other parties upstream of Sisters, although most of the difference is due to TSID alone. The comparison shows that median winter flows were historically 85 to 90 percent of unregulated flows because diversions occurred only intermittently during the winter. In the summer, however, irrigation diversions historically resulted in substantial reductions of Whychus Creek flows. Summer flows in Whychus Creek have increased since 2005 due to conserved water projects by TSID that have reduced canal seepage and created instream water rights in Whychus Creek.

The natural hydrology of Whychus Creek is typical of streams associated with the Cascade Mountains. The highest flows occur during occasional winter storm events when rain and melting snow combine to produce flood conditions (Figure 6-48). Lesser, but more regular and sustained peak flows occur during snowmelt in April through July. Low flows occur in the winter when the upper watershed is frozen, and in late summer after runoff from snowmelt has subsided. The effects of recent historical diversions by TSID and others on Whychus Creek flows are most apparent during the irrigation season (April through October), when median flows can represent a reduction of up to 83 percent from median unregulated flows (Figure 6-49).

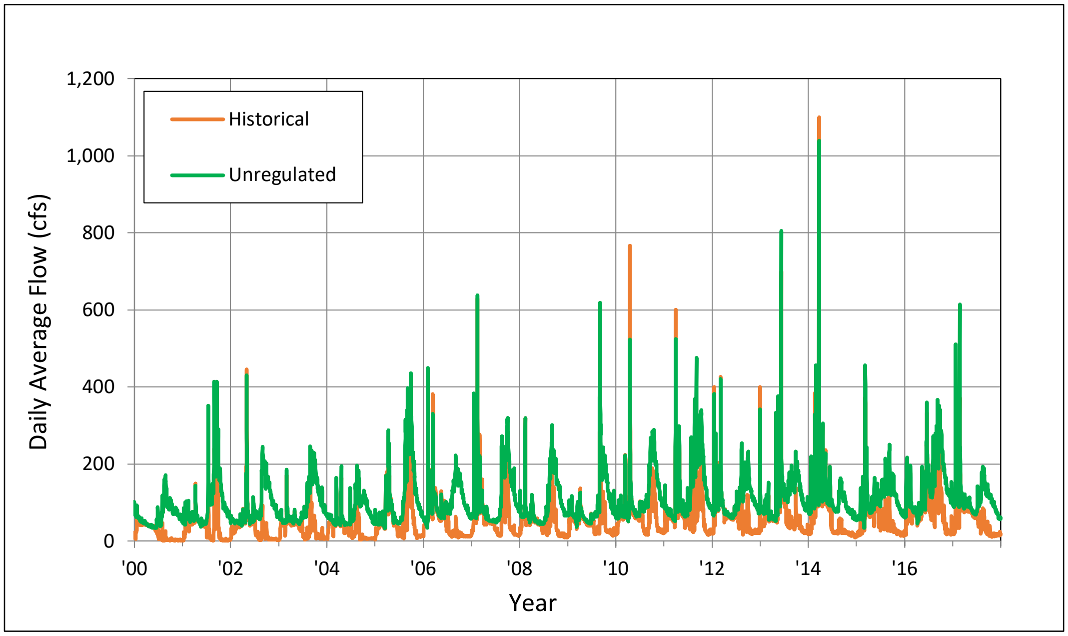

Figure 6-48. Daily average flows for unregulated and historical conditions in Whychus Creek at Sisters (OWRD Gage 14076050) from 2001 through 2018. Sources: OWRD 2020g; Reclamation 2020a.

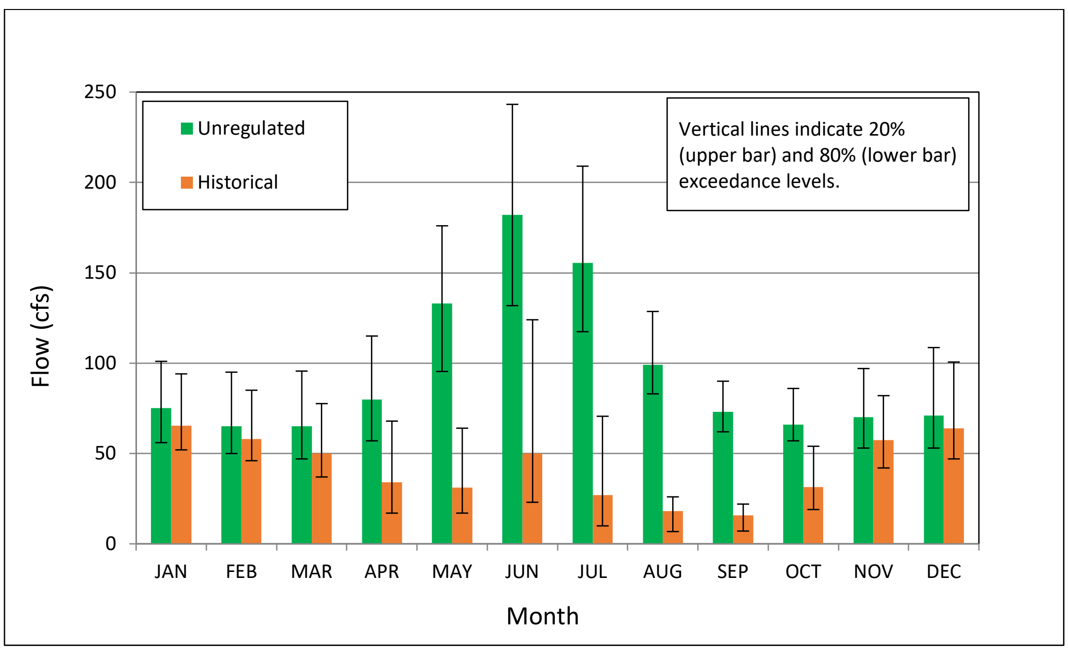

Figure 6-49. Monthly medians of daily average flows for unregulated and historical conditions in Whychus Creek at Sisters (OWRD Gage 14076050) from 2001 through 2018. Sources: OWRD 2020g; Reclamation 2020a.

6.4.3.3 Effects of Historical Diversions on Whychus Creek Water Temperature

Whychus Creek is listed as water temperature limited under Section 303(d) of the Clean Water Act from RM 40.3 (16 miles upstream of the TSID diversion) to the mouth. Summer water temperatures in Whychus Creek generally increase with downstream movement until a substantial infusion of groundwater at Alder Springs (RM 1.4) has a marked cooling effect (Figure 6-50). Peak summer temperature (Max 7-DADM) has generally been less than 18°C upstream of the TSID diversion at RM 24.2, but frequently over 18°C downstream from the diversion to Alder Springs, particularly in years of low instream flow (Watershed Sciences and MaxDepth Aquatics 2008). Summer water temperatures have decreased over the past decade due to the establishment of instream water rights, but 7-DADM temperatures as high as 23°C were reported at RM 6.0 in 2013 (Figure 6-50; Mork 2014). The TSID diversion contributes to high summer temperatures downstream of that point by reducing the thermal mass of water in the stream and indirectly increasing the effects of conductive and radiant (solar) heating. Additional diversions unrelated to the covered activities have similar additive effects on water temperature.

Figure 6-50. Longitudinal profile of peak summer temperatures in Whychus Creek from 2007 through 2013. Source: Mork 2014.

6.4.3.4 Effects of DBHCP Measure WC-1 on Whychus Creek Hydrology

Recent conserved water projects (canal piping) by TSID have resulted in instream water rights of 31.18 cfs in Whychus Creek. TSID will manage its diversion in accordance with Conservation Measure WC-1 using the proportionality calculator developed collaboratively by the District and the DRC to comply with the instream water rights and prevent diversions from causing extreme low summer flows in lower Whychus Creek. The instream rights have a priority date equal to that of TSID's irrigation right, so that water is shared proportionally whenever the natural flow upstream of the diversion is insufficient to meet all rights (i.e., TSID's diversion right is not be senior to the instream rights). In addition, TSID will further reduce its diversions whenever necessary to maintain an instream flow of 20 cfs. The flow in Whychus Creek downstream of the TSID diversion will only fall below 20 cfs when the natural flow upstream of the diversion is less than 20 cfs. From 1981 through 2018, the natural flow was less than 20 cfs for only 3 days during February of 1993 (OWRD 2020g), suggesting flows of less than 20 cfs will be extremely rare in the future with the DBHCP in place.

Flows under the DBHCP will generally be higher than recent historical flows (Figures 6-51 and 6-52). Median flows will be higher under the DBHCP in all months except March, April, October and November. Low (80% exceedance) flows under the DBHCP will be higher than recent historical conditions in most months as well. These differences reflect the fact that recent historical flows cover the period from 2001 to 2018, during which time the Whychus Creek instream flow rights were still increasing as a result of TSID's piping program. Projections of future flows under the DBHCP, on the other hand, reflect full instream rights of 31.18 cfs. The effects of these water rights will be most apparent during the peak of the irrigation season in June and July. The apparent decreases in median flows in Whychus Creek during March, October and November under the DBHCP are the result of TSID diversions in these months being artificially low from 2000 through 2017 due to canal piping projects that prevented the District from diverting water. These reduced diversions increased the historical stream flows shown in Figure 6-52. Now that piping is completed, TSID will return to its normal practice of diverting water from March through November and Whychus Creek flows will return to levels similar to those that occurred prior to 2000.

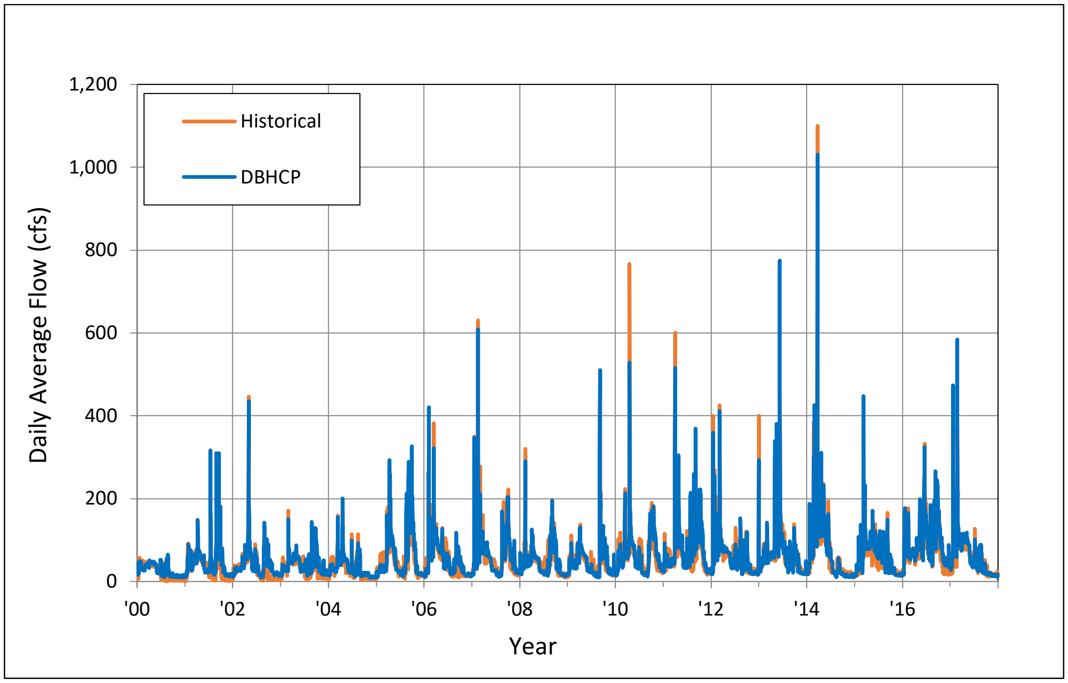

Figure 6-51. Daily average flows for historical conditions (reported) and DBHCP conditions (projected) in Whychus Creek at Sisters (OWRD Gage 14076050) from 2001 through 2018. Sources: OWRD 2020g; Reclamation 2020a.

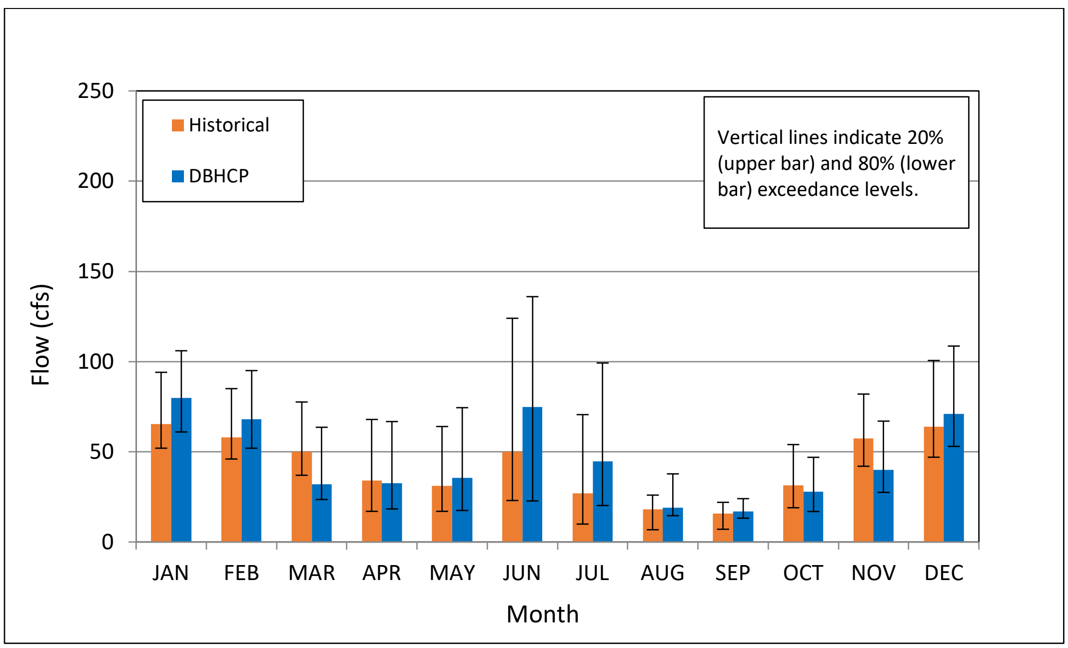

Figure 6-52. Monthly medians of daily average flows for historical conditions (reported) and DBHCP conditions (projected) in Whychus Creek at Sisters (OWRD Gage 14076050) from 2001 through 2018. Sources: OWRD 2020g; Reclamation 2020a.

Historically TSID managed its diversions to maintain target instream flows on a daily average basis, which resulted in periods of 1 hour or more within each day when instream flows could be less than the required minimums. To avoid this in the future, TSID has modified its diversion facility to allow more precise monitoring and adjustment of diversion rates. TSID will now maintain target instream flows on an hourly basis whenever the natural flow in Whychus Creek is 60 cfs or less. This improvement will reduce the potential duration of flows below the required minimums to less than 1 hour.

6.4.3.5 Effects of DBHCP Measure WC-1 on Whychus Creek Water Temperature

Water temperatures in Whychus Creek under historical and future (DBHCP) conditions were compared using a regression equation developed by Mork and Houston (2016). The authors evaluated multiple parameters and concluded the strongest predictors of instream water temperature were the natural log of average daily instream flow and the 3-day moving average of daily maximum air temperature. The following equation predicted the 7-DADM at RM 6.0 in Whychus Creek during the month of July with a correlation coefficient (r^2) of 0.87:

Equation 1: 7-DADM = 18.39 – (2.55601 x Log_N Flow) + (0.345 x 3DAir)

Where: - ***7-DADM*** is the 7-day average of daily maximum water temperature (°C) at RM 6.0

- ***Flow*** is the daily average flow (cfs) at OWRD Gage 14076050 at the City of Sisters
- ***3DAir*** is the 3-day rolling average maximum air temperature (°C) at Colgate, Oregon

Mork and Houston (2016) selected RM 6.0 for analysis because it lies within the warmest reach of Whychus Creek and shows the maximum influence of upstream land uses and flow alterations (see DBHCP Section 4.5.3, *Whychus Creek Water Temperature*). They developed separate regression equations for each month of the year, and we used July for the DBHCP analysis because it is traditionally the hottest month of the year in the Deschutes Basin (WRCC 2017) as well as a month of peak irrigation diversions. To facilitate the comparison of different instream flows, air temperature was held constant at 29.17°C, which was the average daily maximum during the month of July for the period 1981-2010 (WRCC 2017). The rolling 3-day average of maximum air temperature is likely higher than this at times during July, but the objective was to compare different flows at a constant air temperature rather than to calculate maximum water temperature at a given flow. Since air temperature plays a much smaller role than solar insolation in determining surface water temperature, a small change in air temperature would not be expected to significantly alter the relative differences in calculated water temperature between flows.

The results of the temperature analysis are presented in Table 6-5. The recent historical median July flow of 27 cfs and DBHCP median July flow of 45 cfs result in increases in 7-DADM at RM 6.0 of 4.5 and 3.2 °C, respectively, compared to the unregulated median flow of 155 cfs. The DBHCP instream water rights of 31.18 cfs for July, which results in a flow at Sisters of approximately 23.18 cfs, represents an increase in 7-DADM of about 2.9°C from the unregulated minimum flow of 71 cfs, but a decrease of 6.3°C from the historical minimum of 2 cfs. The DBHCP minimum flow of 20 cfs will produce a 7-DADM 4.5°C higher than the unregulated minimum and 4.6°C lower than the historical minimum. Overall, this suggests the monthly median 7-DADM at RM 6.0 in July under the DBHCP will be slightly lower than recent historical operations, which reflects much of the recent conserved water projects completed by TSID, and about 3°C higher than would occur in the absence of irrigation diversions. Monthly maximum 7-DADM in July will decrease at least 4°C and as much as 6°C from historical conditions, and will be about 3°C to 5°C higher than the unregulated condition.

Mork and Houston (2016) did not extrapolate the use of their regression equations to other reaches of Whychus Creek, but it can be assumed the relative differences between flow conditions shown in Table 6-6 are applicable, within limits, to the entire distance between RM 6.0 and the TSID diversion at RM 24.2. Measurable departures from this relationship can be expected immediately downstream of larger tributaries (e.g., Indian Ford Creek at RM 19.5) and irrigation diversions. As noted previously, actual temperatures under all scenarios could be higher, depending on site-specific conditions, and this analysis should not be considered a predictor of absolute temperature under any flow regime.

Table 6-6. Predicted 7-day average of daily maximum water temperature (7-DADM) at River Mile 6.0 in Whychus Creek under historical and future (DBHCP) conditions.

Flow Condition	Flow at OWRD Gage 14076050 in Sisters, OR	7-DADM at River Mile 6.0
Unregulated (Natural) Median Flow	155 cfs	15.56°C
Unregulated (Natural) Minimum Flow	71 cfs	17.56°C
Historical Median Flow	27 cfs	20.03°C
Historical Minimum Flow	2 cfs	26.68°C
DBHCP Median Flow	45 cfs	18.72°C
DBHCP Instream Water Rights[1]	23.18 cfs	20.42°C
DBHCP Minimum Flow[1]	12 cfs	22.10°C

Note:

[1] The instream water rights of 31.18 cfs and minimum flow of 20 cfs described in Conservation Measure WC-1 are both measured directly downstream of the TSID diversion at RM 24.2. Channel losses estimated between the TSID diversion and Gage 14076050 at Sisters are assumed to reduce instream flow by 8 cfs during July.

6.4.4 Rationale for Conservation Measure WC-2

6.4.4.1 Overview

As indicated in Figure 6-52, natural flows in Whychus Creek may be too low at times to meet irrigation demands and provide an instream flow of 31.18 cfs downstream of the TSID diversion. To address this, TSID will continue a program it has utilized in the past of funding the purchase of water rights from individual patrons on a temporary basis. Under Oregon State law (OAR 690-77) the temporary leasing of irrigation rights for instream placement is considered a beneficial use that preserves the irrigation right while simultaneously enhancing instream values. Individual holders of water rights may voluntarily allow all or a portion of their right to remain instream rather than being diverted for up to five consecutive irrigation seasons per lease, and leases may be renewed an unlimited number of times. The DBBC Districts and the DRC have used this program successfully over the past decade to improve aquatic habitat conditions throughout the Deschutes Basin. The DRC and TSID have consistently found willing patrons to lease water for temporary placement in Whychus Creek, and this is expected to continue into the future. The funding provided by Measure WC-2 will be used to encourage participation in the program. While some patrons may be willing to lease water instream without compensation, TSID and the DRC have found monetary compensation to be the most effective means of ensuring participation. All instream flow acquired through temporary leases will be added to water from permanent instream rights to meet or exceed the target of 31.18 cfs.

6.4.4.2 Effects of DBHCP Measure WC-2 on Whychus Creek

Conservation Measure WC-2 will be used to increase flows in Whychus Creek downstream of the TSID diversion in April through October, primarily at times when natural flows upstream of the TSID diversion are less than 62 cfs and the resulting flow downstream of the diversion would be less than 31 cfs. TSID will have the option to fund temporary instream leases at any time, but the most effective use of the funding will be to reduce the amount of time during the irrigation season when the flow downstream of the TSID diversion is less than 31 cfs. The resulting effects on water temperature and aquatic habitat will be as described above in Section 6.4.3.

6.4.5 Rationale for Conservation Measure WC-3

6.4.5.1 Overview

In the absence of man-made barriers, anadromous fish have volitional access in Whychus Creek upstream to a natural falls at RM 37.1. Prior to 2010, however, the TSID diversion at 24.2 interfered with fish movement and allowed limited use of the upper 13 miles of habitat. The diversion structure in place prior to 2010 had provisions for upstream passage, but these had limited effectiveness and needed frequent maintenance. The diversion was rebuilt in conjunction with a stream restoration effort in 2010. It is now a low concrete structure that fish can swim over in the upstream and downstream directions. A V-notch near the left abutment (opposite the intake) provides volitional passage at low flows. Steelhead trout can now reach all naturally-accessible habitat in Whychus Creek. Bull trout also have physical access to RM 37.1, but water temperatures, even with unregulated conditions, likely limit use by this cold-water species above Alder Springs at RM 1.4.

In conjunction with replacement of the diversion structure, TSID installed a new fish screen in 2011 to prevent entrainment of juvenile salmonids. The Farmers Conservation Alliance-type fish screen is designed to meet ODFW and NMFS criteria for resident and anadromous fish. It is about 140 feet in length and horizontally aligned so the water flows parallel to, and over, the top of the screen. Fish entering the diversion are returned to the creek through a separate bypass pipe about 300 feet downstream of the intake, prior to entering the irrigation system. TSID has recently prepared a formal maintenance plan for the screens (Appendix C) in collaboration with NMFS, USFWS and ODFW. This plan will guide maintenance and operation of the screens during DBHCP implementation. Included in the plan are procedures for the annual turn-off of the diversion in November to minimize stranding of fish within the diversion structure.

6.4.5.2 Effects of DBHCP Measure WC-3 on Covered Fish Species

Once constructed, fish passage facilities and screens require periodic monitoring and maintenance to remain functional. Under Measure WC-3, TSID will maintain the diversion structure and fish screen so that upstream migrants continue to have unimpeded access above RM 24.2, and downstream migrants are not entrained or harmed by the irrigation water intake. In this way, the potential for adverse effects of the diversion on upstream and downstream migrants will be eliminated.

6.4.6 Rationale for Conservation Measure WC-4

6.4.6.1 Overview

Patrons of TSID own and maintain 33.3 miles of lateral canals that convey water from the District canals (points of delivery) to the irrigated fields. As of 2020, about 28 miles of these patron laterals had been piped, largely with assistance from TSID, to reduce seepage losses and increase on-farm efficiency. The TSID assistance has been in the form of project design, applications for funding, and pipe installation. Patrons have also been encouraged to pipe by TSID’s program of piping District canals. The piping of patron canals has marginal economic benefits when District canals are un-piped because patrons still incur the costs of pumping water out of District canals and pressurizing it. When District deliveries are pressurized, however, patrons can benefit from piping their own canals and keeping the water under pressure from the point of delivery to the point of application. Much of the patron piping within TSID had been a direct result of District piping.

6.4.6.2 Effects of DBHCP Measure WC-4 on Whychus Creek

The piping of patron canals will lead to additional instream flow in Whychus Creek during the irrigation season. Reducing seepage losses can reduce the amount of water TSID needs to deliver to patrons, particularly early in the irrigation season. This, in turn, can reduce the amount of water TSID diverts from Whychus Creek. While there is typically no permanent instream water right associated with the piping of patron laterals, the benefits to instream flow are realized nonetheless. In addition, the reductions in seepage losses can make water available for landowners to voluntarily transfer instream on a temporary basis through the leasing program funded by Conservation Measure WC-2.

6.4.7 Rationale for Conservation Measure WC-5

6.4.7.1 Overview

TSID manages irrigation deliveries on an "on-demand" basis, which means water is diverted from Whychus Creek only at rates needed to meet current patron demands. This approach keeps diversion rates as low as possible and eliminates the need for return flow (the flow of unused water from District canals and/or patron lands back to Whychus Creek). The alternative would be to divert water at a constant (typically high) rate and allow unused water to spill back into the creek as patron demand fluctuates. This latter approach is necessary on large districts with open canals and long distances between diversions and deliveries, but TSID is able to manage on-demand because the District is relatively small and the distribution network is mostly piped.

One disadvantage of operating on-demand is that the rate of diversion fluctuates frequently on a daily basis, resulting in fluctuating creek flows downstream of the diversion. TSID is able to partially reduce the need to fluctuate diversions by raising and lowering water levels in its two reregulating reservoirs (Watson and McKenzie Canyon), but it cannot altogether eliminate daily fluctuations at its diversion.

When the natural flow in Whychus Creek is high, a change in the rate of diversion results in relatively little change in creek flow. When the natural flow is low, however, irrigation diversions can represent a large proportion of total flow. A sudden change in the rate of diversion at low flow can produce a significant change in downstream water depth and potentially lead to the stranding or flushing of young fish. To reduce this potential, TSID will limit the rate of change in diversion to 5 cfs per hour whenever the flow in Whychus Creek downstream of the diversion is 30 cfs or less. When the flow is between 30 and 50 cfs, the amount of water being diverted will not be increased or decreased more than 10 cfs per hour.

6.4.7.2 Effects of DBHCP Measure WC-5 on Whychus Creek

The rating curve for Whychus Creek at OWRD Gage 14076020, located about 0.3 mile downstream of the TSID diversion, shows a relatively steep change in stage (water depth) with change in discharge (flow) below 50 cfs, and less of a change in depth with change in flow above 50 cfs (Figure 6-53). A change of 10 cfs when the creek is flowing above 50 cfs would produce a change in water depth of 1 inch or less at the gage. A similar change in flow when total flow is less than 30 cfs could produce a change in water depth of as much as 2 inches at the gage. By design, Gage 14076020 is located in a confined reach of Whychus Creek where a given change in flow will have a greater effect on water depth than it would in less-confined reaches. The rating curve for Gage 14076020 is therefore considered a high estimate of the change in water depth associated with a given change in flow.

The limit of 10 cfs per hour in Conservation Measure WC-5 when the flow is between 30 and 50 cfs will effectively prevent changes in water depth, particularly decreases, of more than 1.4 inches per hour. When the flow is below 30 cfs and the limit on change is 5 cfs per hour, the associated change in water depth will be 1 inch or less.

Hunter (1992) conducted a review of scientific literature on the effects of flow fluctuations on salmonid fishes in the Pacific Northwest, and recommended a maximum rate of change in water depth of 1 inch per hour when fry are present and 2 inches per hour at other times of year. The recommended rate was lower for salmonid fry because they are less mobile than later life stages and they inhabit the shallow margins of streams where they are presumably more susceptible to stranding during sudden drops in water level.

Juvenile steelhead can be present in Whychus Creek year round. TSID irrigation diversions begin in April. From April through June, when diversions are occurring and fry are present, the daily average flow downstream of the diversion can be less than 50 cfs (Figure 6-52). When the flow is between 50 cfs and 30 cfs, the maximum rate of change in diversion will thus be 10 cfs per hour and the maximum change in water depth will be 1.4 inches. When the flow is 30 cfs or less, the maximum rate of change will be 1 inch per hour. The potential change in water depth of up to 1.4 inches per hour is greater than the recommendation of 1 inch per hour for salmonid fry, but it is within the recommended maximum for other salmonid life stages (Hunter 1992). As noted above, the higher rate is necessary to maintain the on-demand operation of TSID and avoid diverting excess water when it is not needed.

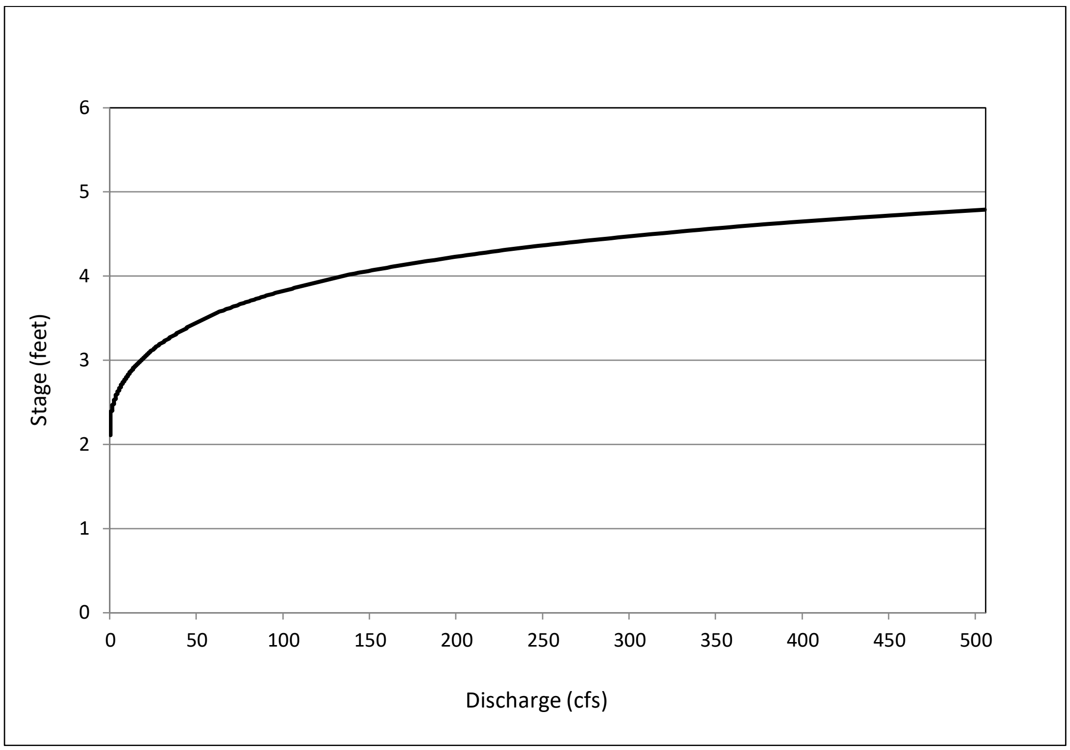

Figure 6-53. Rating curve for OWRD Gage 14076020, Whychus Creek below TSID diversion near Sisters, Oregon, as of October 2017. Source: OWRD 2017b.

6.4.8 Rationale for Conservation Measure WC-6

6.4.8.1 Overview

A primary goal of the DBHCP for Whychus Creek is to support the ongoing reintroduction of steelhead trout. TSID has recently completed the piping of its entire canal system and creation of instream water rights of 31.18 cfs in Whychus Creek. This effort has contributed significantly to the increase in total wetted area of aquatic habitat for salmonids in lower Whychus Creek and the decrease in peak summer water temperatures. Additional work remains, however, to reduce peak summer temperatures in lower Whychus Creek to ranges suitable for juvenile salmonid rearing.

As noted above, Conservation Measure WC-2 will contribute to the effort to reduce peak water temperatures by funding temporary instream leasing of water during the irrigation season. In addition to that, Conservation Measure WC-6 will support efforts to improve conditions for juvenile salmonids by restoring/enhancing riparian, aquatic and floodplain habitats. In recent decades TSID has established itself as one of the primary participants in fisheries habitat restoration on Whychus Creek. The District has contributed funding to stream restoration efforts by other parties, but more importantly it has provided on-the-ground expertise, personnel and equipment to conduct the restoration projects. Because of its proximity to the creek, its experience with the logistics of restoration in Deschutes County and its ability to provide manpower and equipment at cost, TSID has proven to be an extremely efficient and effective resource to parties conducting habitat restoration. Conservation Measure WC-6 will ensure TSID's support and involvement in habitat restoration will continue for the term of the DBHCP.

6.4.8.2 Effects of DBHCP Measure WC-6 on Whychus Creek

A wide variety of habitat restoration and enhancement projects are envisioned for Whychus Creek over the next 30 years, and the effects of those projects are equally variable. While they all share a common goal of improving fish habitat conditions, they can vary from establishment of riparian vegetation for shade, nutrient and large-wood recruitment to channel, side-channel and floodplain restoration. The specific projects to benefit from TSID's involvement cannot be predicted at this time, but the common goal for all participants of improving habitat conditions ensures that TSID's involvement will have a positive effect on steelhead and bull trout in the creek.

6.4.9 Rationale for Conservation Measure WC-7

6.4.9.1 Overview

Conservation Measure WC-7 represents a specific example of the type of habitat restoration project TSID will support through Conservation Measure WC-6. Plainview Dam is the last remaining man-made impediment to salmonid migration on Whychus Creek. TSID has agreed to provide the manpower and equipment needed to remove the dam and restore the creek bed and banks. Concurrent with this, TSID will install a screen to prevent entrainment of juvenile salmonids at the Runco diversion, a small irrigation diversion that previously received water from the Plainview Ditch.

6.4.9.2 Effects of DBHCP Measure WC-7 on Whychus Creek

The work at Plainview Dam and the Runco diversion being supported by TSID will provide steelhead and bull trout with unimpeded access to Whychus Creek upstream of Plainview Dam.

6.5 Crooked River, Ochoco Creek and McKay Creek

6.5.1 Conservation Goals and Objectives for the Crooked River Subbasin

6.5.1.1 Crooked River Goal No. 1

Assist in the reintroduction of anadromous salmonids in the Crooked River subbasin by contributing to instream flows.

6.5.1.2 Measurable Resource Objectives for Crooked River Goal No. 1

Crooked River Objective 1-A: Allow Reclamation to forego irrigation storage in Prineville Reservoir if needed to help maintain an instream flow of 50 cfs in the Crooked River at the City of Prineville after fish and wildlife mitigation water and uncontracted water in Prineville Reservoir are depleted for the year.

Crooked River Objective 1-B: Manage the storage, release and diversion of water in Ochoco Creek to maintain minimum flows of 5 cfs during the irrigation season and 3 to 5 cfs during the rest of the year.

Crooked River Objective 1-C: Manage release and diversion of water in McKay Creek to maintain a minimum flow of 2 to 5 cfs during the irrigation season.

6.5.1.3 Rationale for Crooked River Goal No. 1

Efforts are underway to reintroduce steelhead trout to the lower Crooked River and its tributaries (Ochoco Creek and McKay Creek). The covered activities affect habitats in the lower Crooked River subbasin through changes in hydrology, particularly seasonal reductions in flow caused by the storage, release and diversion of irrigation water. Recent enactment of the Crooked River Collaborative Water Security and Jobs Act of 2014 (Crooked River Act) enables Reclamation to use over 40 percent of the storage capacity of Prineville Reservoir (uncontracted water) for the enhancement of flows in the lower Crooked River. The uncontracted water is believed sufficient to meet fish and wildlife objectives in the Crooked River in average and wet years (when Prineville Reservoir fills), but there is concern it may not be sufficient for maintaining target habitat conditions in years when the reservoir does not fill. Flows in the tributary streams are unaffected by the Crooked River Act, and they remain predominantly under the influence of the covered irrigation activities. Crooked River Goal No. 1 is intended to promote modifications to irrigation storage and diversion practices in the subbasin in ways that improve instream habitat conditions and assist with fish reintroduction efforts.

6.5.1.4 Crooked River Goal No. 2

Support fish and wildlife habitat restoration efforts in the Crooked River subbasin.

6.5.1.5 Measurable Resource Objective for Crooked River Goal No. 2

Crooked River Objective 2-A: Provide annual financial contributions to support habitat restoration and enhancement projects that will benefit covered species in the Crooked River subbasin.

6.5.1.6 Rationale for Crooked River Goal No. 2

Numerous efforts are underway to restore and enhance habitats for fish and wildlife in the Crooked River subbasin. Several more are in the planning stages. Instream flows provided according to Crooked River Goal No. 1 will assist with these efforts by improving hydrologic conditions. Financial support from the Permittees will also help make restoration and enhancement projects possible.

6.5.1.7 Crooked River Goal No. 3

Minimize the impacts of irrigation diversions on the safe upstream and downstream passage of salmonid fishes.

6.5.1.8 Measurable Resource Objectives for Crooked River Goal No. 3

Crooked River Objective 3-A: Maintain fish screens covered by the DBHCP to applicable standards.

Crooked River Objective 3-B: Assist irrigation district patrons with the screening of pump intakes in waters occupied or potentially occupied by covered species.

6.5.1.9 Rationale for Crooked River Goal No. 3

The DBHCP covers eight primary diversion structures (mostly dams) in the Crooked River subbasin, all of which are screened to prevent entrainment of fish. Over the term of the DBHCP the screens will require maintenance, repair, and in some cases replacement. Conducting these repairs and replacements to current standards for fish protection will reduce impacts to covered species and help with overall reintroduction efforts in the subbasin.

Irrigation district patrons divert smaller amounts of water at another 67 pumps in the Crooked River and Ochoco Creek. Very few of these patron diversions are screened to exclude fish. The patron diversions are not covered by the DBHCP, but screening of the diversions with assistance from the Permittees will have benefits to the covered species.

6.5.2 Conservation Measures for the Crooked River Subbasin

Measure CR – 1: Crooked River Flow Downstream of Bowman Dam

In coordination with Reclamation, Ochoco Irrigation District (OID) will bypass live flow and/or release OID contracted storage to maintain a daily average flow of 50 cfs[1] at OWRD Gage 14080500 below Bowman Dam (Hydromet Station PRVO) outside the active irrigation season[2] whenever all of the following conditions exist:

1. All uncontracted storage available in Prineville Reservoir on the annual day of allocation, up to a maximum of 13,000 acre-feet, is held until the end of the active irrigation season[2] and thereafter released at a daily average rate of 50[1] cfs as measured at PRVO.
2. All City of Prineville mitigation storage available in Prineville Reservoir on the annual day of allocation and not required for another mitigation use[3], up to a maximum of 5,100 acre-feet, is held until December 1 and thereafter released in lieu of uncontracted storage to maintain the daily average flow of 50 cfs as measured at PRVO.
3. The combined total of available uncontracted storage (up to 13,000 acre-feet) and available City of Prineville mitigation storage described herein is insufficient to maintain the daily average flow of 50 cfs as measured at PRVO until the beginning of the next irrigation season.

Water that is temporarily leased instream from OID patrons may be used to support the flow of 50 cfs (±5 cfs), except during the period from December 1 through January 31.

During the active irrigation season, the DBHCP will not obligate OID or NUID to allow bypass of live flow or release of contracted storage by Reclamation on OID's or NUID's behalf to maintain specific instream flows at PRVO Gage or CAPO Gage. However, OID will not divert stored water at the Crooked River Diversion until the water has been released from Prineville Reservoir and adequate time has elapsed for the water to reach the diversion. In addition, as the operator of Bowman Dam, OID will respond to calls for Prineville Reservoir stored water from other contract holders and begin releasing the requested water within 24 hours.

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[1] Actual flows in the Crooked River may be ±10% of flows specified in Measure CR-1 due to inherent inaccuracies in flow measuring devices.

[2] For purposes of this conservation measure, the *active irrigation season* on the Crooked River is the period of time during which water is being diverted at the Crooked River Diversion for delivery to OID patrons. This period typically occurs from mid-April to mid-October, with actual dates varying slightly from year to year.

[3] The use of City of Prineville mitigation storage in this way is contingent on approval by Oregon Water Resources Department and subject to any preemptory use of the water. The actual amount of City of Prineville mitigation storage used as described in this measure may be less than the total present in Prineville reservoir on the day of allocation.

Measure CR – 2: Ochoco Creek Flow

OID Contributions to Ochoco Creek Flow: OID will contribute to the flow in Ochoco Creek as specified in Table CR-2 by releasing water from the Ochoco Main Canal downstream of Ochoco Reservoir. These contributions will be additive to any permanent instream water right transfers and/or temporary instream leases secured through the Crooked River Conservation Fund (Measure CR-5) on Ochoco Creek. The OID contributions will not be made if they would require pumping from inactive storage in Ochoco Reservoir (below water surface elevation 3,074.94 feet) unless OID is pumping water from inactive storage for irrigation purposes. If mechanical failure or malfunction at Ochoco Dam prevents the release of the full amount specified in Table CR-2, the OID contribution will be the maximum amount Reclamation determines can safely be released, and the full contribution will be resumed as soon as the mechanical problem or malfunction is corrected.

Table CR-2. Ochoco Irrigation District contributions to Ochoco Creek flow.

Stream Reach	Average OID Contribution [1]		Measurement Location	Averaging Interval
	During Active Irrigation Season[2]	Outside Active Irrigation Season		
Ochoco Dam (RM 11.2) to D-2 Drain Confluence (RM 6.3)	5.0 cfs	3.0 cfs	OWRD Gage 14085300 below Ochoco Dam	Hourly
D-2 Drain Confluence (RM 6.3) to mouth	5.0 cfs	5.0 cfs	RM 4.7 at Ryegrass Diversion	Daily

Notes:

1 Actual contributions to flow in Ochoco Creek may be ±10% of amounts specified in Table CR-2 due to inherent inaccuracies in flow measuring devices.

2 For purposes of this conservation measure, the *active irrigation season* on Ochoco Creek is the period of time during which water is being released from Ochoco Reservoir into the Ochoco Main Canal for irrigation. This period typically occurs from mid-April to mid-October, with actual dates varying slightly from year to year.

Pass-through of Upstream Temporary and Permanent Instream Transfers: Subject to approval by OWRD on a case-by-case basis, OID will allow water from temporary and permanent instream water right transfers upstream of Ochoco Reservoir to pass through the reservoir and to the mouth of Ochoco Creek without storage or diversion, regardless of whether the associated water rights are senior or junior to OID's storage and diversion rights. These instream enhancement projects may be subject to other private diversions based on priority dates according to the doctrine of prior appropriation.

Measure CR – 3: McKay Creek Flow

Minimum Flow in McKay Creek: Water will be bypassed and/or released into McKay Creek, as needed, to provide the minimum instream flows specified in Table CR-3 during the active irrigation season[1]. Outside the active irrigation season, McKay Creek will be allowed to flow without diversion by OID or its patrons.

Table CR-3. Minimum instream flows for McKay Creek during the active irrigation season.

Stream Reach	Minimum Daily Average Instream Flow During the Active Irrigation Season [1, 2]		Measurement Location
	Prior to McKay Creek Water Switch	After Full Implementation of McKay Creek Water Switch [3]	
Jones Dam (RM 5.8) to Dry Creek (RM 3.9)	Equal to flow immediately upstream of Jones Dam, to a maximum of 2.0 cfs	Equal to flow immediately upstream of Jones Dam, to a maximum of 11.2 cfs	At Jones Dam
Dry Creek (RM 3.9) to Reynolds Siphon (RM 3.2)	3.0 cfs	Equal to flow immediately upstream of Jones Dam, to a maximum of 12.2 cfs	At Reynolds Siphon
Reynolds Siphon (RM 3.2) to mouth	5.0 cfs	Equal to flow immediately upstream of Jones Dam, to a maximum of 14.2 cfs	At Cook Inverted Weir (RM 1.3)

Notes:

1 For purposes of this conservation measure, the *active irrigation season* on McKay Creek is the period of time during which water is being diverted from the Crooked River into the Crooked River Diversion Canal and/or released from Ochoco Reservoir into the Ochoco Main Canal for irrigation. This period typically occurs from mid-April to mid-October, with actual dates varying slightly from year to year.

2 Actual flows in McKay Creek may be ±10% of flows specified in Table CR-3 due to inherent inaccuracies in flow measuring devices. Additional flow variation may result from circumstances beyond the control of OID, such as irrigation diversions by parties other than OID and its patrons.

3 Flows in this column are based on full implementation of the McKay Creek water switch, which is expected to replace 11.2 cfs of live flow diversion upstream of Jones Dam with water from the Crooked River. In the event of a partial or phased switch, the instream flow below Jones Dam will reflect the actual McKay Creek switch instream right above Jones Dam.

McKay Creek Water Switch: OID will fulfill its obligations under the Memorandum of Understanding (MOU) between OID and the Deschutes River Conservancy (DRC) effective as of May 30, 2017, subject to the terms and conditions of the MOU. OID will not exercise its termination rights under the MOU, provided that the DRC fulfills its obligations under the MOU and OID determines, in its discretion, that the contingencies described in Paragraph F of the MOU are satisfied.

Measure CR – 4: Crooked River Conservation Fund

Within 6 months after issuance of the Incidental Take Permits, and no later than March 1 of each year thereafter for the term of the Permits, OID, NUID and the City of Prineville will contribute a combined total of $8,000 annually to the Crooked River Conservation Fund. The fund shall be held, managed and distributed by Deschutes River Conservancy or another third-party selected and approved by USFWS, NMFS and the Permittees. This amount will be adjusted annually for inflation in direct proportion to the change in annual average Consumer Price Index for all urban consumers (CPI-U), West Region, all items, Base Period 1982-84=100, published by the Bureau of Labor Statistics. Individual permittee contributions to the fund will be as specified in Table CR-4.

The fund may be used for activities that support DBHCP conservation measures and/or benefit the covered species within the Crooked River subbasin. Any use of the fund must be approved by USFWS and NMFS after consultation and coordination with OID, NUID and the City of Prineville.

Water purchased from OID patrons with the Conservation Fund for temporary instream leasing may be stored in Ochoco Reservoir or Prineville Reservoir, as appropriate, and released at any time during the OID legal irrigation season (February 1 through November 30) determined by USFWS and NMFS.

Table CR-4. District and City responsibilities for contributing to the Crooked River Conservation Fund.

Permittee	Proportional Responsibility Based on Total Fund Amount (assumes annual increase in fund based on CPI)		
	Total Amount $8,000	**Total Amount $8,001 to $12,000**	**Total Amount > $12,000**
City	$4,000	$4,000	One-third of total
OID	$4,000	$4,000	One-third of total
NUID	$0	Amount over $8,000	One-third of total

Measure CR – 5: Screening of Diversion Structures

District Diversions: OID and NUID will maintain and operate fish screens to prevent the entrainment of juvenile salmonids on all District-controlled diversions accessible to covered fish species. Existing screens will be maintained and operated to ensure they function to their original design standards for safe fish exclusion. In the event that any screens require replacement during the term of the DBHCP, the replacement screens will meet NMFS criteria for downstream migrant fish screens current at the time of construction.

Patron Diversions:

a. OID will provide $5,000 per year in cash or in-kind contributions of labor and technical expertise for the first 5 years of DBHCP implementation, for a total of $25,000, to fund the voluntary screening of patron pumps on the Crooked River, Ochoco Creek and McKay Creek.

b. OID will proactively contact patrons, arrange screen manufacturers and actively seek matching funds to encourage screening as quickly as possible.

c. Prior to OID funding of an individual screen the patron must:

    i. willingly enter into a written agreement with OID to allow the screening, and

    ii. agree in writing to maintain the screen in proper working order and to allow OID, USFWS, NMFS and ODFW access for routine inspection of the screen outside the active irrigation season with 48-hour notice of the patron.

Measure CR – 6: Crooked River Flow Downstream of the Crooked River Pumps

For the term of the DBHCP, except for water made available to North Unit Irrigation District (NUID) from Prineville Reservoir, whether under a Temporary Water Service Contract with Reclamation or acquisition from another contract holder, NUID will only divert water at the Crooked River Pumps (RM 27.6) when the minimum daily average flow indicated in Table CR-6 can be maintained, as measured in real time at OWRD Gage 14087300 (RM 27.0) or an alternate gage location established by Oregon Water Resources Department (OWRD) that adequately describes stream flow in the reach downstream of the Crooked River Pumps.

Table CR-6. Minimum flows to be maintained downstream of the Crooked River Pumps when NUID is diverting water at the pumps [1].

Month	Minimum Daily Average Flow (cfs)	
	Dry Year	Non-Dry Year
Apr	120	181
May	50	95
Jun	54	86
Jul	51	61
Aug	56	68
Sep	57	114
Oct	121	151

For purposes of this measure, Dry Years and Non-Dry Years shall exist when OWRD makes a written declaration according to the following metrics:

1. Dry Year Declaration in March – Established only if the following conditions apply:
   a. The OWRD's or Bureau of Reclamation's predicted March month-end contents of Prineville Reservoir are less than or equal to the 50 percent exceedance level of the contents at March 31 based on all data from the prior 30 years, and
   b. Either:
      i. The Prineville Reservoir outflow has not exceeded 75 cfs within 30 days of the actual date of OWRD's Non-Dry Year/Dry Year declaration, or
      ii. The Prineville Reservoir outflow has exceeded 75 cfs within 30 days of the actual date of OWRD's Non-Dry Year/Dry Year declaration only to supply irrigation demands for downstream users.
2. Non-Dry Year Declaration – Established if any of the following conditions apply:
   a. The conditions necessary for a Dry Year Declaration do not apply, or
   b. When OWRD fails to make any written Dry Year Declaration.

OWRD shall maintain discretion to apply and interpret the Dry Year Declaration metric if there is an extenuating circumstance(s) with respect to predicted March month-end contents of Prineville Reservoir or its outflows 30 days prior to a Dry or Non-Dry Year Declaration so as to target a Dry Year recurrence interval of 3 out of 10 years over a 30-year period. Further, upon request by NUID and the DRC, OWRD may revise the metric, including revisions to the timing for finalizing a Dry Year or Non-Dry Year Declaration, if it is expected that the recurrence interval of a Dry Year Declaration over a 30-year period will change from 3 out of 10 years.

[1] Daily average flows at OWRD Gage 14087300 shall be no less than the specified minimums. NUID will also attempt to keep hourly average flows at or above the specified minimums by manually adjusting diversion rates in response to changes in flow upstream of the pumps, but in recognition of the inherent difficulty in making manual adjustments around the clock the hourly average flows may be up to 20% less than the specified minimums until December 31, 2024. NUID will install equipment at the pumps to automate diversion rate adjustment, and starting no later than January 1, 2025 the daily average and hourly average flows shall both be no less than the specified minimums.

Measure CR – 7: Crooked River Downstream Fish Migration Pulse Flows

OID and NUID will not divert water from the Crooked River that is part of a downstream fish migration pulse flow, where such flow is defined as a quantity of uncontracted Prineville Reservoir storage that is determined by Reclamation, in consultation with NMFS and USFWS, to be released above and beyond the base release of uncontracted storage for the purpose of facilitating downstream migration of young anadromous salmonids in the Crooked River. A pulse flow will begin when the rate of release of uncontracted storage is increased above the base release of uncontracted storage (measured at CAPO), and it will end when the rate of release of uncontracted storage returns to the base rate of release. The pulse flow will include the time needed for ramping up to the desired maximum flow, time spent at the desired maximum flow, and time needed for ramping back down to the base rate of release of uncontracted water. The entire process may last up to 10 days, including ramping time.

Prior to the release of a downstream fish migration pulse flow, USFWS, NMFS and Reclamation shall give OID and NUID 72-hour advance notice on the timing (start time and end time) of the release, the maximum anticipated rate (cfs) of the release and the total anticipated volume (acre-feet) of the release so that OID and NUID may make any necessary adjustments or accommodations at their diversions.

6.5.3 Rationale for Conservation Measure CR-1

6.5.3.1 Overview

Efforts are currently underway to reintroduce anadromous steelhead to the lower Crooked River, where they have been excluded for several decades by the presence of the Pelton Round Butte Hydroelectric Project. Concurrent with the reintroduction efforts, Congress recently authorized the use of 42 percent of the capacity of Prineville Reservoir to store and release water for fish and wildlife habitat enhancement in the lower river.

Conservation Measure CR-1 requires OID to allow use of its irrigation water (storage or live flow) to support minimum instream flows in the lower Crooked River during the winter in years when there is insufficient fish and wildlife water stored in Prineville Reservoir. The measure is based on the assumption that the primary responsibility for achieving target instream flows for fish and wildlife in the lower Crooked River lies with Reclamation through its use of 42 percent of Prineville Reservoir storage.

6.5.3.2 Effects of Historical Operations on the Hydrology of the Crooked River

The hydrology of the Crooked River from Bowman Dam (RM 70.5) to Opal Springs (RM 7.5) is dominated by the storage and release of irrigation water at Prineville Reservoir (a federal activity that is not covered by the DBHCP), the removal of water at OID's Crooked River Diversion (RM 56.8) and NUID's Crooked River Pumps (RM 27.6) (activities that are covered by the DBHCP) and multiple smaller diversions by other entities not covered by the DBHCP. The influx of at least 1,000 cfs cumulatively from groundwater discharge over several miles beginning at about RM 18 dramatically increases year round flow and diminishes the effects of irrigation activities on Crooked River hydrology.

The total active storage capacity of Prineville Reservoir is currently 148,633 acre-feet. OID, NUID and 14 smaller entities hold contracts with Reclamation to store 68,273 acre-feet on their behalf for irrigation. Under the provisions of the Crooked River Act another 12,740 acre-feet of Prineville Reservoir storage are allocated for irrigation uses and 5,100 acre-feet are dedicated to mitigate for the impacts of City of Prineville groundwater pumping on Crooked River flows. The remaining storage capacity (about 62,520 acre-feet) is used to maintain target instream flows between Bowman Dam and Lake Billy Chinook for fish and wildlife under the direction of Reclamation. Prineville Reservoir is also operated for flood control, which requires Reclamation to maintain storage volumes at or below specified levels in the winter and spring to capture flood events and protect public and private resources downstream of Bowman Dam.

During the storage season (typically mid-October through March) Crooked River flows were historically kept to a minimum from Bowman Dam to Opal Springs, except when additional water was released from Prineville Reservoir for flood control purposes. There are no irrigation diversions, few stock water diversions, and relatively small inflows to the Crooked River between Bowman Dam and Opal Springs during the storage season. Consequently, streamflow varies only slightly through this reach during the winter (LaMarche 2008).

During the irrigation season (April to mid-October) flows in the Crooked River have historically varied considerably by reach due to multiple diversions and return flows. In the 14 miles from Bowman Dam to the Crooked River Diversion the flow was typically high because storage is released from the reservoir for diversion by OID and others. The largest change in flow occurs at the Crooked River Diversion, where up to 190 cfs are removed. Downstream of the Crooked River Diversion the flow is alternately decreased (by diversions) and increased (by tributary inflows and irrigation returns) in a manner that is highly variable from day to day.

Historical daily average flows at three locations in the Crooked River are illustrated in Figures 6-54 through 6-56. Directly below Bowman Dam (Figure 6-54) winter flows have mostly been low due to irrigation storage, with occasional releases of up to 3,000 cfs for flood management. Summer flows have been consistently about 200 to 250 cfs as water is released for downstream diversion. Near Terrebonne at RM 27 (Figure 6-55) winter peaks are still apparent, but summer flows have historically been more variable and generally lower than directly below Bowman Dam due to the multiple diversions and inflows between the two points. Downstream of Opal Springs (Figure 6-56) flows were considerably higher throughout the year.

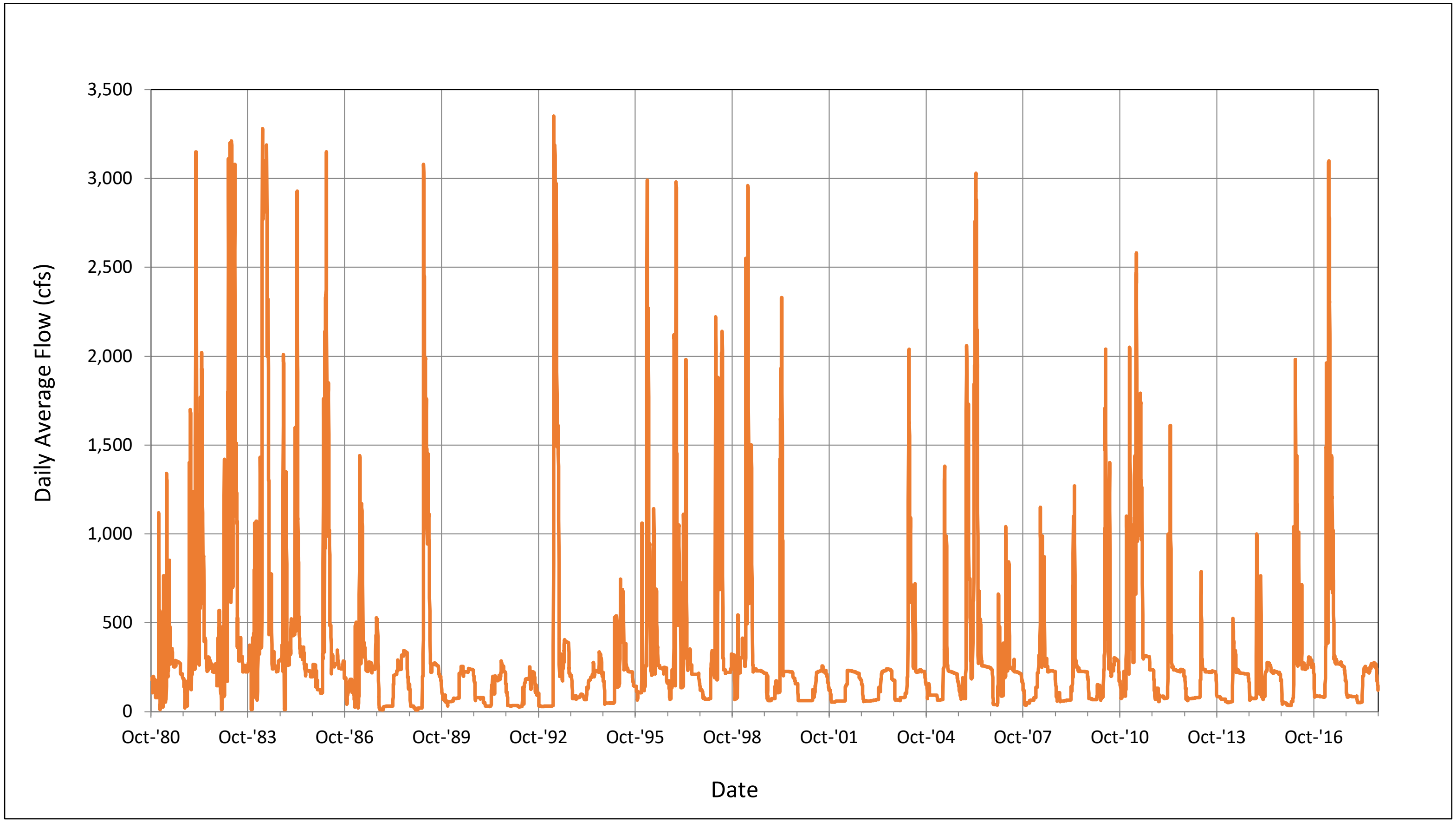

Figure 6-54. Historical daily average flows in the Crooked River below Bowman Dam (Hydromet Station PRVO) from 1981 through 2018. Source: OWRD 2020h.

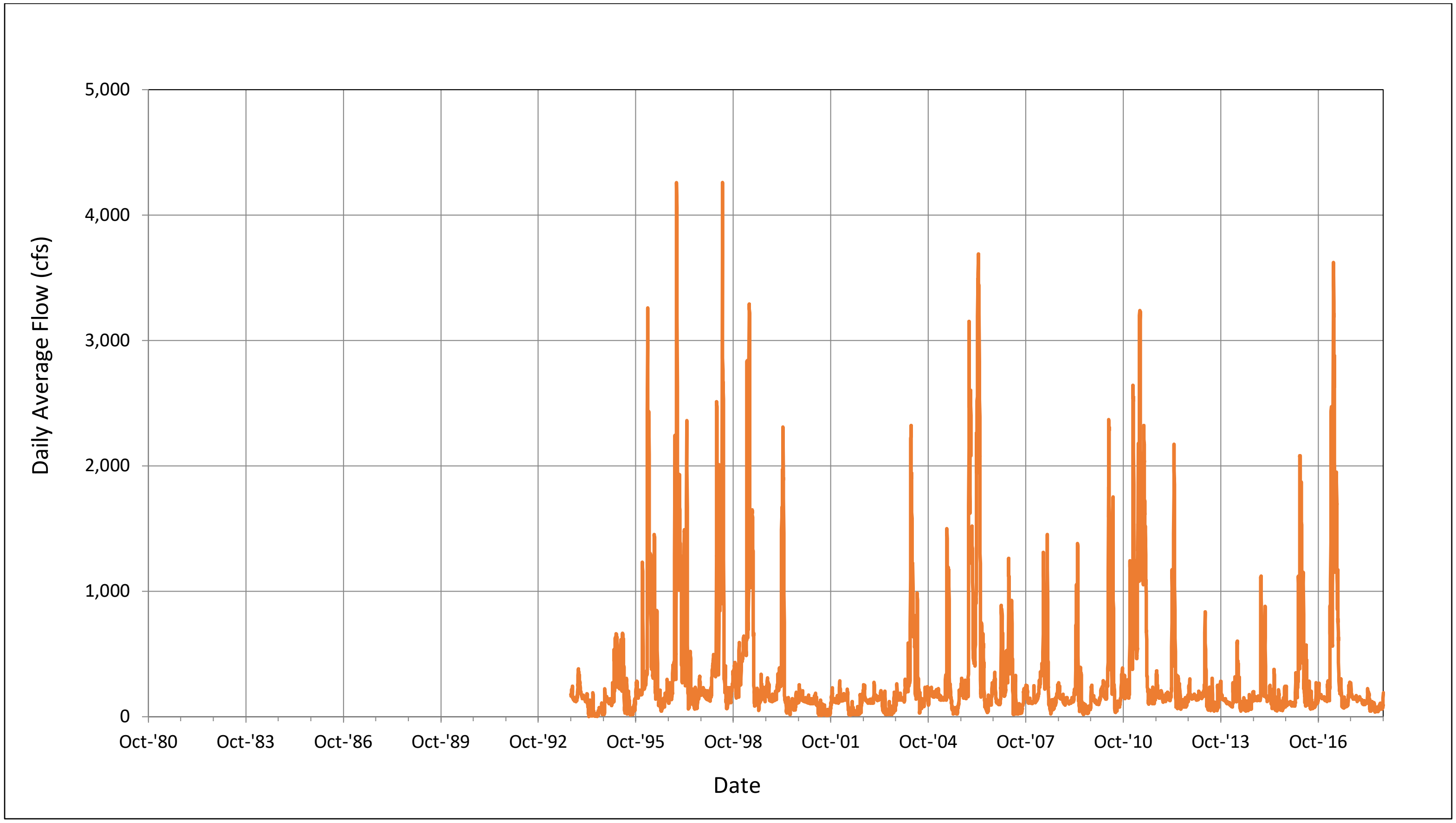

Figure 6-55. Historical daily average flows in the Crooked River near Terrebonne (OWRD Gage 14087300) from 1994 through 2018. Source: OWRD 2020i.

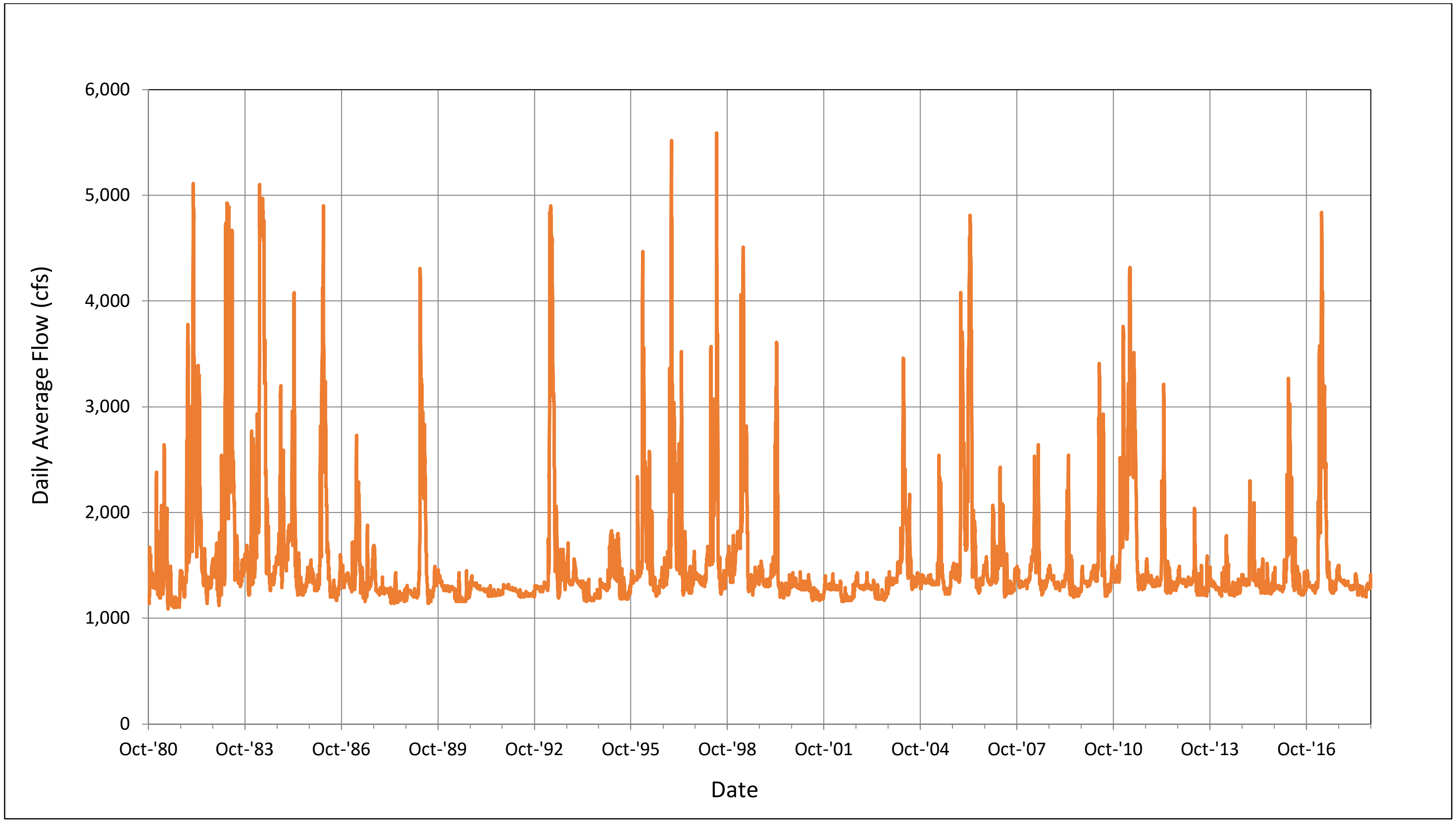

Figure 6-56. Historical daily average flows in the Crooked River below Opal Springs near Culver (OWRD Gage 14087400) from 1981 through 2018. Source: OWRD 2020j.

Historical flows below Bowman Dam are compared to unregulated flows on a monthly basis in Figure 6-57 to illustrate the seasonal effects of reservoir operation. Historical flows were consistently lower than unregulated flows from November through May when water was stored, and higher than unregulated flows from June through October due to the release of storage. Figure 6-57 also illustrates the strong seasonal pattern in unregulated flow, which is typical of the Crooked River subbasin where about two-thirds of the annual precipitation comes as snow (CRWC 2002). Natural runoff is high during winter storm events and spring snowmelt, but very low by mid-summer. Runoff is also quite variable from year to year due to annual differences in snowfall.

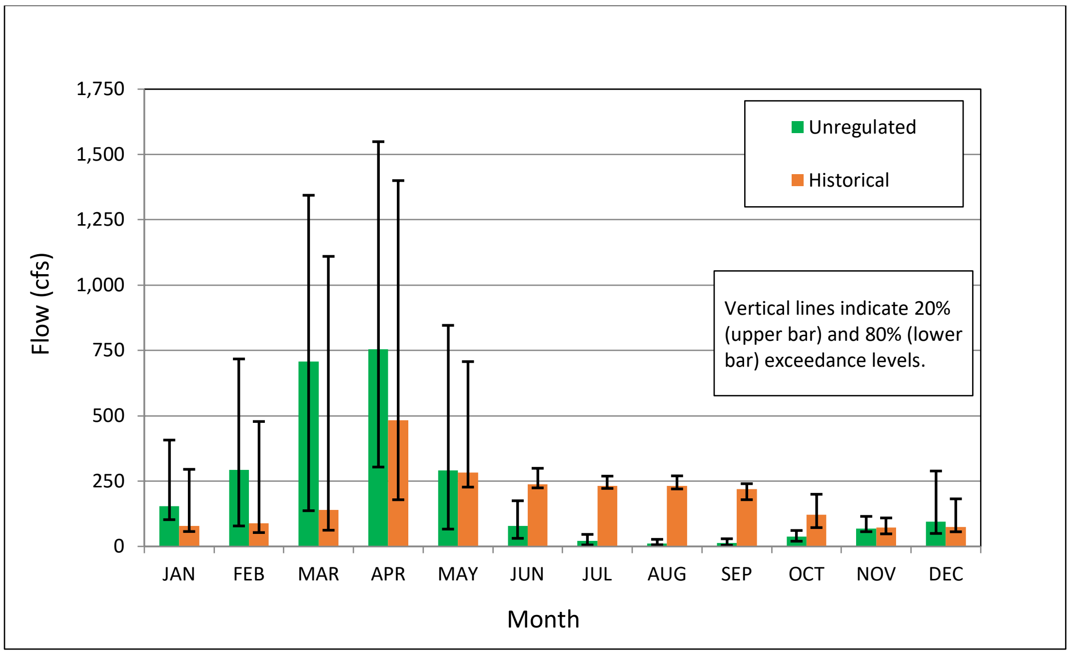

Figure 6-57. Monthly medians of daily average flows in the Crooked River below Bowman Dam (Hydromet Station PRVO) for historical and unregulated conditions. Sources: OWRD 2020h, Reclamation 2020a.

6.5.3.3 Effects of DBHCP Measures CR-1 on the Hydrology of the Crooked River

The use of a portion of Prineville Reservoir storage for fish and wildlife habitat enhancement in accordance with the Crooked River Act began in 2015 and is still in a state of flux as Reclamation determines optimal use of the water through a process of adaptive management and coordination with USFWS and NMFS. This process is expected to continue into the early years of DBHCP implementation. Consequently, there is no historical record for implementation of the Crooked River Act that can be used as a basis for comparison of the benefits of the DBHCP. Rather, the Crooked River Act and the DBHCP will be implemented concurrently and collaboratively to achieve the greatest net benefit of the two combined. The following analysis therefore compares future conditions (Crooked River Act plus DBHCP) with historical conditions prior to the implementation of either.

Daily average flows in the Crooked River below Bowman Dam (Hydromet Station PRVO) will increase in some months and decrease in other months during implementation of Conservation Measure CR-1 (Figures 6-58 and 6-59). No historical data are available immediately downstream of the Crooked River Diversion, but a new gage in this reach (Hydromet Station CAPO) can be used to illustrate the effects of the diversion (Figure 6-60). From October through March, when diversions from the river are limited to small stock water runs by entities other than the Permittees, there will be very little change in flow between Bowman Dam and CAPO. During the irrigation season, however, monthly medians of daily average flows will decrease from at least 200 cfs below Bowman Dam to as low as 49 cfs at CAPO due to diversions. Further downstream below Opal Springs (Figure 6-61) differences from historical flows will still be measurable, but the relative magnitude of difference will be considerably smaller due to the higher overall flows.

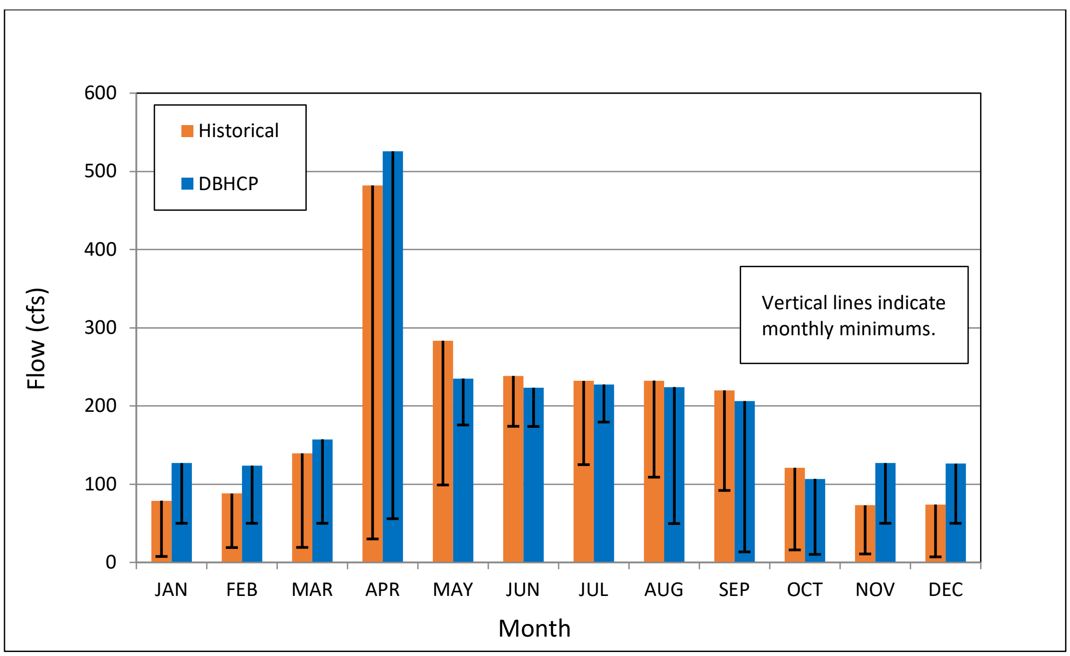

Figure 6-58. Monthly medians of daily average flows in the Crooked River below Bowman Dam (Hydromet Station PRVO) for historical and DBHCP conditions.
Sources: OWRD 2020h, Reclamation 2020a.

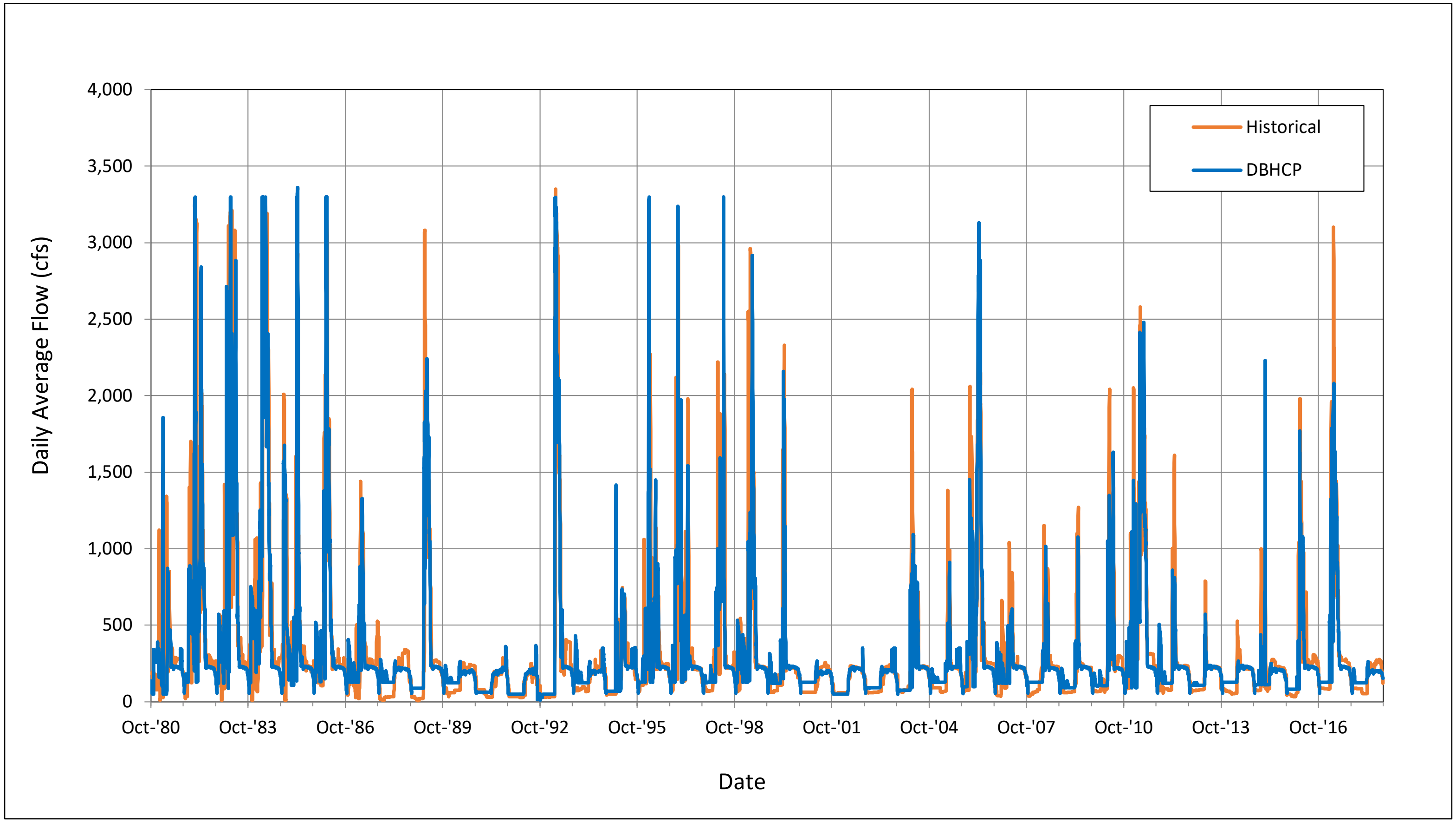

Figure 6-59. Daily average flows in the Crooked River below Bowman Dam (Hydromet Station PRVO) for historical conditions and projected DBHCP conditions. Sources: OWRD 2020h, Reclamation 2020a.

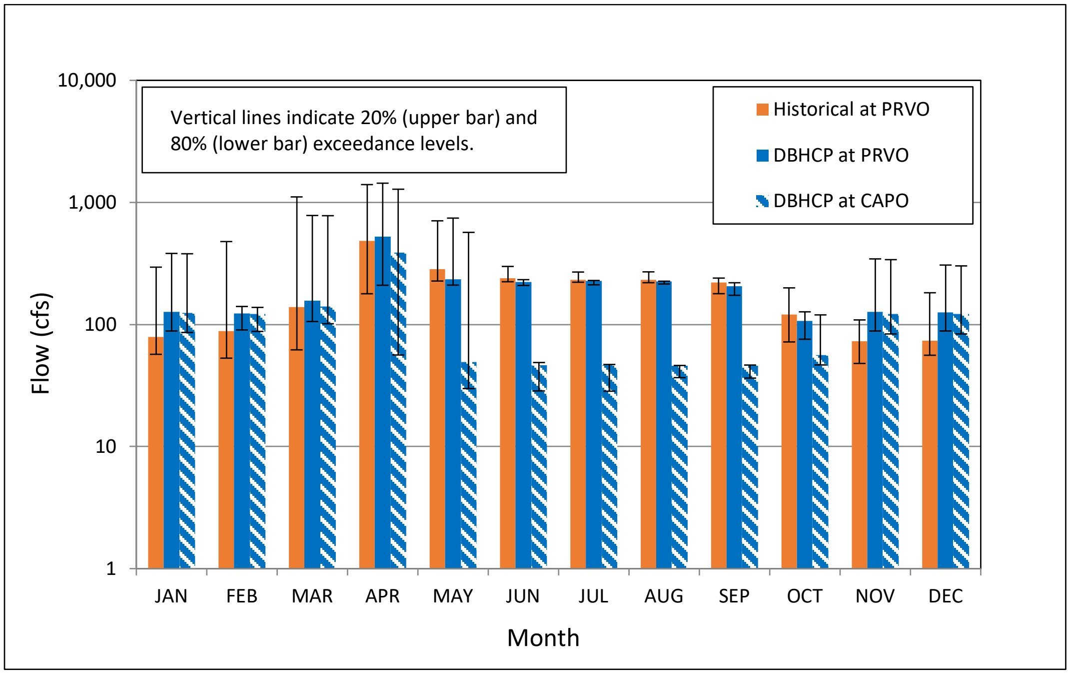

Figure 6-60. Monthly medians of daily average flows in the Crooked River below Bowman Dam (Hydromet Station PRVO) and at Highway 126 (Hydromet Station CAPO) (Note that vertical axis is log_{10} scale). Sources: OWRD 2020h, Reclamation 2020a.

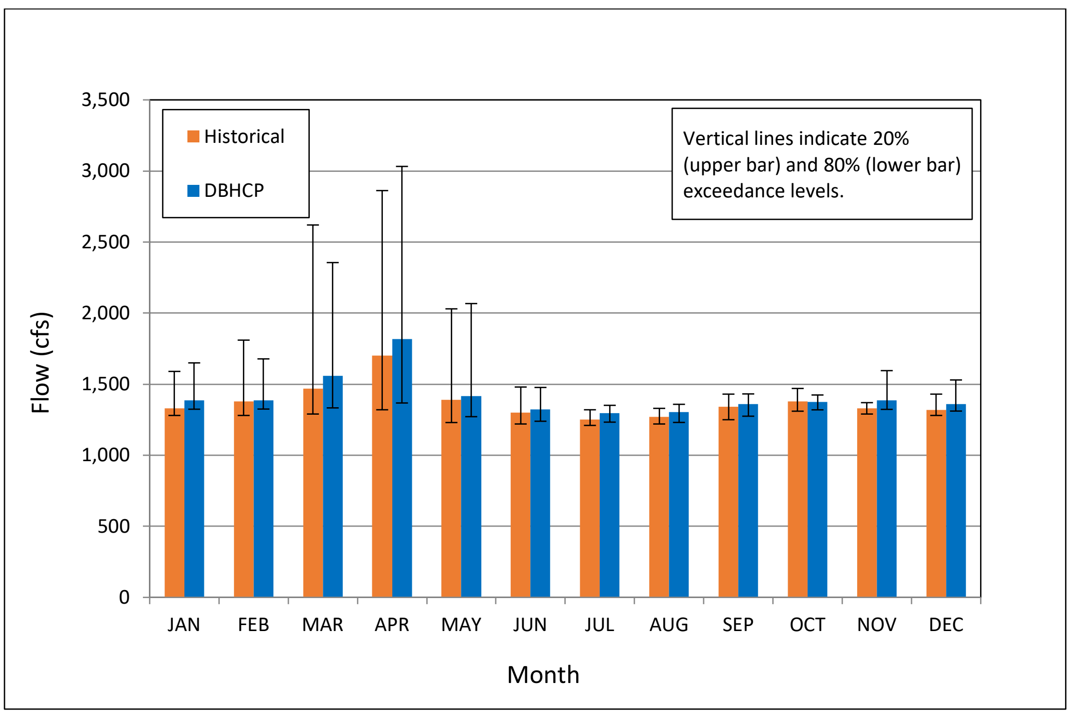

Figure 6-61. Monthly medians of daily average flows in the Crooked River below Opal Springs (USGS Gage 14087400) for historical and projected DBHCP conditions. Sources: OWRD 2020j, Reclamation 2020a.

Storage volumes in Prineville Reservoir will generally decrease in all months, particularly in dry years, due to increased use of storage for fish and wildlife habitat enhancement (Figures 6-62 and 6-63).

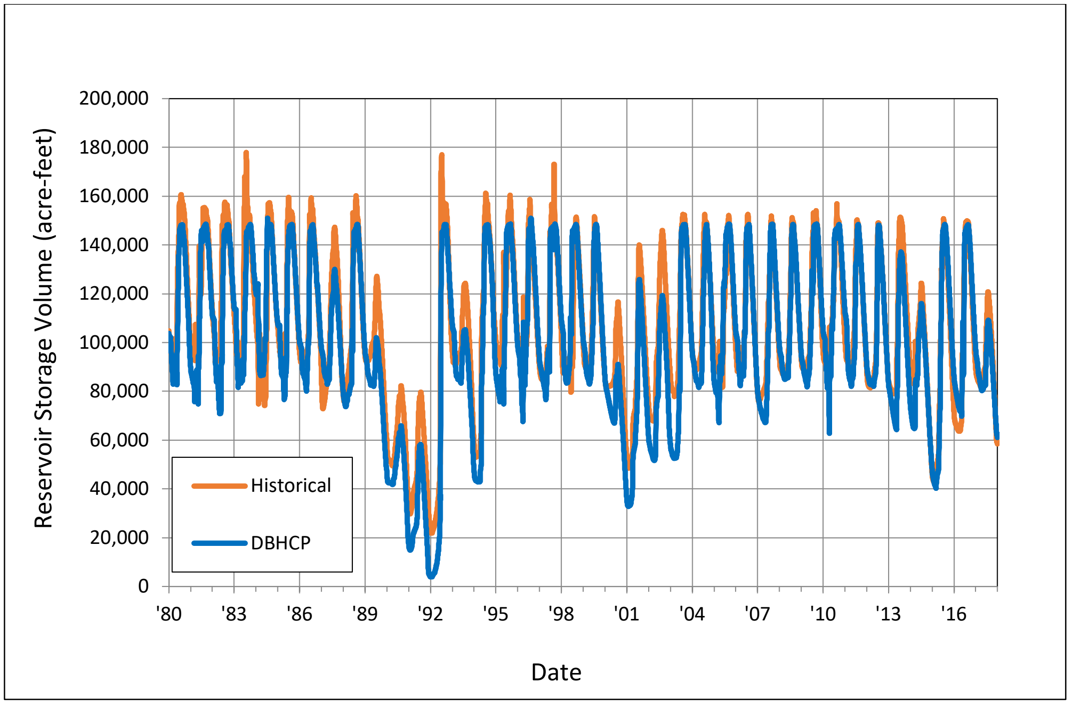

Figure 6-62. Daily average storage volumes in Prineville Reservoir for historical and DBHCP projected conditions. Sources: Reclamation 2020a, 2020d.

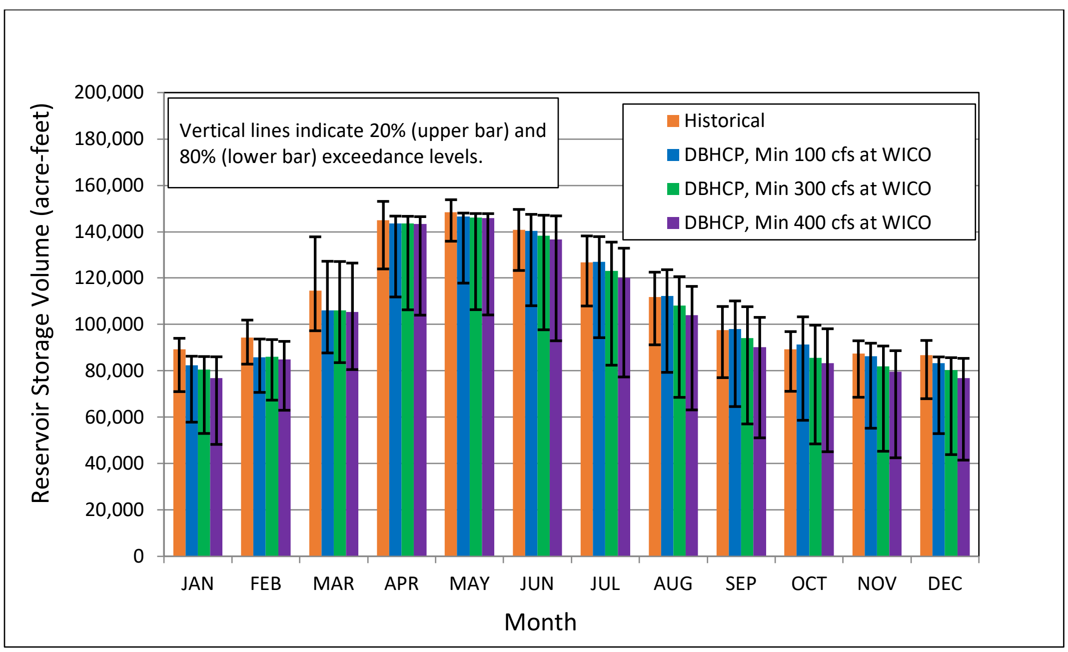

Figure 6-63. Monthly medians of daily storage volumes in Prineville Reservoir for historical and DBHCP projected conditions. Sources: Reclamation 2020a, 2020d.

6.5.4 Rationale for Conservation Measure CR-2

6.5.4.1 Overview

The lower 11 miles of Ochoco Creek are accessible to anadromous fish and within the area targeted for reintroduction of steelhead. Flows in this reach are determined by the storage, release and diversion of irrigation water. Compared to unregulated conditions, historical operations have decreased median flows during the storage season and increased median flows during the irrigation season. At times in the past, however, minimum flows in portions of Ochoco Creek have been extremely low (as low as 0 cfs). Conservation Measure CR-2 will eliminate those extremely low flows by establishing minimum flows for the entire reach between Ochoco Dam and the mouth. While minimum flows will increase, median flows in Ochoco Creek are expected to be unchanged from historical conditions because OID demand for irrigation water is not expected to change. The conveyance of irrigation water within Ochoco Creek, which provides most of the instream flow during the summer, will continue much as it has in the past. The establishment of minimum flows will require slightly more use of Ochoco Reservoir storage in dry years, with corresponding reductions in available storage for OID.

6.5.4.2 Effects of Historical Operations on the Hydrology of Ochoco Creek

Ochoco Reservoir has a storage capacity of 44,330 acre-feet. Water is captured and stored from mid-October through March and released from April through early October. Water leaving the reservoir goes directly into the Ochoco Main Canal. Some of the water entering the canal is spilled back into the creek downstream of the dam, while the rest remains in the canal for ultimate delivery to OID patrons. Of the water spilled into the creek, most is subsequently removed during the irrigation season at four primary points of diversions and over 30 small OID patron pumps between the dam and the mouth. Water is also returned to lower Ochoco Creek at two locations during the irrigation season. The largest return flow occurs at RM 5.1, where excess water in the Crooked River Diversion Canal (average about 10 cfs) is routinely spilled into the creek. During the storage season, any water released from the reservoir and spilled into the creek below the dam travels unimpeded for the 11 miles to the confluence with the Crooked River, with negligible contribution from return flows.

The historical effects of storage, release and diversion on the lower 11 miles of Ochoco Creek are summarized in Figure 6-64. Compared to the unregulated condition, flow immediately below the dam has been reduced substantially during the storage season and increased during the irrigation season. Much of the water released into the creek below the dam is subsequently diverted, so the increases in summer flow indicated in Figure 6-64 are not indicative of the entire 11 miles from the dam to the mouth. Nevertheless, an unmeasured portion of the water reaches RM 5.1 where it is joined by water from the Crooked River Diversion Canal spill, and the overall flow likely still exceeded unregulated flow, particularly in the dry months of August through October.

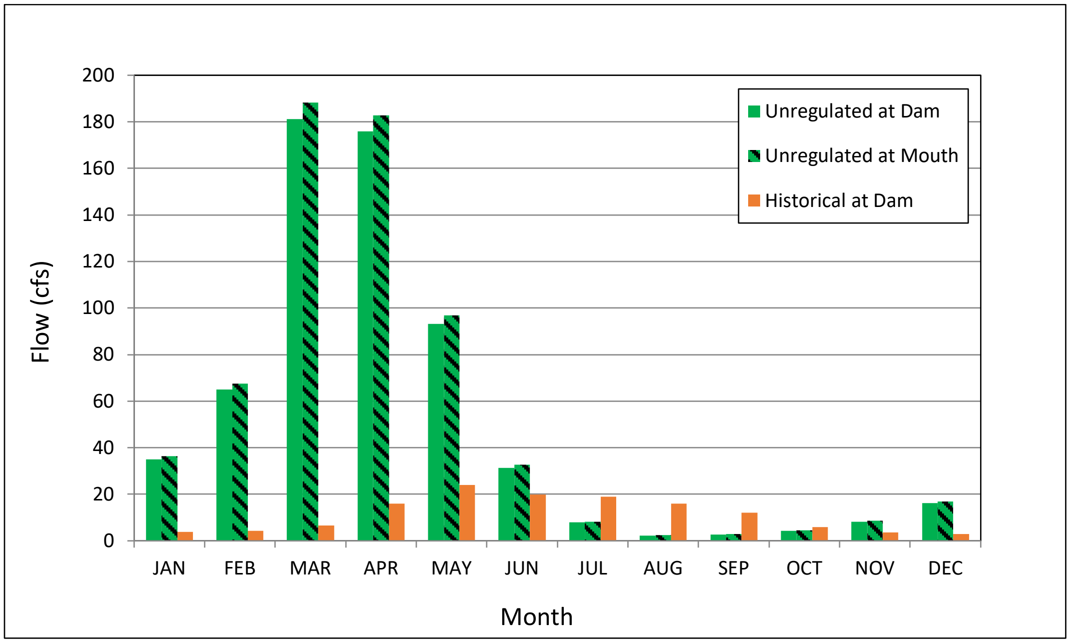

Figure 6-64. Monthly medians of daily average flows in Ochoco Creek for unregulated and historical conditions. Sources: R2 and Biota Pacific 2014, OWRD 2020k.

6.5.4.3 Effects of DBHCP Measures CR-2 on the Hydrology of Ochoco Creek

Flows in lower Ochoco Creek are not expected to change appreciably under the DBHCP, with the exception that steps will be taken to manage flows at or above specified minimums. OID demand for irrigation water from Ochoco Creek will not change, so winter storage and summer release will continue much as they have in the past. However, the potential for extremely low flows at all times of year will be eliminated by Conservation Measure CR-2 through the installation of a monitoring device in the lower creek (RM 4.7) and requirements for minimum flows at that location as well as below the dam (RM 11.2). The new gage will be strategically placed downstream of the last large diversion structure on the creek so as to detect the lowest possible flow in the 11-mile reach. During the irrigation season, the flow in the creek will not be allowed to drop below 5 cfs unless there is insufficient water from reservoir storage and inflow to maintain this level (a rare event). During the storage season the minimum flow will be 3 cfs immediately below the dam and 5 cfs in the lower 4.7 miles. The storage season minimum varies by location to reflect the fact that groundwater discharge within the reach will add at least 2 cfs throughout the winter.

The hydrologic effects of Measure CR-2 are illustrated in Figure 6-65. The minimum flow in Ochoco Creek will exceed the unregulated minimum from July through November. It will also exceed the historical minimum in all months (the historical minimum is not shown in Figure 6-65 because it is 0 cfs in all months). As noted above, median flows in Ochoco Creek are not expected to change from historical conditions (see Figure 6-64). Water used to maintain the specified minimum flows will reduce Ochoco Creek storage in some years, but the magnitude of reduction is not expected to be significant.

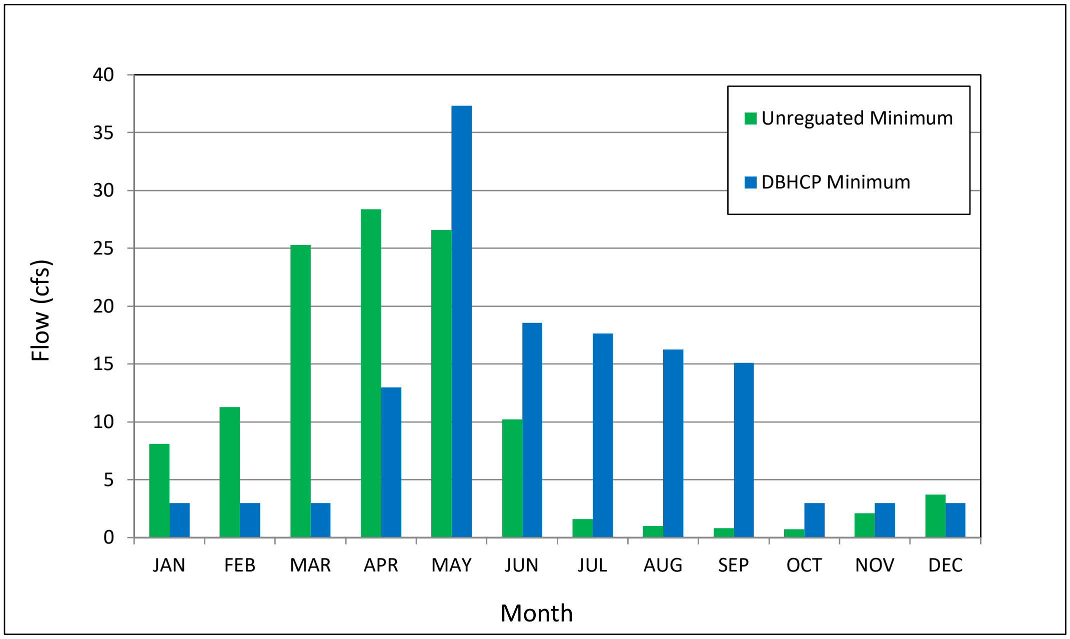

Figure 6-65. Monthly minimums of daily average flow in Ochoco Creek below Ochoco Dam (Hydromet Station OCHO) for unregulated and DBHCP conditions. Sources: R2 and Biota Pacific 2014, OWRD 2020k.

6.5.5 Rationale for Conservation Measure CR-3

6.5.5.1 Overview

The entire 5.8-mile reach of McKay Creek within the OID district boundary is potentially accessible to anadromous fish as a result of ongoing reintroduction efforts. The same reach is heavily influenced by OID activities during the irrigation season, but free-flowing the rest of the year. The greatest concern related to irrigation activities in McKay Creek is the potential for extremely low flows during the irrigation season. Conservation Measure CR-3 will require the maintenance of specified minimum flows in the creek, and these minimums will be increased over time as conservation actions in the upper watershed increase the flows that reach OID.

6.5.5.2 Effects of Historical Operations on the Hydrology of McKay Creek

The unregulated hydrology of McKay Creek is typical of the Crooked River subbasin, with high flows occurring during winter storms and snowmelt in March, April and May, and low flows occurring in late summer (Figure 6-66). The difference between early spring and late summer unregulated flows can be substantial.

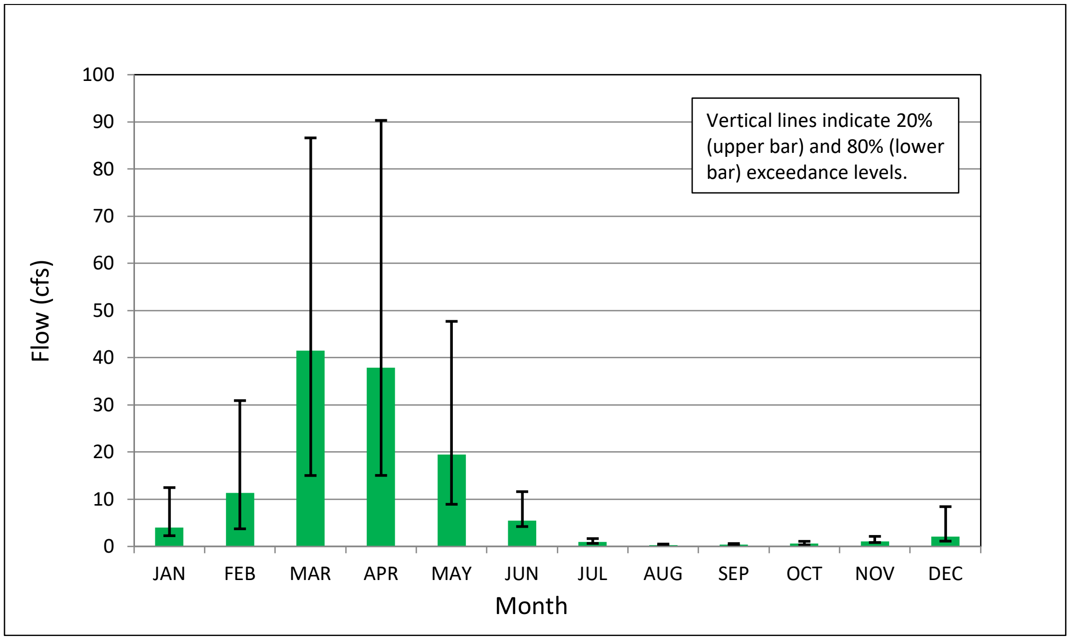

Figure 6-66. Monthly medians of unregulated daily average flows at the mouth of McKay Creek. Source: R2 and Biota Pacific 2014.

OID diverts natural flow from McKay Creek at the upstream boundary of the district (RM 5.8) during the irrigation season, and also utilizes the creek for conveyance of water that has been diverted from Ochoco Creek and the Crooked River. The Ochoco Creek and Crooked River water is spilled into McKay Creek at various locations and subsequently diverted downstream for delivery to patrons. This combination of diversion and conveyance of water has a substantial effect on the flow of McKay Creek during the irrigation season. Outside the irrigation season, OID has no effect on the hydrology of McKay Creek.

There are no recording gages on McKay Creek downstream of Jones Dam, and thus no record of the historical effects of irrigation activities on the hydrology of the stream. Nevertheless, the multiple diversions of flow within the OID district boundary during the irrigation season create the potential for extremely low flows immediately downstream of those diversions.

6.5.5.3 Effects of DBHCP Measures CR-3 on the Hydrology of McKay Creek

Conservation Measure CR-3 will benefit McKay Creek on a reach-specific basis. At Jones Dam (RM 5.8; the upstream limit of OID influence) the District will allow the first 2 cfs of flow reaching the dam to pass, thereby preventing dewatering of the creek downstream of that point provided there is flow reaching Jones Dam. At Dry Creek (RM 3.9) OID will provide a minimum flow of 3 cfs at all times during the irrigation season. If natural flow in the creek is less than 3 cfs, OID will spill additional water into the creek as needed to achieve 3 cfs at the Dry Creek confluence. At Reynolds Siphon (RM 3.2), where OID has the opportunity to spill additional water into McKay Creek, the minimum flow will be 5 cfs during the irrigation season.

All the minimum flows specified in Conservation Measure CR-3 will be increased as needed to ensure that water left instream by the McKay Creek Water Switch is not diverted by OID. The

McKay Creek Water Switch is a program being pursued by the DRC, OID and landowners along upper McKay Creek to eliminate those irrigation diversions and replace them with Crooked River water conveyed by OID. If successful, the program would increase instream flows in several miles of McKay Creek during the irrigation season. Conservation Measure CR-3 would help ensure the benefits of the McKay Creek Water Switch are realized all the way to the mouth of the creek. Without this provision in the conservation measure, landowners would have the option of exercising their State water rights to divert all live flow from McKay Creek.

Historical flows at the mouth of McKay Creek are not known, but unregulated flows estimated by R2 and Biota Pacific (2014) can be compared to DBHCP minimum flows to illustrate the hydrologic effects of Conservation Measure CR-3 (Figure 6-67). Minimum flows during the irrigation season will not drop below 5 cfs at the mouth of McKay Creek, whereas unregulated flows could be less than 1 cfs by late summer. Outside the irrigation season the creek is unaffected by OID activities, and unregulated flows will prevail.

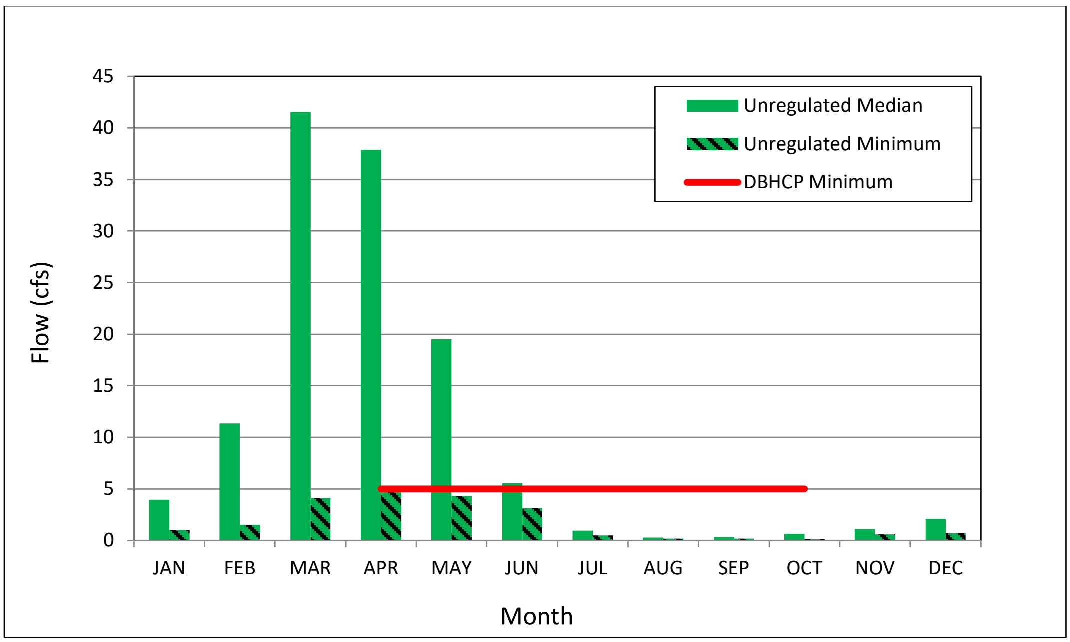

Figure 6-67. Daily average flows at the mouth of McKay Creek for unregulated and DBHCP conditions. Source: R2 and Biota Pacific 2014.

6.5.6 Rationale for Conservation Measure CR-4

Numerous conservation projects are occurring in the Crooked River subbasin to improve habitat conditions for fish and wildlife, and more are being planned. Many of the future projects will have direct or indirect benefits to the species covered by the DBHCP. A common challenge to completing habitat conservation projects is lack of funding. Conservation Measure CR-4 will provide $8,000 per year for the term of the DBHCP to support projects with demonstrated benefits to the covered species, as determined by USFWS and NMFS. The actual benefits to covered species will be variable, depending on the nature of the project (e.g., flow enhancement versus physical habitat restoration). The range of potential projects is intentionally left open in Conservation Measure CR-3 to give USFWS and NMFS maximum flexibility in determining the best use of the funds at the time they become available.

6.5.7 Rationale for Conservation Measure CR-5

OID diverts water from the Crooked River at one location, from Ochoco Creek at four locations and from McKay Creek at three locations. NUID also diverts water from the Crooked River at a single location. In addition, OID patrons divert small amounts of water directly from the Crooked River at 34 locations and from Ochoco Creek at 33 locations. The District-owned diversions are all screened or otherwise designed to prevent the entrainment of resident salmonid fry according to criteria provided by ODFW at the time of construction. Most of the small patron diversions are unscreened. Measure CR-5 will help ensure that screens are maintained to their original design criteria, and that any replacement screens during the term of the DBHCP will be designed to the most current NMFS criteria for downstream migrating steelhead and salmon fry.

6.5.8 Rationale for Conservation Measure CR-6

In 2012 NUID entered an agreement with the DRC to maintain specified minimum flows immediately downstream of the NUID pumps on the Crooked River whenever the pumps are operating and water is being diverted. NUID has no obligation to ensure the flow in the Crooked River upstream of the pumps meets or exceeds these specified minimums, but NUID cannot cause the flow downstream of the pumps to fall below the minimums through its diversions at the pumps. This agreement between NUID and the DRC was entered voluntarily. Incorporation of the agreement into the DBHCP will provide added assurance that flow improvements that have been in place since 2012 will continue for the term of the DBHCP. For purposes of the DBHCP the minimum flow requirement of the DRC agreement for the month of May in Dry Years has been increased from 43 cfs to 50 cfs. This was done to provide for a minimum flow of 50 cfs when the pumps are operating, regardless of month or flow conditions. These flows are reflected in the hydrologic analyses described in Section 6.5.3.

6.5.9 Rationale for Conservation Measure CR-7

Reclamation, NMFS and USFWS have coordinated in recent years on the release of pulse flows from Prineville Reservoir during the spring to facilitate the downstream migration of juvenile steelhead. Under State water law, OID and NUID could divert these pulse flows for irrigation use, thereby diminishing the effectiveness of the flows at moving juvenile fish downstream to Lake Billy Chinook and beyond. To avoid this possibility, Conservation Measure CR-7 requires

OID and NUID to avoid diverting the pulse flows. Reclamation, NMFS and USFWS will notify the Districts in advance of the pulses, and the Districts will take the necessary steps at their diversions to ensure they only divert the amounts of water available to them in the absence of the pulses. The frequency, timing and magnitude of pulse flows are still being determined by Reclamation, NMFS and USFWS through an adaptive management process, so the effects of the pulses on Crooked River hydrology cannot be determined at this time. Regardless of the timing and magnitude of the pulses, however, Conservation Measure CR-7 will ensure the full benefits of the pulses to steelhead are realized without being diminished by irrigation activities.

6.5.10 City of Prineville Sewage Treatment Effluent

The City of Prineville's sewage treatment effluent discharge to the Crooked River is a covered activity. The discharge is also covered by a National Pollutant Discharge Elimination System (NPDES) permit that limits the rate and timing of the discharge. Consequently, no additional mitigation is necessary in the DBHCP.

The discharge is allowed under the conditions of NPDES Permit No. 101433; ODEQ Permit No. 973920; and EPA Permit No. OR0023612 (ODEQ 2003). The NPDES permit allows discharge of effluent to the Crooked River at RM 46.8 only during the winter (November 1 to April 30) and only when river flows are greater than 15 cfs. The treatment plant currently generates about 1 mgd (1.5 cfs), but the NPDES permit limits discharges to a minimum dilution ratio of 15:1 (receiving water volume to discharge volume). When river flows are insufficient to accept all generated effluent, the excess effluent is stored in a lagoon at the treatment plant for later use to irrigate uplands or discharge into a man-made wetland.

The required dilution of 15:1 discharge limits the effluent to 6.7 percent of the receiving water. Since: a) the discharge does not occur during the warm summer months, b) the reported river temperatures downstream following effluent discharge are slightly cooler than upstream river temperatures (City of Prineville 2007, 2008), and c) the water temperatures are cooler than the biological criteria for the life stages of covered species potentially present during the discharge period, this seasonal discharge does not offer the potential for an adverse thermal effect on covered fish species.

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FINAL

DESCHUTES BASIN HABITAT CONSERVATION PLAN

Chapter 7 – Monitoring, Reporting and Adaptive Management

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7 – MONITORING, REPORTING AND ADAPTIVE MANAGEMENT

7.1 Introduction

The DBHCP includes multiple provisions for monitoring, reporting and adaptive management of the conservation measures. Unless otherwise indicated in this chapter, all monitoring, reporting and adaptive management results will be compiled in the DBHCP annual report delivered to the Services by January 31 of each year, with the first annual report due January 31, 2022.

Compliance monitoring will be conducted to demonstrate the conservation measures are being implemented as required. The results of compliance monitoring will be reported to the Services at specified intervals.

Implementation monitoring will be conducted to provide current information on the status of the covered lands and covered species throughout the term of the DBHCP. The information gathered through implementation monitoring will be used to guide management decisions provided for in the conservation measures in Chapter 6. The results of implementation monitoring will be reported to the Services at various specified intervals.

Effectiveness monitoring will be conducted to address uncertainties about the effectiveness of certain conservation measures. The results of effectiveness monitoring will be used to support adaptive management of those conservation measures according to the provisions of this chapter.

Compliance and implementation monitoring and reporting are described in Section 7.2. Effectiveness monitoring and adaptive management are described in Section 7.3. Within each section, the monitoring provisions are organized by conservation measure.

7.2 Compliance and Implementation Monitoring and Reporting

7.2.1 Conservation Measure CP–1 (Crane Prairie Reservoir Operation)

7.2.1.1 Crane Prairie Reservoir

Midnight stage (water surface elevation in feet) and storage volume (acre-feet) for Crane Prairie Reservoir will be monitored daily at Hydromet Station CRA (or a comparable replacement) for the term of the DBHCP. COID will use these data to direct day-to-day operation of Crane Prairie Dam in compliance with Measure CP-1. Water surface elevations outside the *allowable range of deviation* in Table CP-1 will be reported to USFWS via email within 12 hours of occurrence. The report will include an explanation for the deviation and the steps being taken to bring water surface elevation back within the allowable range of deviation. COID will assist USFWS in determining the impact of the water surface deviation on the Oregon spotted frog. USFWS will determine what, if any, remedial actions are necessary to mitigate the impacts, and COID will implement those actions.

No later than January 31 of each year, daily (midnight) water surface elevation and storage volume data for the preceding water year (October 1 through September 30) will be reported to the Services in Microsoft Excel or other format approved by the Services. In addition, annual reports will identify all daily water surface elevations outside the *required range* specified in Table CP-1 of Measure CP-1, explain the reason for each such deviation, and identify any remedial actions identified by USFWS and taken by COID.

7.2.1.2 Deschutes River below Crane Prairie Dam

Daily average flow (cfs) in the Deschutes River below Crane Prairie Dam will be monitored at Hydromet Station CRAO (or a comparable replacement) for the term of the DBHCP. COID will use these data to direct day-to-day operation of Crane Prairie Dam in compliance with Measure CP-1. Daily average flows outside the *allowable range of deviation* in Table CP-1 will be reported to USFWS via email within 12 hours of occurrence, and will include an explanation for each such deviation. The report will include an explanation for the deviation and the steps being taken to bring daily average flow back within the allowable range of deviation. COID will assist USFWS in determining the impact of the flow deviation on the Oregon spotted frog. USFWS will determine what, if any, remedial actions are necessary to mitigate the impacts, and COID will implement those actions.

No later than January 31 of each year, daily average flow data for the preceding water year (October 1 through September 30) will be reported to the Services in Microsoft Excel or other format approved by the Services. In addition, annual reports will identify all daily average flows outside the *required range* specified in Table CP-1 of Measure CP-1, explain the reason for each such deviation, and identify any remedial actions identified by USFWS and taken by COID.

7.2.2 Conservation Measure WR-1 (Wickiup Reservoir Operation)

7.2.2.1 Wickiup Reservoir and Deschutes River Downstream of Wickiup Dam

Midnight storage volume (acre-feet) in Wickiup Reservoir (measured at Hydromet Station WIC or a comparable replacement), daily average flow (cfs) in the Deschutes River below Wickiup Dam (measured at Hydromet Station WICO or a comparable replacement) and daily average flow in the Deschutes River at Benham Falls (measured at Hydromet Station BENO or a comparable replacement) will be monitored daily for the term of the DBHCP. Water depth (stage) will also be monitored on a continuous basis at Hydromet Station WICO (or a comparable replacement) whenever flow at WICO is ≤ 800 cfs. NUID will use these data to direct day-to-day operation of Wickiup Dam in compliance with Measure WR-1. Flows and water surface elevations outside the *allowable range of deviation* in Table WR-1 of Conservation Measure WR-1 will be reported to USFWS via email within 12 hours of occurrence. The report will include an explanation for the deviation and the steps being taken to bring flow and water surface elevation back within the allowable range of deviation. NUID will assist USFWS in determining the impact of the deviation on the Oregon spotted frog. USFWS will determine what, if any, remedial actions are necessary to mitigate the impacts, and NUID will implement those actions.

No later than January 31 of each year, monthly storage volume, daily average flow and continuous water stage data (as required above) for the preceding water year (October 1 through September 30) will be reported to the Services in Microsoft Excel or other format approved by the Services. In addition, annual reports will identify all daily average flows and continuous water surface elevations outside the *required range* specified in Table WR-1 of

Conservation Measure WR-1, explain the reason for each such deviation, and identify any remedial actions identified by USFWS and taken by NUID.

Each year beginning in Year 1 of DBHCP implementation NUID will report on the volume of water NUID has obtained as live flow from COID on a permanent basis in that year, and the volume of Wickiup Reservoir storage NUID has subsequently converted to instream flow or otherwise made available to support winter minimum flows at WICO required under Conservation Measure WR-1. This information will be included in the DBHCP annual report provided to the Services by January 31 of each year.

To assist USFWS with management of Oregon spotted frogs in the Upper Deschutes Basin, the Permittees will provide the following monitoring. The results of this monitoring will be used solely to further the understanding of Oregon spotted frog habitat conditions in the Upper Deschutes River, and will not result in change in the operation of Crane Prairie or Wickiup reservoir or changes in any other requirement of the Permittees under the DBHCP.

- The Permittees will provide up to two qualified biologists for up to 40 hours each per year to assess habitat conditions in Dead Slough if the flow at WICO decreases by 20 percent over any 5-day period between May 1 and June 30. The assessment will be done in coordination with USFWS and will include documentation (including photographs) of the level of inundation in the slough. All information gathered by the biologists will be provided to USFWS within 24 hours of collection, as well as in the DBHCP annual report submitted to the Services by January 31 of each year.
- Starting in Year 1 and repeating every 5 years for the term of the DBHCP, the Permittees will provide funding for two qualified biologists for up to 40 hours each (or up to 80 hours total for one biologist) to conduct Oregon spotted frog habitat suitability analyses at up to three sites along the Deschutes River selected by USFWS. The analyses may include, but are not limited to, determining surface water elevations relative to flood plains, monitoring vegetation (including presence of invasive reed canarygrass), monitoring bullfrogs, and conducting drone flights. Methodology will vary by site and will be developed in coordination with USFWS.

7.2.3 Conservation Measure UD-1 (Upper Deschutes Basin Conservation Fund)

No later than January 31 of each year, the Permittees will provide USFWS with documentation of their contributions to the Upper Deschutes Basin Conservation Fund for the previous year.

7.2.4 Conservation Measure DR-1 (Middle Deschutes River Flow Outside the Irrigation Season)

Daily average flow (cfs) in the Deschutes River below Bend will be monitored at Hydromet Station DEBO (or a comparable replacement) from November 1 through March 31 for the term of the DBHCP. These data will be used by AID, COID and SID to conduct winter stock water runs in compliance with Measure DR-1. These three Districts will report any flows of less than 235 cfs at DEBO during stock water runs to the Services via email within 12 hours of occurrence. The report will include an explanation for the flow below 235 cfs and the steps being taken to bring the flow back to the target minimum of 250 cfs. The three Districts will assist the Services in determining the impact of the deviation on covered species. The Services will determine what, if any, remedial actions are necessary to mitigate the impacts, and the three Districts will implement those actions.

No later than January 31 of each year, daily average flow data for the preceding November 1 through March 31 will be reported to the Services in Microsoft Excel or other format approved by the Services. The report will include all daily average flows less than 250 cfs during stock water runs and any remedial actions identified by the Services and implemented by the Districts for flows less than 235 cfs.

7.2.5 Conservation Measures CC-1 (Crescent Creek Flow Management), CC-2 (Crescent Dam Ramping Rates) and CC-3 (Crescent Lake Reservoir Irrigation Release Season)

Daily average flow (cfs) in Crescent Creek below Crescent Lake Dam will be monitored at Hydromet Station CREO (or a comparable replacement) for the term of the DBHCP. TID will use these data to direct day-to-day operation of Crescent Lake Dam in compliance with Measures CC-1, CC-2 and CC-3. Flows outside the compliance allowances specified in Conservation Measures CC-1, CC-2 and CC-3 will be reported to USFWS via email within 12 hours of occurrence. The report will include an explanation for the deviation and the steps being taken to bring flows back within the allowances. TID will assist USFWS in determining the impact of the deviation on the Oregon spotted frog. USFWS will determine what, if any, remedial actions are necessary to mitigate the impacts, and TID will implement those actions.

No later than January 31 of each year, daily average flow data for the preceding water year (October 1 through September 30) will be reported to the Services in Microsoft Excel or other format approved by the Services. In addition, annual reports will identify all flows outside the allowances specified in Measures CC-1, CC-2 and CC-3, explain the reason for each such deviation, and identify any remedial actions identified by USFWS and taken by TID. TID will maintain a flow monitoring gage in Crescent Creek downstream of Big Marsh Creek confluence (near the Highway 58 Bridge) and include daily average flows at that gage in the DBHCP annual report delivered to the Services by January 31 of each year. No later than December 31 of Year 1 of DBHCP implementation, TID will instrument the gage to provide USFWS with on-line access to flow information in real time. Until real-time access to flow information is available, TID will report daily average flows to USFWS at two-month intervals, with reports provided to USFWS no later than the last day of the following (third) month. Once real-time access to flow data is available to USFWS, TID will cease reporting at 2-month intervals and will report daily average flows only in the DBHCP annual report.

In the DBHCP annual report, TID will also report the volume of water in Crescent Lake Reservoir available for Oregon spotted frog management (OSF storage) on July 1 of the preceding calendar year according to Conservation Measure CC-1, as well as the volume of water released from OSF storage during the preceding water year (October 1 – September 30).

To support USFWS decisions on the use of OSF storage in Crescent Lake Reservoir as specified in Conservation Measure CC-1, TID will provide the following monitoring. The results of this monitoring will be used solely to assist USFWS with determining the use of OSF storage, and will not result in change in the size or timing of availability of OSF storage, or changes in any other requirement of TID under the DBHCP.

- TID will support USFWS with the Oregon spotted frog breeding surveys in Crescent Creek by providing annual funding for two qualified biologists for up to 40 hours each for the term of the DBHCP. Breeding surveys will be coordinated and led by USFWS or another entity designated by USFWS.
- Starting in Year 1 and repeating every 3 years for the term of the DBHCP, TID will provide funding for two qualified biologists for up to 40 hours each (or up to 80 hours total for one biologist) to check known Oregon spotted frog breeding sites along Crescent Creek and Little Deschutes River for rearing Oregon spotted frogs in May/June (early rearing period) to determine if stranding is occurring. USFWS will be notified if there is a situation where stranding is observed. If USFWS determines a change in use of OSF storage is warranted to reduce stranding and improve Oregon spotted frog survival, TID will implement the change within the limits of the OSF storage described in Conservation Measure CC-1.
- Starting in Year 1 and repeating every 5 years for the term of the DBHCP, TID will provide funding for two qualified biologists for up to 40 hours each (or up to 80 hours total for one biologist) to conduct Oregon spotted frog habitat suitability analyses at up to three sites along Crescent Creek and/or Little Deschutes River selected by USFWS. The analyses may include, but are not limited to, determining surface water elevations relative to flood plains, monitoring vegetation (including presence of invasive reed canarygrass), monitoring bullfrogs, and conducting drone flights. Methodology will vary by site and will be developed in coordination with USFWS.

7.2.6 Conservation Measures WC–1 (Whychus Creek Instream Flows) and WC-5 (Whychus Creek Diversion Ramping Rate)

7.2.6.1 Permanent Instream Water Rights

No later than January 31 of each year, TSID will report to the Services all permanent instream transfers of TSID irrigation rights completed during the previous calendar year, along with any other senior downstream water right transfers TSID would be required to pass.

7.2.6.2 Whychus Creek and TSID Diversion

Whenever TSID is diverting water at its primary diversion, flow (cfs) will be monitored hourly at the diversion (OWRD Gages 14076001 and 14076010 or comparable replacements) and in Whychus Creek downstream of the diversion (OWRD Gage 14076020 or a comparable replacement). TSID will use these data to direct day-to-day operation of its diversion in compliance with Measures WC-1 and WC-5. Flows lower than those required by Conservation Measures WC-1 will be reported to the Services via email within 12 hours of occurrence. The report will include an explanation for the deviation and the steps being taken to bring flows back to the required level. TSID will assist the Services in determining the impact of the deviation on covered species. The Services will determine what, if any, remedial actions are necessary to mitigate the impacts, and TSID will implement those actions.

No later than January 31 of each year, flow data at each of the above gages for the preceding water year (October 1 through September 30) will be reported to the Services in Microsoft Excel or other format approved by the Services. The report will include the raw data available each day TSID was diverting, as well as the processed data for those same days (preliminary, provisional or published) available from OWRD on September 30. In addition, annual reports will identify all flows lower than those required by Measure WC-1, explain the reason for each such deviation, and identify any remedial actions identified by the Services and implemented by TSID.TSID will also provide data on daily average flow and daily maximum water temperature in Whychus Creek at Camp Polk Road available for OWRD Gage 14076100 for all days when TSID is diverting water at its primary diversion. These data will be provided to the Services in Microsoft Excel or other format approved by the Services in the DBHCP annual report no later than January 31 of each year for the preceding water year (October 1 through September 30). Temperature data will be compiled from existing third-party data sources as long as they continue to be available. Should the data cease to be generated by third parties, TSID will fund and/or conduct temperature monitoring consistent with current protocols and include the results in the DBHCP annual report.

7.2.7 Conservation Measure WC–2 (Whychus Creek Temporary Instream Leasing)

No later than January 31 of each year, TSID will provide the Services with documentation of its contributions to Whychus Creek Temporary Instream Leasing for the previous year.

7.2.8 Conservation Measure WC–3 (Whychus Creek Diversion Fish Screens and Fish Passage)

TSID will schedule one full day each year for the Services to conduct annual inspection of the Whychus Creek diversion and associated fish screens. TSID personnel will be present for the inspection to provide the Services with full access to the facilities. The date for the annual inspection will be determined by the Services no later than January 31 of each year, and the inspection will occur at least 30 days after TSID has been informed of the date. The Services may also visit the Whychus Creek diversion and fish screens at any time outside the scheduled annual inspection by providing TSID with notice at least 24 hours in advance.

Every 5 years, beginning in Year 5 of the DBHCP, TSID will conduct a detailed evaluation of the Whychus Creek diversion and fish screens. The evaluation, which will be conducted by a qualified professional with appropriate fish screen and fish passage expertise, will include visual examination of the facilities for damage and/or deterioration, as well as measurements of water depths and velocities to verify the facilities are meeting their original design specifications. The evaluation report will identify any deficiencies or malfunctions, and make recommendations to correct those conditions. The evaluation report, along with an action plan for correcting any deficiencies or malfunctions within 90 days of the evaluation, will be provided to the Services no later than January 31 of the year following the evaluation.

No later than January 31 of each year, TSID will report any difficulties/deviations encountered implementing the TSID Diversion Screen Maintenance Plan during the preceding calendar year.

7.2.9 Conservation Measure WC-4 (Piping of Patron Laterals)

No later than January 31 of each year, TSID will report to the Services the miles of patron laterals that were piped and the associated reductions in seepage losses during the preceding calendar year.

7.2.10 Conservation Measure WC – 6: Whychus Creek Habitat Conservation Fund

No later than January 31 of each year, TSID will provide documentation to the Services of the District's direct financial and in-kind contributions to the Whychus Creek Habitat Conservation Fund during the preceding calendar year. The documentation will include the basis for calculating the financial value of the in-kind services.

7.2.11 Conservation Measure WC – 7: Plainview Dam Removal

No later than January 31 of the year following the removal of the Plainview Dam, TSID will provide the Services documentation of the removal.

7.2.12 Conservation Measures CR-1 (Crooked River Flow Downstream of Bowman Dam, CR-2 (Ochoco Creek Flow) and CR-3 (McKay Creek Flow)

7.2.12.1 Flow Monitoring

Flow data will be collected within the Crooked River subbasin at the locations and time intervals specified in Table 7-1. These data will be used by OID to manage releases from Ochoco Reservoir and diversions at multiple locations on the Crooked River, Ochoco Creek and McKay Creek in compliance with Measures CR-1, CR-2 and CR-3. The data will also be available to Reclamation to manage releases from Prineville Reservoir. Flows outside the compliance allowances specified in Conservation Measures CR-1, CR-2 and CR-3 will be reported to the Services via email within 12 hours of occurrence. The report will include an explanation for the deviation and the steps being taken to bring flows back within the allowances. OID will assist USFWS in determining the impact of the deviation on covered species. The Services will determine what, if any, remedial actions are necessary to mitigate the impacts, and OID will implement those actions.

No later than January 31 of each year, flow data for the preceding water year (October 1 through September 30) will be reported to the Services in Microsoft Excel or other format approved by the Services. In addition, annual reports will identify all flows outside the allowances specified in Measures CR-1, CR-2 and CR-3, explain the reason for each such deviation, and identify any remedial actions identified by the Services and taken by OID.

Table 7-1. DBHCP flow monitoring requirements for the Crooked River subbasin.

Water Body	Location	Data to be Collected
Crooked River (RM 70.0)	OWRD Gage 14080500 (Hydromet Station PRVO)	Daily average flow
Crooked River (RM 56.5)	Manual staff gage downstream of Crooked River Diversion	Flow at time of change in diversion rate
Crooked River (RM 48.0)	OWRD Gage 14081500 (Hydromet Station CAPO)	Daily average flow
Ochoco Creek (RM 11.2)	OWRD Gage 14085300 (Hydromet Station OCHO)	Hourly average flow
Ochoco Creek (RM 10.2)	Manual staff gage at Red Granary Diversion	Flow at time of change in diversion rate
Ochoco Creek (RM 9.4)	Recording gage with telemetry downstream of Golf Course Dam	Hourly average flow
Ochoco Creek (RM 7.5)	Manual staff gage at Breese Dam	Flow at time of change in diversion rate
Ochoco Creek (RM 5.1)	Recording gage with telemetry at Crooked River Diversion Spill	Hourly average flow
Ochoco Creek (RM 4.7)	Manual staff gage at Ryegrass Diversion	Flow at time of change in diversion rate
McKay Creek (RM 5.8)	Manual staff gage at Jones Dam	Flow at time of change in diversion rate
McKay Creek (RM 3.2)	Manual staff gage at Reynolds Siphon	Flow at time of change in diversion rate
McKay Creek (RM 1.3)	Recording gage with telemetry at Cook Inverted Weir	Daily average flow
McKay Creek (RM 0.6)	Manual staff gage at Smith Inverted Weir	Flow at time of change in diversion rate

7.2.12.2 Temporary Instream Leasing and Permanent Water Right Transfers

No later than January 31 of each year, OID will provide the Services a report on temporary instream leases and permanent water right transfers of Crooked River and Ochoco Creek irrigation rights during the preceding calendar year. The report will identify the quantity of water covered by each temporary or permanent transfer, and the fate of that water (timing and rate of bypass at Bowman Dam or Ochoco Dam). For transfers of OID patron water rights, the report will also identify whether any of the water was temporarily stored by OID.

7.2.12.3 McKay Creek Water Switch

No later than January 31 of each year, OID will provide the Services a report on the status of the McKay Creek water switch. The report will identify the amount of McKay Creek irrigation water that was transferred instream during the preceding year, as well as the total amount of water transferred to date through the McKay Creek switch.

7.2.13 Conservation Measure CR-4 (Crooked River Conservation Fund)

No later than January 31 of each year, NUID, OID and the City will provide the Services with documentation of their contributions to the Crooked River Conservation Fund for the previous year.

7.2.14 Conservation Measure CR-5 (Screening of Diversion Structures)

7.2.14.1 District Diversions

OID will schedule one full day each year for the Services to conduct annual inspections of District's diversions and associated fish screens. OID personnel will be present for the inspections to provide the Services with full access to the facilities. The date for the annual inspections will be determined by the Services no later than January 31 of each year, and the inspection will occur at least 30 days after OID has been informed of the date. The Services may also visit OID diversions and fish screens at any time outside the scheduled annual inspection by providing OID with notice at least 24 hours in advance.

Every five years, beginning in Year 5 of DBHCP implementation, OID will conduct detailed evaluations of its diversions and fish screens. The evaluations, which will be conducted by a qualified professional with appropriate fish screen and fish passage expertise, will include visual examinations of the facilities for damage and/or deterioration, as well as measurements of water depths and velocities to verify the facilities are meeting their original design specifications. Evaluation reports will identify any deficiencies or malfunctions, and make recommendations to correct those conditions. Evaluation reports, along with an action plans for correcting any deficiencies or malfunctions within 90 days of the evaluations, will be provided to the Services no later than January 31 of the year following the evaluations.

7.2.14.2 Patron Diversions

No later than January 31 of the second through the sixth year of DBHCP implementation, OID will provide the Services with a report on the screening of patron diversions during the preceding calendar year. The report will identify the screening account balance as of December 31, all account activity (deposits and withdrawals), and all screens funded through the account.

7.2.15 Conservation Measures CR-6 (Crooked River Flow Downstream of the Crooked River Pumps) and CR-7 (Crooked River Downstream Fish Migration Pulse Flow)

NUID will report diversions at its Crooked River Pumps to USFWS and NMFS as part of the DBHCP annual report. The accounting for each day of pumping will include the number of pumps in operation each day, the estimated daily average rate of diversion (cfs) for all operating pumps combined, the estimated total volume (acre-feet) of water diverted by all pumps combined during the 24-hour period, and the reported flow (cfs) at OWRD Gage 14087300 (Crooked River near Terrebonne) at 7:00 AM of each day. If, during the term of the DBHCP, a recording stream gage with real-time access (e.g., telemetry) is installed and operational upstream of the Crooked River Pumps in a location that reasonably estimates the flow reaching the pumps, the Services may approve a change in required reporting whereby NUID may cease reporting pump diversions to USFWS and NMFS and simply provide an annual report of daily average flows at OWRD Gage 14087300 and the new gage.

In addition, NUID will report to NMFS and USFWS by email within 48 hours whenever the flow measured at OWRD Gage 14087300 falls below the required level specified in Conservation Measure CR-6 concurrent with NUID pumping. The report will specify the flow at Gage 14087300, the number of pumps in operation, and the estimated daily average rate of diversion (cfs) when the flow at Gage 14087300 fell below the required level.

7.2.16 Summary of Compliance Monitoring and Reporting

Compliance monitoring and reporting to be conducted for the DBHCP is summarized in Table 7-2.

Table 7-2. Summary of DBHCP compliance and implementation monitoring and reporting.

Measure	Monitoring Requirement	Reporting Frequency	Annual Report Due Date
CP-1	Daily (midnight) Crane Prairie Reservoir water surface elevation and storage volume	Annual, and as needed when deviations occur	Jan 31
	Daily average flow in Deschutes River below Crane Prairie Dam		
WR-1	Daily (midnight) storage volume in Wickiup Reservoir	Annual, and as needed when deviations occur	Jan 31
	Daily average flow and water depth (stage) in Deschutes River below Wickiup Dam		
	Daily average flow in Deschutes River at Benham Falls		
	Transfers of live flow from COID to NUID	Annual	Jan 31
UD-1	Annual contributions to Upper Deschutes Basin Conservation Fund	Annual	Jan 31
	Dead Slough habitat assessment	Real time (within 24 hours) and annual	Jan 31
	Oregon spotted frog habitat suitability analyses	Real time (within 24 hours) and annual	Jan 31
DR-1	Daily average flow in Deschutes River below Bend from November 1 to March 31	Annual, and as needed when deviations occur	Jan 31
CC-1, CC-2, CC-3	Daily average flow in Crescent Creek below Crescent Dam	Annual, and as needed when deviations occur	Jan 31
	Daily average flow in Crescent Creek below Big Marsh Creek	Annual, and bi-monthly until there is real-time access to gage readings	Jan 31
	Storage volume in Crescent Lake Reservoir available for OSF management on July 1, and volume released in water year	Annual	Jan 31
	Oregon spotted frog breeding survey results	Real time (within 24 hours) and annual	Jan 31
	Results of monitoring for stranding of Oregon spotted frog tadpoles	Real time (within 24 hours) and annual	Jan 31
	Results of Oregon spotted frog habitat suitability analyses	Annual	Jan 31

Measure	Monitoring Requirement	Reporting Frequency	Annual Report Due Date
WC-1	Permanent instream water right transfers in Whychus Creek	Annual	Jan 31
WC-1, WC-5	Hourly average flow at TSID Diversion and in Whychus Creek when TSID is diverting water	Annual, and as needed when deviations occur	Jan 31
WC-1	Daily average flow and daily maximum water temperature in Whychus Creek at Camp Polk Road	Annual	Jan 31
WC-2	Annual contributions to temporary instream leasing in Whychus Creek	Annual	Jan 31
WC-3	Annual inspection of TSID fish screen and passage	Annual	TBD
	5-year evaluation of TSID fish screen and passage	Every 5 years	Jan 31
WC-4	TSID patron piping (miles piped and water conserved)	Annual	Jan 31
WC-6	Annual in-kind and cash contributions to Whychus Creek Habitat Conservation Fund	Annual	Jan 31
WC-7	Removal of Plainview Dam	Once, after year of completion	Jan 31
CR-1, CR-2, CR-3	Flow at multiple locations and variable intervals (see Table 7-1)	Annual, and as needed when deviations occur	Jan 31
	Temporary instream leasing in Crooked River and Ochoco Creek	Annual	Jan 31
	Status of McKay Creek Water Switch	Annual	Jan 31
CR-4	Annual contributions to Crooked River Conservation Fund	Annual	Jan 31
CR-5	Annual inspection of OID fish screens and fish passage	Annual	TBD
	5-year evaluation of OID fish screens and fish passage	Every 5 years	Jan 31
	Screening of OID patron diversions	Annual in Years 2-6	Jan 31
CR-6, CR-7	Crooked River Pump diversions	Annual, and as needed when deviations occur	Jan 31

7.3 Effectiveness Monitoring, Reporting and Adaptive Management

7.3.1 Funding for Oregon Spotted Frog Breeding Surveys

Adaptive Management Measure OSF-1: The Permittees will provide funding for up to two biologists qualified to conduct Oregon spotted frog egg mass counts in the Upper Deschutes Basin each year as specified in Adaptive Management Measures CP-1.1, WR-1.1 and WR-1.2. This funding will be provided annually for the term of the DBHCP. Total funding each year will be sufficient to provide 240 hours of professional biologist labor (120 hours each if two biologists are required). The distribution of this funding between Adaptive Management Measures CP-1.1, WR-1.1 and WR-1.2 will be determined each year by USFWS based on need and logistics, but total funding each year will not exceed 240 hours.

7.3.2 Crane Prairie Reservoir

Adaptive Management Measure CP-1.1: The Permittees will support USFWS in the performance of Oregon spotted frog egg mass counts at Crane Prairie Reservoir by providing annual funding for qualified biologists as specified in Adaptive Management Measure OSF-1. Egg mass counts will be designed, coordinated and led by USFWS or another entity designated by USFWS.

If USFWS determines that egg mass counts at Crane Prairie Reservoir indicate Oregon spotted frogs are attempting to lay eggs in the reservoir prior to March 15, USFWS will modify Item A of Conservation Measure CP-1, as needed, to require a water surface elevation of at least 4,443.23 feet (approximate reservoir volume of 46,800 acre-feet) as early as March 1.

Rationale: Conservation Measure CP-1 (see Section 6.2.2) requires that Crane Prairie Reservoir reach a water surface elevation of at least 4,443.23 feet by March 15 each year to ensure Oregon spotted frog breeding habitat is inundated at the onset of egg deposition. This target date of March 15 is based on observations of Oregon spotted frog breeding in the reservoir since 2013. The timing of egg deposition in the reservoir has been observed varying by a week or more between years, presumably in response to the annual timing of reservoir thaw. March 15 is currently assumed to be the earliest date by which egg deposition could begin, but the limited period of record (6 years) means the full range of breeding initiation dates may not have been observed and egg deposition could begin earlier than March 15 in some years. It is also possible that long-term changes in the climate of the upper Deschutes Basin could result in earlier breeding during the term of the DBHCP. To account for the possibility of Oregon spotted frog breeding prior to March 15 in Crane Prairie Reservoir, Adaptive Management Measure CP-1.1 requires that egg deposition be monitored annually and the timing of spring reservoir fill be adjusted, as needed, to as early as March 1. The adaptive management measure does not require the reservoir to reach 4,443.23 feet prior to March 1 because Oregon spotted frog breeding prior to this date is considered highly unlikely.

Reporting: The biologists funded by the Permittees in accordance with Adaptive Management Measure OSF-1 will provide the breeding survey data they collect to USFWS and/or the entity leading the spring egg mass counts by June 1 each year. The data will be provided in a format determined by USFWS. The data collected by these biologists will also be included in the DBHCP annual report submitted to the Services by January 31 of each year.

Adaptive Management Measure CP-1.2: During the first 2 years of DBHCP implementation and for 2 years out of 10 thereafter, the Permittees will provide qualified biologists to monitor Crane Prairie Reservoir during drawdown (July 16 through October 31) for signs of stranding of Oregon spotted frog tadpoles, juveniles and adults. If stranding of tadpoles is observed it will be reported to USFWS within 24 hours. In the event of stranding, USFWS will delay the onset of drawdown to no later than August 15 and/or reduce the rate of drawdown after July 31 to as low as 0.05 foot per day, as needed, to prevent stranding, provided these changes will not prevent a net seasonal reduction in reservoir storage volume of 10,000 acre-feet by September 30. After August 15, USFWS will increase the allowable rate of drawdown to as much as 0.25 foot per day, as needed, if no stranding of tadpoles, juveniles or adults is observed. Funding for biologists to conduct this monitoring will be separate from and in addition to funding specified in Adaptive Management Measure OSF-1.

Rationale: Crane Prairie Reservoir will be lowered by as much as 10,000 acre-feet near the end of each summer. While the annual release of water from the reservoir is considered important to the maintenance of habitat conditions over the long term (see Section 6.2.3, *Rationale for Conservation Measure CP-1*), the rate and timing of release also must be controlled to avoid adverse effects on Oregon spotted frogs in the short term. Conservation Measure CP-1 (see Section 6.2.2) includes requirements for the timing and rate of reservoir drawdown based on observations of Oregon spotted frog larval development and metamorphosis in the reservoir in recent years. Under the conservation measure, drawdown cannot begin before July 16, and the rate of drawdown cannot exceed 0.05 foot (0.6 inch) per day until August 1.

As with the timing of egg deposition, the timing of metamorphosis in Crane Prairie Reservoir is based on a limited number of direct observations since 2013. To account for the possibility that some Oregon spotted frog larvae may not complete metamorphosis and be capable of moving during reservoir drawdown in late July, Adaptive Management Measure CP-1.2 requires monitoring for signs of larval stranding during drawdown and adjustment to the timing and rate of drawdown if stranding is observed. The monitoring will be repeated in each decade of DBHCP implementation to detect any long-term changes in the timing of metamorphosis and make the appropriate adjustments.

In addition to reducing impacts to Oregon spotted frogs during reservoir drawdown, the monitoring required by Adaptive Management Measure CP-1.2 will also be used to determine whether the rate of drawdown can be increased after August 15. This provision in the measure will increase the potential for the Districts to have full access to 10,000 acre-feet of irrigation storage. By increasing the rate of drawdown when doing so is not harmful to frogs, a larger percentage of the 10,000 acre-feet of drawdown can be released into Wickiup Reservoir rather than being lost to seepage and evaporation in Crane Prairie Reservoir. In addition, if the onset of reservoir drawdown is delayed to avoid impacting larval Oregon spotted frogs in late July, an increased rate of drawdown in late August may give the Districts the ability to access the water before the end of the current water year when it is likely to be most needed.

Reporting: Observations of stranding of tadpoles during drawdown of Crane Prairie Reservoir will be reported to USFWS within 24 hours. In years when ramp-down monitoring is conducted, the results for the year will be reported in the DBHCP annual report submitted to the Services by January 31 of the following year.

Adaptive Management Measure CP-1.3: Within the first 5 years of DBHCP implementation, the Permittees will determine the total area of breeding/rearing/nonbreeding habitat in Crane Prairie Reservoir (as defined in Objective CP-1) through LiDAR or other available digital bathymetry, interpretation of aerial photographs and ground verification. Bathymetry and topographic contours will be overlain on orthographic photos to determine the total area (acres) of vegetation below the maximum reservoir operating elevation of 4,443.48 feet (storage volume of approximately 48,000 acre-feet). Ground verification will be used to determine the species composition of the vegetation and to confirm the slope of the substrate and the extent of vegetation from elevation 4,443.48 feet to elevation 4,439.23 feet (i.e., to a depth of 24 inches below the annual low water elevation of 4,441.23 feet). The interpretation of current aerial imagery and ground verification will be repeated at 5-year intervals for the term of the DBHCP to detect changes in the areal extent or species composition of the vegetation.

If the total area of vegetation below elevation 4,443.48 decreases or the species composition of the vegetation changes in a way that reduces the total area of Oregon spotted frog breeding/rearing/nonbreeding habitat in the reservoir (as defined in Objective CP-1), USFWS may modify the timing and rate of reservoir drawdown specified in Items B and C of Conservation Measure CP-1, provided the drawdown will never begin prior to July 1, never end later than October 31, never proceed at a rate of more than 0.2 foot/day, and never involve a net reduction in seasonal reservoir storage volume of less than 10,000 acre-feet. In addition, the results of monitoring under Adaptive Management Measure CP-1.2 will be considered to ensure a balance between the long-term effects on vegetation and the short-term effects on Oregon spotted frog tadpoles.

Rationale: The conservation goal for Crane Prairie Reservoir is to maintain or improve habitat conditions for Oregon spotted frogs within the reservoir (see Section 6.2.1.1, *Crane Prairie Goal CP-1*). Under Conservation Measure CP-1, seasonal fluctuation of the reservoir will be reduced from historical levels with the objective of improving winter habitat conditions, and the reservoir will be kept near full inundation longer into the growing season than it was historically to protect habitat for summer rearing and foraging. While it is assumed these changes will be beneficial to Oregon spotted frogs, the full effects of reduced seasonal fluctuation and prolonged inundation on wetland vegetation within the reservoir are somewhat uncertain (see Section 8.4.1.1, *Crane Prairie Reservoir*). It is possible that higher overall water levels and prolonged seasonal inundation could reduce the total area of vegetated wetland within the reservoir or change the species composition of the wetlands to plants that are less suitable for Oregon spotted frogs (e.g., cattails). Adaptive Management Measure CP-1.3 requires monitoring of wetland vegetation within the reservoir to detect changes in the quantity or quality of habitat for Oregon spotted frogs. The areal extent and species composition of wetland vegetation will be documented within the first 5 years of DBHCP implementation to provide a baseline condition. Monitoring will then continue through repeated measurements at 5-year intervals. If a change is detected and that change is reducing the quantity or quality of Oregon spotted frog habitat within the reservoir, USFWS may modify reservoir operation within the limits specified in Adaptive Management Measure CP-1.3.

Reporting: In years when habitat monitoring is conducted in Crane Prairie Reservoir, the results of the monitoring will be reported in the DBHCP annual report submitted to the Services by the following January 31.

7.3.3 Wickiup Reservoir and Upper Deschutes River

Adaptive Management Measure WR-1.1: Each spring, prior to the Oregon spotted frog breeding season, the Permittees will provide funding for qualified biologists as specified in Adaptive Management Measure OSF-1 to assess Oregon spotted frog pre-breeding activity, weather conditions, and habitat conditions at known breeding locations along the Upper Deschutes River. This information will be provided to USFWS to inform its decision on whether breeding season flows at WICO specified in Conservation Measure WR-1, Item A should be less than 600 cfs on April 1. If the April 1 flow is set at less than 600 cfs, this information will also be used by USFWS to determine when within the first two weeks of April the flow should increase to 600 cfs.

Rationale: Item A of Conservation Measure WR-1 requires flows in the Deschutes River at Hydromet Station WICO to be at least 600 cfs on April 1 of each year, unless it is found through effectiveness monitoring that a lower flow will provide comparable benefit to Oregon spotted frogs. Adaptive Management Measure WR-1.1 provides that effectiveness monitoring. The ramp-up to 600 cfs on April 1 is anticipated to coincide with the onset of Oregon spotted frog breeding along the Upper Deschutes River. In some recent years, however, cold weather conditions and delayed snowmelt have been found to delay the onset of breeding past April 1. When this occurs, the ramp-up to 600 cfs can also be delayed to conserve water for use later in the irrigation season. Over the term of the DBHCP, Adaptive Management Measure WR-1.1 will be used in this way to support the most effective and efficient use of Wickiup Reservoir storage in April.

Reporting: Observations made in accordance with this adaptive management measure will be reported to USFWS daily as they are made (within 24 hours). All observations for the year will be reported in summary fashion in the DBHCP annual report submitted to the Services by January 31 of each year.

Adaptive Management Measure WR-1.2: The Permittees will support USFWS in the monitoring of Oregon spotted frog egg/larvae survival at spotted frog habitats along the Upper Deschutes River by providing annual funding for qualified biologists as specified in Adaptive Management Measure OSF-1. Monitoring will be designed, coordinated and led by USFWS or another entity designated by USFWS.

If USFWS determines through this monitoring that Oregon spotted frog eggs/larvae in Dead Slough can tolerate decreases in water depth of more than 1 inch without being adversely affected, USFWS may modify Item C of Conservation Measure WR-1 to increase the maximum allowable decrease in flow at Hydromet Station WICO in April.

Monitoring of other OSF sites on the Deschutes will inform the shaping and release of winter flows for the life of the permit.

Rationale: Item C of Conservation Measure WR-1 limits reductions in flow in the Deschutes River at Hydromet Station WICO during April to 30 cfs (equivalent to 1-inch reduction in water depth) to protect Oregon spotted frog eggs from desiccation and stranding. However, the measure allows for reductions of more than 30 cfs if it is found through effectiveness monitoring that eggs can tolerate a greater change in water depth. Adaptive Management Measure WR-1.2 provides that effectiveness monitoring.

Oregon spotted frogs generally lay their eggs in shallow water (12 inches or less). This enables them to take maximum advantage of solar warming, but it also makes them vulnerable to changes in water depth. Eggs can become exposed, and even stranded out of water altogether, if water depths decrease several inches during incubation. The limit of 30 cfs (1 inch) in Conservation Measure WR-1 is intended to be conservative, with the assumption that a decrease of this amount or less will easily prevent stranding associated with water management. With site-specific analysis, however, it may be possible to allow a decrease of more than 1 inch while still accomplishing the objective of protecting all egg masses. The effectiveness monitoring conducted for Adaptive Management Measure WR-1.2 will provide the information upon which future adjustment to Conservation Measure WR-1 can be based.

Reporting: The biologists funded by the Permittees in accordance with Adaptive Management Measure OSF-1 will provide the breeding survey data they collect to USFWS and/or the entity leading the spring egg mass counts by June 1 each year. The data will be provided in a format determined by USFWS. The data collected by these biologists will also be included in the DBHCP annual report submitted to the Services by January 31 of each year.

Adaptive Management Measure WR-1.3: Beginning no later than Year 13 of DBHCP implementation, minimum flow at WICO shall be between 400 cfs and 500 cfs from September 16 through March 31, with actual flow during this period determined according to the variable flow tool described herein. The variable flow tool shall be developed collaboratively by USFWS and the Permittees in consultation with OWRD and Reclamation. USFWS must approve the final tool for usage. A prototype of the variable flow tool shall be developed by the end of Year 10 of DBHCP implementation and tested in Years 11 and 12. The final variable flow tool shall be implemented beginning in Year 13. The variable flow tool shall be used to establish the September 16 to March 31 minimum flow at WICO each year based on available storage in Wickiup Reservoir at the beginning of the storage season and anticipated inflow to the reservoir during the storage season. Monitoring, reporting and adaptive management provisions for the variable tool shall also be developed by the end of Year 10. For purposes of this calculation, target reservoir storage volume at the end of the storage season shall never be less than 92,000 acre-feet.

Rationale: Winter minimum flows of greater than 400 cfs at WICO are assumed desirable for Oregon spotted frog overwintering in the Upper Deschutes River, but the process for establishing a minimum flow greater than 400 cfs without having adverse consequences on irrigation storage and summer flows is currently uncertain. Winter minimum flows of up to 400 cfs required by Conservation Measure WR-1 will result in profound changes to the hydrology of the Upper Deschutes River, and several years of compliance monitoring (as described in Section 7.2.2.1, *Wickiup Reservoir and Deschutes River Downstream of Wickiup Dam*) will be needed to determine when and how minimum flows greater than 400 cfs can be provided. Adaptive Management Measure WR-1.3 requires the Permittees and USFWS to develop a variable flow tool for increasing winter minimum flows above 400 cfs on a sustainable basis, and allows them up to 12 years to observe DBHCP implementation, develop the tool and test the tool.

Reporting: The reporting requirements for this adaptive management measure will be determined as part of the development of the variable flow tool.

7.3.4 Middle and Lower Deschutes River

There will be no effectiveness monitoring or adaptive management associated with the Deschutes River downstream of Bend. There is no identified uncertainty about the effectiveness of the DBHCP conservation measures for the middle and lower reaches of the Deschutes River.

7.3.5 Crescent Creek and the Little Deschutes River

There will be no effectiveness monitoring or adaptive management specifically associated with Crescent Creek and Little Deschutes River. Implementation monitoring associated with the OSF Storage in Crescent Lake Reservoir is described in Section 7.2.5.

7.3.6 Whychus Creek

There will be no effectiveness monitoring or adaptive management specifically associated with Whychus Creek. There is no identified uncertainty about the effectiveness of Conservation Measures WC-1, WC-2, WC-3, WC-4, WC-5, WC-6 and WC-7.

7.3.7 Crooked River, Ochoco Creek and McKay Creek

There will be no effectiveness monitoring or adaptive management specifically associated with the Crooked River, Ochoco Creek or McKay Creek. There have been no areas of uncertainty identified for Conservation Measures CR-1 through CR-5.

7.3.8 Summary of Reporting on Effectiveness Monitoring

Effectiveness monitoring and reporting to be conducted for the DBHCP is summarized in Table 7-3.

Table 7-3. Summary of DBHCP effectiveness monitoring and reporting.

Measure	Monitoring Requirement	Reporting Frequency	Annual Report Due Date
CP-1.1	Monitoring for Oregon spotted frog breeding	Annual	Jun 1 for initial report; Jan 31 for final
CP-1.2	Crane Prairie drawdown monitoring	Real time (within 24 hours) and annual during years of monitoring	Jan 31
CP-1.3	Crane Prairie vegetation monitoring	Annual during years of monitoring	Jan 31
WR-1.1	Monitoring of spring breeding conditions for Oregon spotted frogs	Real time (within 24 hours) and annual	Jan 31
WR-1.2	Monitoring of Oregon spotted frog egg mass survival	Real time (within 24 hours) and annual	Jan 31
WR-1.3	Monitoring of implementation of the variable flow tool for Upper Deschutes River winter minimum flows	To be determined	To be determined

FINAL

DESCHUTES BASIN HABITAT CONSERVATION PLAN

Chapter 8 – Effects on the Proposed Incidental Take on the Covered Species

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8 – EFFECTS OF THE PROPOSED INCIDENTAL TAKE ON THE COVERED SPECIES

8.1 Bull Trout

The Deschutes Basin is considered a population stronghold for bull trout (USFWS 2015). The species is present or potentially present in the Deschutes River upstream to Big Falls (RM 132.2), in Whychus Creek upstream to a natural barrier at RM 37.1, in the Crooked River upstream to Bowman Dam (RM 70.5), in Ochoco Creek upstream to Ochoco Dam (RM 11.2) and in McKay Creek upstream to a natural barrier at RM 19.6 (Figure 8.1). Fish passage facilities recently completed at Opal Springs Dam eliminated a man-made barrier at RM 7.2 on the Crooked River, but it remains to be seen how far upstream of Opal Springs bull trout will travel on a consistent basis. Bull trout are federally listed as threatened (USFWS 1999). USFWS (2010) has designated critical habitat for bull trout, which includes about 100 miles of rivers and creeks on the covered lands.

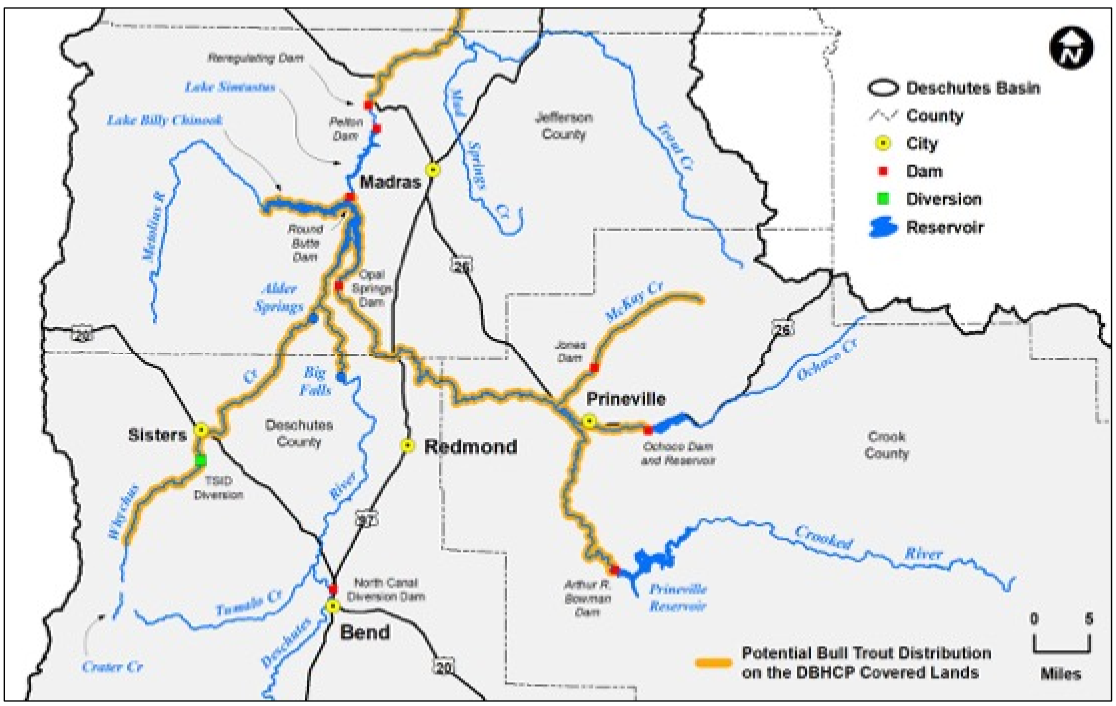

Figure 8-1. Waters covered by the DBHCP that are currently or potentially accessible to bull trout.

Bull trout prefer cold waters, particularly for spawning and rearing (Table 8-1). Naturally high water temperatures throughout the accessible reaches of the Deschutes Basin limit bull trout spawning and rearing to those tributaries with summer water temperatures below 11°C. Specifically, these naturally cold waters are found in the Metolius River subbasin and portions of Warm Springs River and Shitike Creek, all of which are outside the covered lands and uninfluenced by the covered activities.

Table 8-1. Seasonal presence and water temperature suitability for bull trout in the Upper Deschutes Basin.

Life History Stage	Season[1/]	Water Temperature Suitability (°C)				
		Preference	Avoidance	Stress/ Disease	Delay	Lethal
Adult Migration[2/]	Apr-Jun	< 15.0	> 18.0	ND	ND	ND
Spawning[3/]	Aug-Oct	5.6 – 9.0	> 11.0	ND	ND	ND
Incubation[4/]	Aug-Mar	2.0 – 6.0	ND	> 6.0	ND	ND
Juvenile Rearing[5/]	All Year	7.0 – 15.0	> 16.0	> 16.0	ND	20.8[6/] 23.0[7/]

Notes:

1) NPCC 2004; PGE and CTWSRO 2016, 2017, 2018, 2019
2) Rieman and McIntyre 1993; Dunham et al. 2003; USFWS 2012
3) USEPA 2001b; USFWS 2012
4) McPhail and Baxter 1996; Batt 1996; Brun and Dodson 2000; USEPA 2001b
5) McPhail and Baxter 1996; Wydoski and Whitney 2003; Fraley and Shepard 1989; Goetz 1989; Brown 1992; Underwood et al. 1992; Batt 1996; McMahon et al. 1998, 1999; USEPA 2001a; Myrick 2002; Essig et al. 2003
6) 60-day exposure (McMahon et al. 1999)
7) 7-day exposure (McMahon et al. 1999)

Use of the covered lands by bull trout is limited to foraging and migration by adults, subadults, and possibly juveniles. On covered lands upstream of the Pelton Round Butte Project, bull trout may forage in accessible reaches of the Deschutes River, Whychus Creek, Crooked River, Ochoco Creek and McKay Creek when water temperatures are low enough, although actual observations of bull trout in these areas have been quite limited (Ratliff et al. 1996). For the Deschutes Basin, USFWS (2014a) has suggested that foraging adult and subadult bull trout require a maximum 7-day average of the daily maximum temperature (Max 7-DADM) of no more than 16.0°C, and rearing juvenile bull trout require a Max 7-DADM of no more than 12°C.

Over the term of the DBHCP, the covered activities will not affect bull trout spawning, incubation and early juvenile rearing because these do not occur on the covered lands. However, irrigation activities could affect conditions for adult, subadult and juvenile bull trout foraging in the mainstem Deschutes River (upstream and downstream of Pelton Round Butte Project), Whychus Creek, Crooked River, Ochoco Creek and McKay Creek. These effects will occur indirectly through the changes in hydrology described in detail in Chapter 6, *Habitat Conservation*. Direct effects could also occur through entrainment and blockage to migration if screens and passage were not provided and maintained. The conservation measures described in Chapter 6 have been designed to address both indirect and direct effects of the covered activities on bull trout and other covered species.

Changes to hydrology resulting from the covered activities are variable by season and by location on the covered lands. In general, flows in those reaches that are accessible to bull trout are reduced by irrigation storage and stock water diversions in the fall and winter and by irrigation water diversions in the spring and summer. Specific effects on bull trout are discussed in detail for each of the five geographic areas of the covered lands where bull trout could be present (Middle Deschutes River, Whychus Creek, Crooked River subbasin, Lake Billy Chinook and Lower Deschutes River).

The effects of the covered activities on covered fish species are determined by comparing historical conditions on the covered lands to future conditions under the DBHCP. For consistency with the hydrologic analyses presented in Chapter 6, historical conditions are defined as conditions that existed from 1981 through 2018 and future DBHCP conditions are those that will occur during DBHCP implementation beginning in 2021. In most cases, historical conditions are the same as current conditions (i.e., conditions immediately prior to DBHCP implementation), but in a number of cases current conditions are different (i.e., improved) from average or median historical conditions due to recent conservation actions, such as irrigation canal piping, that occurred progressively over the 11 years of DBHCP development. These early conservation actions cannot be attributed directly to the DBHCP because they occurred prior to federal approval of the DBHCP, but they nevertheless have resulted in improved conditions for covered species. Habitat improvements associated with early conservation actions will be identified in the following analysis and distinguished from the effects of the DBHCP.

Natural (also called unregulated) conditions are discussed briefly for some geographic areas to describe the natural habitat potential of those affected reaches, but not as a basis for comparison of the effects of the DBHCP. Natural conditions are not used as the basis for comparison because they are no longer achievable after 100 years or more of land use change in the basin, and because in certain locations irrigation activities have been beneficial to covered species and a return to natural conditions would be undesirable. Natural conditions are important to note, however, because they provide insights into the natural potential of the covered lands to support the covered species. In many cases, the conservation benefits of the DBHCP are limited by the natural potential of the covered lands.

8.1.1 Middle Deschutes River

Overview

The analysis of effects of the DBHCP on bull trout in the Middle Deschutes River is limited to the 12.2 miles of river currently or potentially occupied by the species between Big Falls (RM 132.2) and Lake Billy Chinook (RM 120.0). There are no irrigation storage reservoirs, diversions or return flows within this reach; the effects of the covered activities are limited to changes in flow resulting from the storage, release and diversion of water in the Deschutes River and its tributaries more than 30 miles upstream.

Historical hydrology and water quality of this reach are described in Section 4.2, *Upper and Middle Deschutes River*. The first 2 miles of the reach below Big Falls are heavily influenced by upstream irrigation activities; flows are generally low in the summer due to irrigation diversions and low in the winter due to irrigation storage. While the remaining 10 miles of the reach are also influenced by irrigation activities, the flows are higher at all times of year because of groundwater discharge and surface tributary inflow that reduce the relative effects of upstream storage and diversion. Instream water rights that were established as a result of conserved water projects (i.e., irrigation canal piping) prior to 2020 provide a minimum mid-summer flow of 143 cfs at the upstream end of this reach. At the downstream end of the reach, flows exceed 500 cfs in most months (see Figure 4-5). The instream water rights of 143 cfs are part of the current condition, but they are not fully reflected in average or median historical conditions because many of the conserved water projects occurred after 2010.

The DBHCP will not change flows in this reach from their current condition during the irrigation season, as indicated by projected daily average flows upstream at RM 160 (Figure 8-2). The *DBHCP, Minimum 100 cfs* flows for April through September shown in Figure 8-2 reflect current conditions, and these are greater than historical flows because they include the benefits of early conservation actions since 2010. Irrigation season flows in this reach will continue to increase from current conditions over the next 30 years as additional conserved water projects occur, but these projects are not reflected in Figure 8-2 or included in this analysis because they will be unrelated to the DBHCP.

During the storage season (October through March) flows in the Middle Deschutes River will increase as a result of DBHCP Conservation Measure WR-1 because fall and winter flows below Wickiup Dam (Hydromet Station WICO) will increase. As with irrigation season flows, the *DBHCP, Minimum 100 cfs* flows for the storage season shown in Figure 8-2 reflect current conditions because the requirement to maintain a minimum flow of 100 cfs at WICO is already being implemented. In the future, as the required minimum flow at WICO increases, the storage season flow in the Middle Deschutes River will also increase. Additional benefit will be derived from Conservation Measure DR-1, which will prevent stock water diversions from reducing flows through Bend to less than 250 cfs from November through March.

Water temperatures at the upstream and downstream ends of the Middle Deschutes River from 2011 through 2016 are presented in Figures 8-3 and 8-4. Temperatures within this reach are not expected to change as a result of the DBHCP. Summer temperatures reflect the large influx of cool groundwater between RM 130 and RM 120, and peak temperatures at the downstream end of the reach can be as much as 7°C cooler than at the upstream end. In 2013, the 7-DADM at Lower Bridge (RM 133) was consistently above 18°C from late June through late September and the peak in 7-DADM in July was over 24°C (see Chapter 4 - Figure 4-13). In contrast, the 7-DADM at Culver (RM 120) never reached 18°C and it exceeded 16.0°C only briefly. The Middle Deschutes River is listed as water temperature limited under Section 303(d) of the Clean Water Act for exceeding the Max 7-DADM of 18°C for salmon and trout rearing and migration. The reach is also listed as water quality limited for dissolved oxygen during salmonid spawning (January 1 to May 1), and for flow modification.

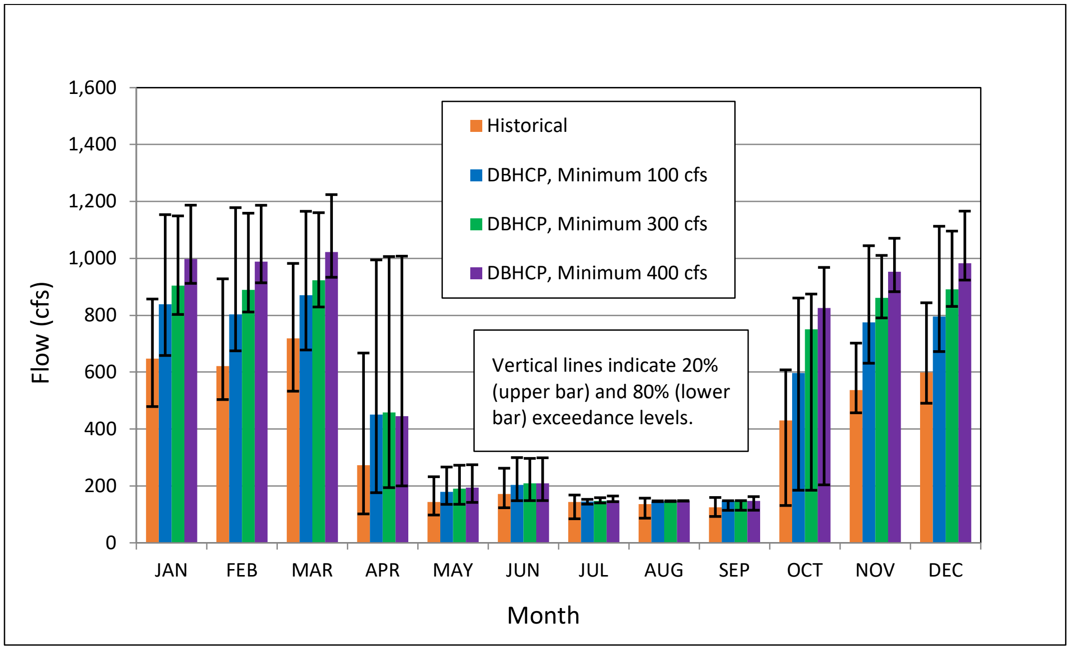

Figure 8-2. **Monthly medians of daily average flows in the Deschutes River below the confluence with Tumalo Creek (RM 160) for historical and DBHCP projected conditions (analysis years 2000-2018).** Sources: OWRD 2020a, 2020b; Reclamation 2020a.

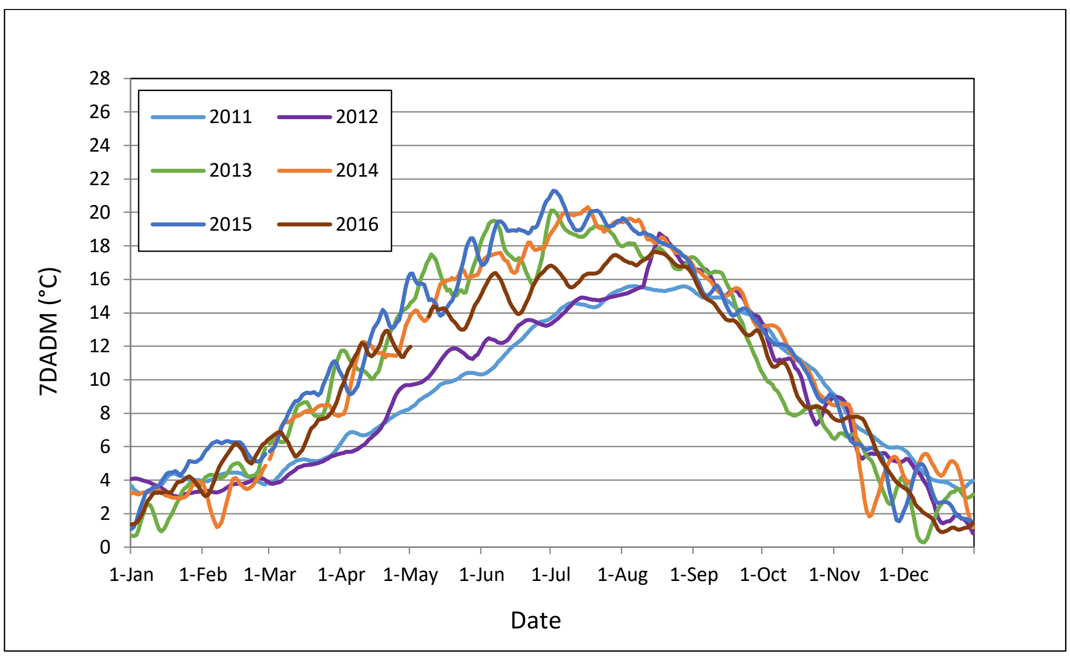

Figure 8-3. **Seven-day averages of daily maximum water temperatures (7-DADM) in the Deschutes River below Bend (RM 164) from 2011 through 2016.** Source: Reclamation 2017**.**

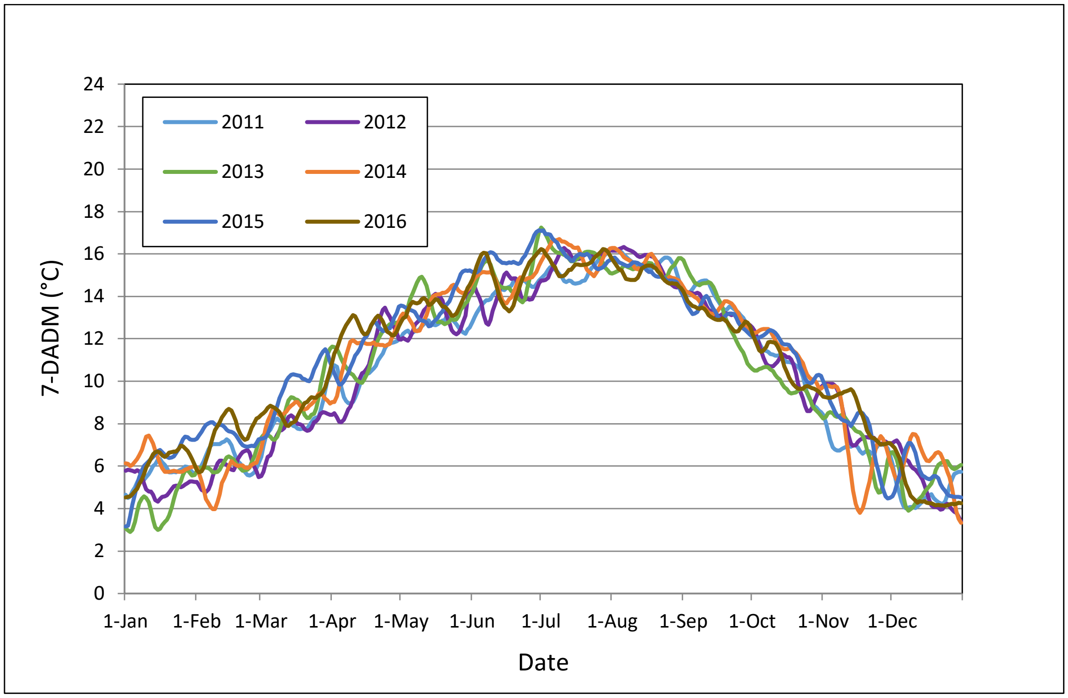

Figure 8-4. Seven-day averages of daily maximum water temperatures (7-DADM) in the Deschutes River near Culver (RM 120) from 2011 through 2016. Source: USGS 2019**.**

Bull Trout Foraging

Mid-summer water temperatures in the Middle Deschutes River currently exceed the preferred range for bull trout foraging at the upstream end of the accessible reach (Big Falls), but remain within the preferred range for adults and subadults at the downstream end. These conditions will not change as a result of the DBHCP. Surface water that enters this reach from upstream are warm and generally exceed the preferred maximum of 16.0°C from April through August (Figure 8-3). However, cool groundwater discharge within the reach results in 7-DADM values at the downstream end that are mostly below 16.0°C the entire summer (Figure 8-4).

The ODEQ Heat Source model (Watershed Sciences and MaxDepth Aquatics 2008) was used to estimate peak summer water temperatures within this 12-mile reach (Figure 8-5). Historical flows in the Heat Source analysis are based on the 2001 instream water rights of 109 cfs at RM 159 (downstream of the confluence with Tumalo Creek). Current (DBHCP) flows are based on the existing instream water rights of 143 cfs at RM 159. Natural flows were defined by ODEQ to be 1,347 cfs. Three general trends can be observed in the Heat Source results. First, water temperature increases considerably between RM 164 and Big Falls at RM 132 due to solar radiation and conductive heat exchange, even though inflow from Tumalo Creek at RM 160 has a cooling effect. Second, water temperature decreases downstream of RM 132 as a result of cool groundwater accretion and surface inflow from Whychus Creek. Noticeable decreases in temperature at RM 132.1, 130.5, 124.8 and 124.0 indicate the effects of groundwater discharge and surface inflow. Third, current and historical temperatures are higher than natural temperatures for the first 2 miles below Big Falls, but comparable to or lower than natural temperatures in the remaining 10 miles downstream to Lake Billy Chinook. The river currently undergoes more cooling within this reach than it did under natural conditions because the current flows are lower than natural flows and thus influenced more by the cold groundwater that is discharged within the reach. Natural flows are high but warm, and the cold groundwater is less able to lower the temperature of the water as it moves downstream. The predicted Max 7-DADM for natural flow is below 18°C at Big Falls, but it never drops to 16.0°C anywhere in the reach. The Max 7-DADM for the current and future conditions is nearly 22°C at Big Falls, but it cools to less than 16.0°C downstream of RM 124.8. The increase in flow from 109 cfs historically to 143 cfs currently (and under the DBHCP) produced cooler water at the upstream end of this reach but warmer water at the downstream end.

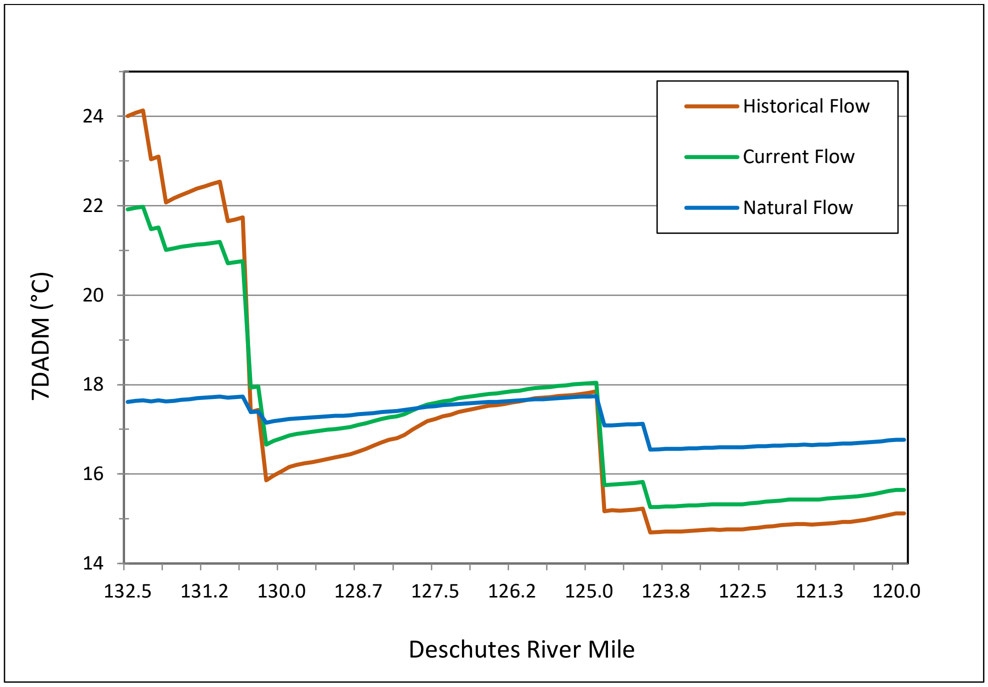

Figure 8-5. Heat Source predictions of the annual maximum of the 7-day average of daily maximum water temperatures (Max 7-DADM) for the Deschutes River between Big Falls (RM 132.2) and Lake Billy Chinook (RM 120.0).

The historical temperature data and Heat Source model results suggest the 4.8 miles of the Deschutes River between RM 124.8 and Lake Billy Chinook are suitable for bull trout adult and subadult foraging throughout the year, but too warm for juvenile bull trout from April through September. The reach upstream of RM 124.8 is most likely too warm for all life stages of bull trout from May through September. These temperature conditions are not expected to change as a result of the DBHCP.

The DBHCP will result in little change from current flows in the Middle Deschutes River during the irrigation season (compare the 100 cfs scenario to the 300 cfs scenario for April through September in Figure 8-2), but it will increase flows during the storage season from October through March when temperatures will be suitable for foraging by all life stages of bull trout. These higher winter flows are anticipated to have a beneficial effect on bull trout foraging by increasing the total area of usable habitat.

Bull Trout Spawning, Incubation and Rearing

Bull trout are not known to spawn or rear in the Middle Deschutes River between Lake Billy Chinook and Big Falls, and they are not expected to do so during the term of the DBHCP. The covered activities will have no effect on bull trout spawning, incubation or early juvenile rearing in this reach of the river.

Net Effect on All Life Stages of Bull Trout in the Middle Deschutes River

The overall effect of the DBHCP on bull trout in the Middle Deschutes River will be positive. Habitat conditions during the summer will remain unchanged and foraging opportunities for adults and subadults that were provided by historical irrigation activities will persist. These conditions did not exist prior to irrigation diversions because water temperatures were naturally too high during the summer. During the winter, increased flows under the DBHCP may result in an improvement from current conditions for foraging adults, subadults and the small number of juveniles that are present. The DBHCP will have no effect on bull trout spawning, incubation or rearing, as these life stages are not present in the mainstem Middle Deschutes River.

8.1.2 Whychus Creek

Overview

Bull trout do not spawn or rear in Whychus Creek, but adults and subadults from the Metolius River subbasin populations may forage in Whychus Creek. During the winter bull trout could potentially forage upstream as far as the natural migratory barrier at RM 37.1. In the summer, bull trout use of Whychus Creek is most likely limited by high water temperatures and the species is unlikely to move upstream of Alder Springs at RM 1.4 until water temperatures decline in the fall. The covered lands extend upstream in Whychus Creek to RM 26 to include a small diversion operated by one TSID patron, but the vast majority of TSID's effects on flow and water temperature occur downstream of the District's main diversion at RM 24.2. The area of analysis for bull trout in Whychus Creek is therefore the 24.2 miles from the TSID diversion to the mouth, although there is limited evidence of bull trout presence upstream of RM 2.41.

There are no storage reservoirs on Whychus Creek, and no covered activities other than the main diversion at RM 24.2 and the patron diversion at about RM 26. Water is diverted from March through November, but diversion rates are highest during the peak irrigation season of April to October.

The historical hydrology of Whychus Creek is described in Section 4.5, *Whychus Creek*. The effects of the DBHCP on hydrology are presented in Section 6.4.3.4, *Effects of DBHCP Measure WC-1 on Whychus Creek Hydrology.* Natural flows in Whychus Creek vary considerably on a seasonal basis, with peak flows during spring snowmelt and winter storms and low flows in late summer. Historically, irrigation diversions substantially reduced summer flows in the lower 24 miles of the creek. In recent years, however, conserved water projects by TSID and others have resulted in instream water rights of over 31 cfs. The new instream rights are reflected in DBHCP flows at Sisters (Figure 8-6), although flows at Sisters are consistently lower than flows immediately below the TSID diversion, where the water right is measured, due to channel losses and irrigation diversions between the two points. The net effect of the new instream rights is that median and 80 percent exceedance flows in the lower 24 miles of Whychus Creek will be higher throughout the irrigation season than they were historically. The apparent decreases in median flows in Whychus Creek during March, October and November under the DBHCP are the result of TSID diversions in these months being artificially low for recent historical conditions (2000 through 2017) due to canal piping projects that prevented TSID from diverting water. These reduced diversions increased the historical stream flows shown in Figure 8-6. Now that piping is completed, TSID will return to its normal practice of diverting water from March through November and Whychus Creek flows will return to levels similar to those that occurred prior to 2000.

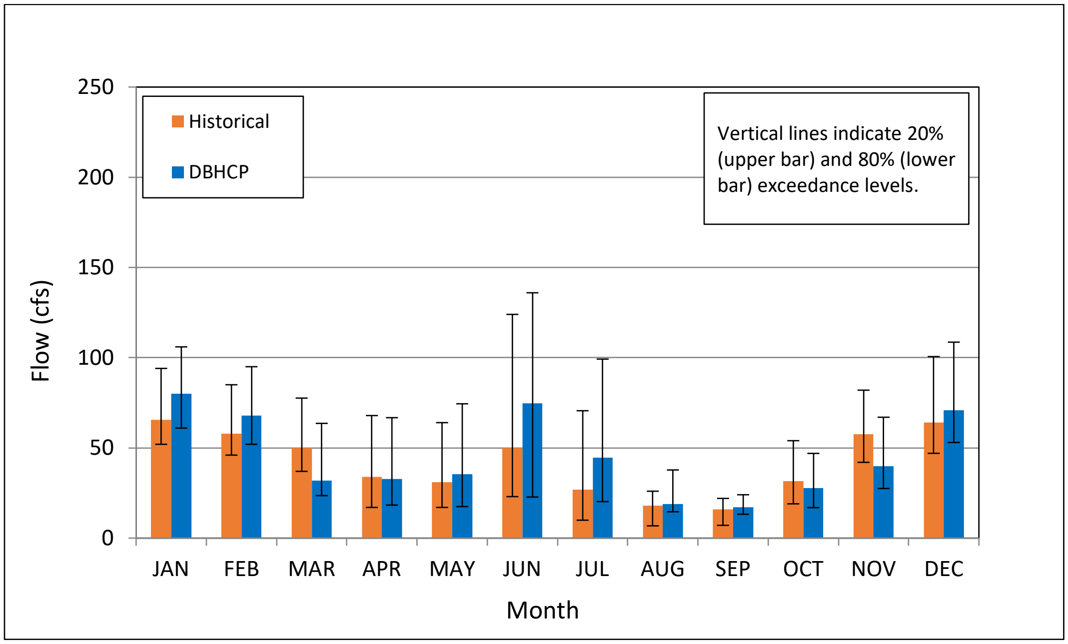

Figure 8-6. Monthly medians of daily average flows for historical conditions (reported) and DBHCP conditions (projected) in Whychus Creek at Sisters (OWRD Gage 14076050). Sources: OWRD 2020c; Reclamation 2020a.

Historical water temperature conditions in Whychus Creek are summarized in Section 4.5, *Whychus Creek* and water temperature conditions under the DBHCP are described in 6.4.3.5, *Effects of DBHCP Measure WC – 1 on Whychus Creek Water Temperature*. Summer temperatures in Whychus Creek generally increase with downstream distance until a cooling effect is provided by groundwater discharge at Alder Springs (RM 1.4). Peak summer temperature (Max 7-DADM) has generally been less than 18°C upstream and immediately downstream of the TSID diversion at RM 24.2 (Figures 8-7 and 8-8), but frequently over 18°C downstream from the diversion to Alder Springs (Figures 8-9 and 8-10), particularly in years of low instream flow. Summer water temperatures have decreased over the past decade due to the establishment of instream water rights, but 7-DADM temperatures as high as 24.1°C were reported at RM 6.0 in 2015 (Figure 8-7).

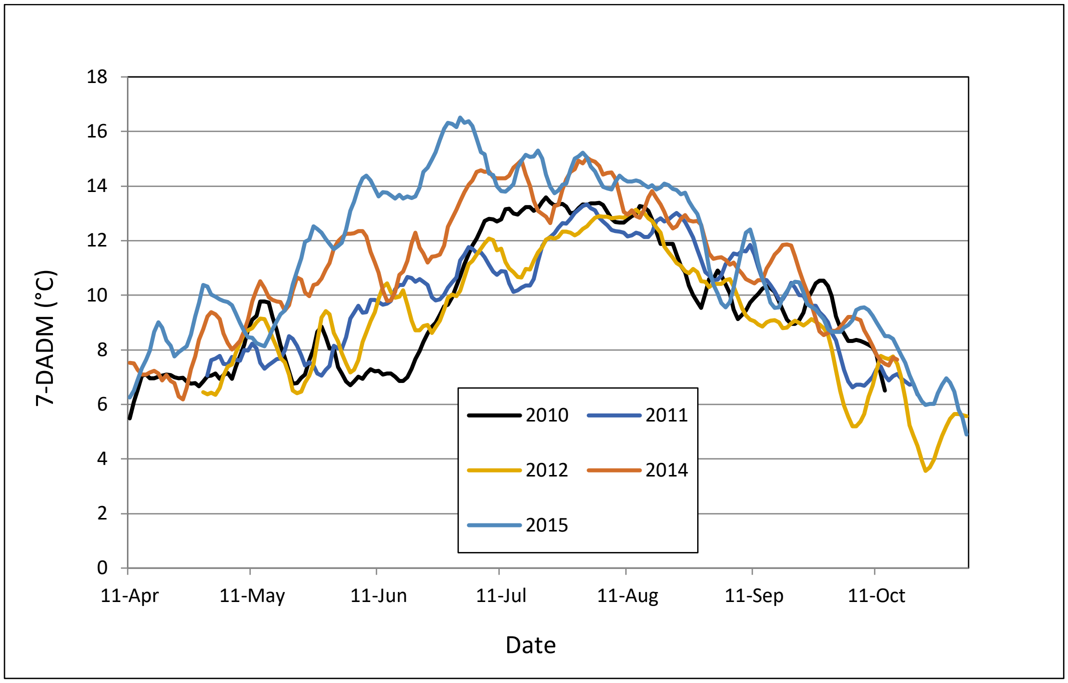

Figure 8-7. Seven-day averages of daily maximum water temperatures (7-DADM) in Whychus Creek upstream of Three Sisters Irrigation District Diversion at OWRD Gage 14075000 during the irrigation season. Source: UDWC 2016.

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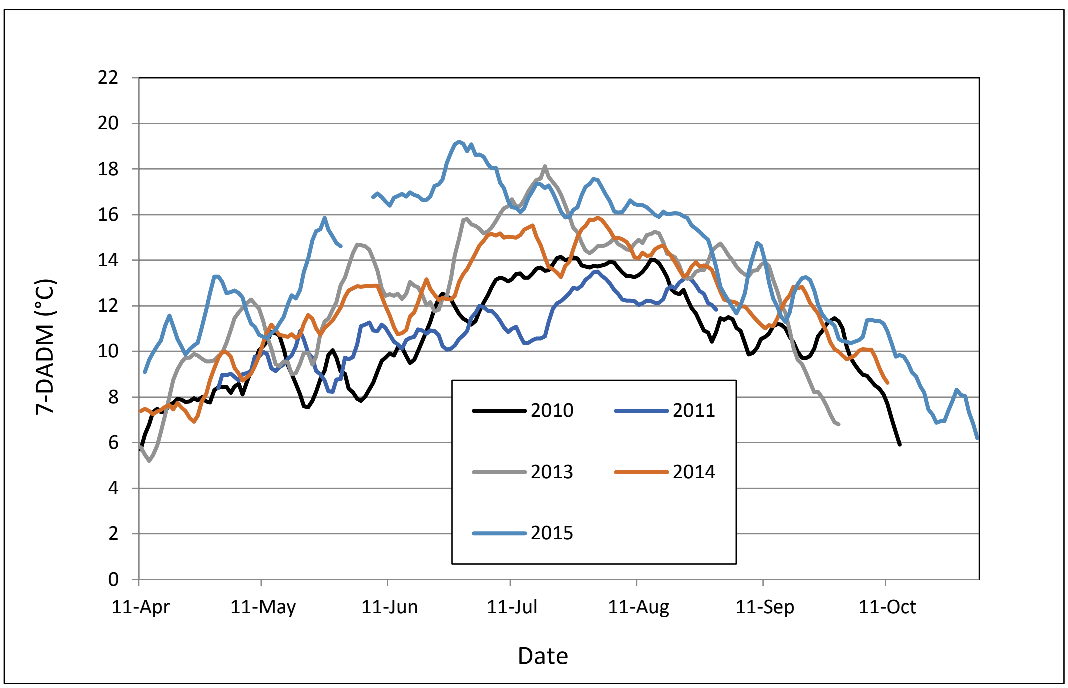


Figure 8-8. Seven-day averages of daily maximum water temperatures (7-DADM) in Whychus Creek downstream of Three Sisters Irrigation District Diversion at Forest Road 4606 during the irrigation season. Source: UDWC 2016**.**

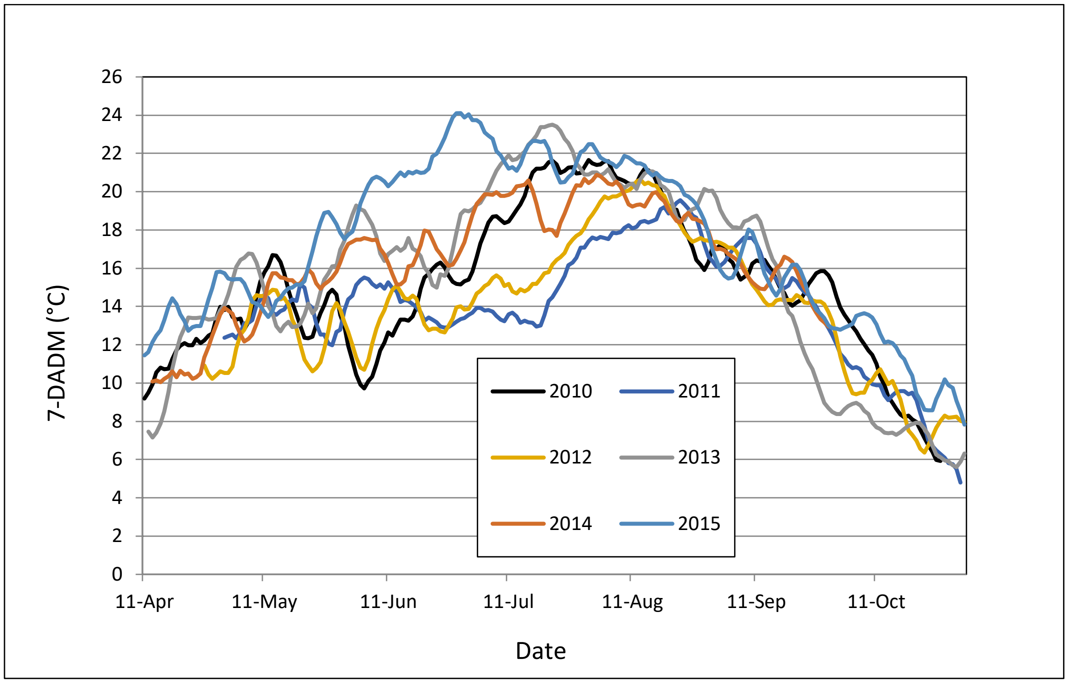


Figure 8-9. Seven-day averages of daily maximum water temperatures (7-DADM) in lower Whychus Creek at Forest Road 6360 (approximate RM 6.0) during the irrigation season. Source: UDWC 2016.

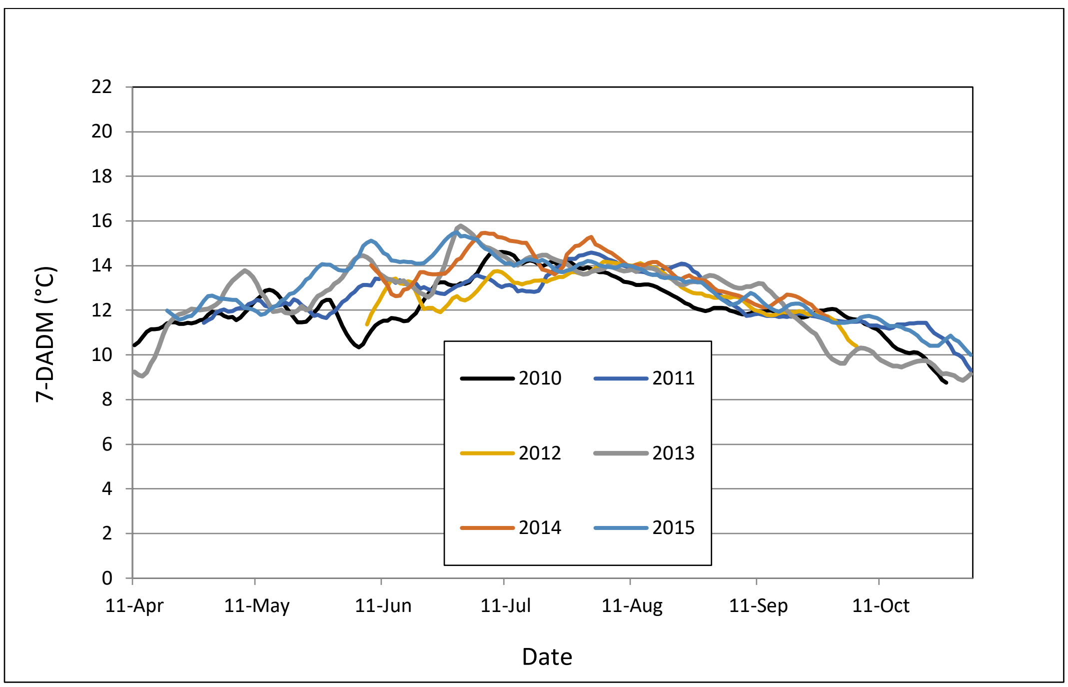


Figure 8-10. Seven-day averages of daily maximum water temperatures (7-DADM) in Whychus Creek near the mouth (RM 0.25) during the irrigation season. Source: UDWC 2016.

Water temperatures in Whychus Creek under historical and DBHCP conditions were compared using a regression equation developed by Mork and Houston (2016) to predict 7-DADM for the warmest portion of the creek (RM 6.0) at the warmest time of year (July). The new instream water right of 31.18 cfs below the TSID diversion, which equates to an estimated 23.18 cfs at Sisters, will result in a Max 7-DADM at RM 6.0 in July of 20.42°C (Table 8-2). This is 3.7°C lower than the recent historical Max 7-DADM at RM 6.0 reflected in Figure 8-9. The DBHCP minimum flow of 20 cfs below the TSID diversion (estimated 12 cfs at Sisters) will result in a Max 7-DADM at RM 6.0 of 22.10°C, which is 2.0°C lower than the historical Max 7-DADM in Figure 8-9. Whychus Creek is listed as water temperature limited under Section 303(d) of the Clean Water Act for exceeding the year-round Max 7-DADM of 18°C for salmon and trout rearing and migration from the mouth to RM 40.3 (ODEQ 2017).

Table 8-2. Predicted maximum 7-day average of daily maximum water temperature (7-DADM) at River Mile 6.0 in Whychus Creek under natural, historical and future (DBHCP) conditions.

Flow Condition	Flow at OWRD Gage 14076050 in Sisters, OR	Max 7-DADM at River Mile 6.0
Unregulated (Natural) Median Flow	155 cfs	15.56°C
Unregulated (Natural) Minimum Flow	71 cfs	17.56°C
Historical Median Flow	27 cfs	20.03°C
Historical Minimum Flow	2 cfs	26.68°C
DBHCP Median Flow	45 cfs	18.72°C
DBHCP Instream Water Rights [1]	23.18 cfs	20.42°C
DBHCP Minimum [1]	12 cfs	22.10°C

Note:
[1] The instream water rights of 31.18 cfs and minimum flow of 20 cfs described in Conservation Measure WC-1 are both measured directly downstream of the TSID diversion at RM 24.2. Channel losses estimated between the TSID diversion and Gage 14076050 at Sisters are assumed to reduce instream flow by 8 cfs during July.

Bull Trout Foraging

Foraging habitat for bull trout in Whychus Creek will not change as a result of the DBHCP. From October through April, water temperatures will be suitable for adult and subadult foraging (7-DADM ≤16°C) throughout the entire analysis reach, as indicated by historical data for the warmest point in the reach at RM 6.0 (Figure 8-9). By mid-May, however, the 7-DADM may exceed 16.0°C at RM 6.0, and by mid-July it will likely exceed 18°C on a regular basis. The potential for water temperatures in excess of 16.0°C will persist through September in most years. Some short segments of the creek between the TSID diversion and Alder Springs may be below 16.0°C at times during the summer, but consistently warm waters for several miles upstream and downstream of RM 6.0 will create a temperature barrier that will discourage bull trout from moving upstream. For most of the summer, only the 1.4 miles of Whychus Creek downstream of Alder Springs will be suitable and accessible to foraging bull trout.

Peak summer temperatures (Max 7-DADM) for the analysis reach were also estimated with the Whychus Creek Heat Source model (Watershed Sciences and MaxDepth Aquatics 2008; ODEQ 2014). The model was run for natural flows, historical flows and DBHCP flows (Figure 8-11). Natural flows were simulated by ODEQ (2014) for the period from July 25 to August 16, 2000. Historical flows are actual flows for the same period. The DBHCP flows represent the current instream water rights of 31.18 cfs and the minimum flow of 20 cfs that will be provided when natural flows are insufficient to simultaneously meet instream and irrigation water rights. While at least 20 cfs will be present in all years, the full water right of 31.18 cfs or more will be present in many years due to the corresponding reduction in TSID's irrigation water rights and the addition of temporary instream leases funded by TSID according to Measure WC-2.

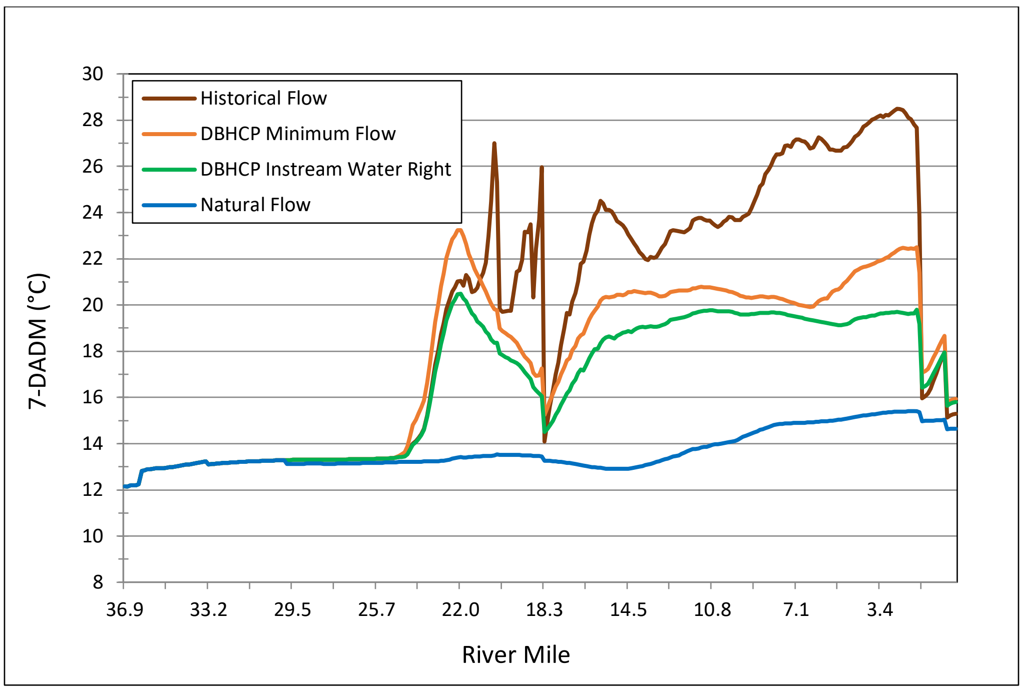


Figure 8-11. Heat Source predictions of the annual maximum of the 7-day average of daily maximum water temperatures (Max 7-DADM) for the anadromous reach of Whychus Creek.

The contrast between historical flows and DBHCP flows in Figure 8-11 illustrates the benefits of conserved water projects that have occurred since 2010. Prior to the reduction in TSID's water rights and establishment of permanent instream rights, flows at Sisters could be less than 3 cfs and the Heat Source predicted Max 7-DADM could exceed 28°C. With an instream flow of 31.18 cfs, which can be expected to occur in many summers, the Heat Source predicted Max 7-DADM is 20.5°C. At the minimum instream flow that will occur during low natural flows, the predicted Max 7-DADM can reach 23.2°C. The additional instream flow will have a cooling effect, but the 7-DADM between the City of Sisters (approximate RM 21) and Alder Springs (RM 1.4) will still be above 16.0°C for most of the summer. Downstream of Alder Springs, cold groundwater discharge will provide suitable foraging conditions for bull trout during the summer.

The total area of bull trout foraging habitat in Whychus Creek will increase slightly under the DBHCP. During the irrigation season, the lower 1.4 miles of creek with suitable water temperatures will experience slightly higher flows (Figure 8-6). Outside the irrigation season, the instream rights of 31.18 cfs will reduce stock water diversions in March, October and November from historical levels for all 24.2 miles downstream of the TSID diversion. From December through February, no diversions will occur and natural flows will prevail.

Bull trout that forage upstream in Whychus Creek as far as the TSID diversion at RM 24.2 will have unimpeded access for another 12.9 miles upstream due to the recent construction of the passable diversion structure. The potential for entrainment into the diversion will also be minimized by the maintenance of fish screens as required by Measure WC-3.

Bull Trout Spawning, Incubation and Rearing

Bull trout are not known to spawn or rear in Whychus Creek and they are not expected to do so during the term of the DBHCP. Similarly, juvenile bull trout are not known to utilize Whychus Creek. The covered activities will have no effect on bull trout spawning, incubation or juvenile rearing in Whychus Creek.

Net Effect on All Life Stages of Bull Trout in Whychus Creek

The overall effect of the DBHCP on bull trout in Whychus Creek will be neutral or slightly positive. Current habitat conditions during the summer are improved compared to historical conditions, and foraging opportunities for adults and subadults in the lower 1.4 miles provided by recent conserved water projects will persist under the DBHCP. Median winter flows will improve slightly from historical conditions, but the historical absence of bull trout from most of Whychus Creek during the winter suggests this is not an important source of habitat for the species.

8.1.3 Crooked River Subbasin

8.1.3.1 Crooked River

Overview

Until recently, bull trout had access in the Crooked River only up to Opal Springs Dam at RM 7.2, which is 0.7 mile upstream of the full pool elevation of Lake Billy Chinook at RM 6.5. As part of the ongoing effort to reintroduce anadromous fish in the subbasin, a fish ladder was recently constructed at the dam. The ladder now provides bull trout volitional access upstream as far as Bowman Dam (RM 70.5). The extent to which bull trout will utilize this reach of the Crooked River remains unknown. All spawning and rearing by bull trout upstream of the Pelton Round Butte Project occurs in the Metolius River subbasin, and these activities are not expected to occur in the Crooked River subbasin under any future circumstances. Similarly, summer foraging by adults and juveniles is precluded by naturally high water temperatures upstream of Opal Springs. Seasonal (winter) foraging has been documented up to Opal Springs Dam in recent years and could potentially extend upstream as far as Bowman Dam now that passage is provided.

The lower 70.5 miles of the Crooked River are affected to varying degrees by Reclamation's storage and release of water at Prineville Reservoir. Portions of the lower 56 miles are also affected by diversion of water at OID's Crooked River Diversion (RM 56.5) and NUID's Crooked River Pumps (RM 27.6). Eleven irrigation returns covered by the DBHCP between RM 49.4 and RM 11.9 also affect flows in the Crooked River (see Chapter 3 for a summary of all covered activities on the Crooked River). Reclamation's operation of Prineville Reservoir affects downstream flows year round; flows are reduced along the entire 70.5 miles during the storage season (October to March) and increased in portions of the 70.5 miles during the irrigation season (April to September). The diversions covered by the DBHCP reduce flows during the irrigation season. Irrigation returns contribute to instream flow year round, but the majority of return flow occurs during the irrigation season and for a month or more afterward. Return flows reach the river through named and unnamed surface tributaries as well as shallow groundwater discharge. The river is also affected by multiple irrigation diversions and returns that are unrelated to the DBHCP, including 34 small OID patron pumps between RM 49.8 and RM 38.4. The Crooked River Diversion and Crooked River pumps are screened to prevent entrainment of juvenile salmonids and are designed to allow unimpeded upstream and downstream movement of fish.

The historical hydrology of the Crooked River is presented in Section 4.8, *Crooked River*, *Ochoco Creek and McKay Creek*. The effects of the DBHCP on Crooked River hydrology appear in Section 6.5.3.3, *Effects of DBHCP Measures CR-1 on the Hydrology of the Crooked River*. Natural flows in the Crooked River have a very strong seasonal component (see Figure 4.45). Inflow to Prineville Reservoir (unregulated flow) typically peaks at 2,000 cfs or more during spring snowmelt and drops to nearly zero in late summer. Winter and spring storms in some years can also produce sudden increases to reservoir inflow. Flows downstream of the reservoir (regulated flows) are determined by natural conditions, reservoir operations and irrigation diversions. Flows in the lower Crooked River are generally low in the winter due to natural conditions (low reservoir inflow) and irrigation storage of runoff events, and variable in the summer due to the complex combination of releases, diversions and returns. The 13.5 miles of river between Bowman Dam and Crooked River Diversion have consistent flows of 200 cfs or more during the summer due to the conveyance of irrigation water from the reservoir to the diversions. Downstream of Crooked River Diversion the flow is considerably less and more variable due to the multiple diversions and returns that respond to common weather conditions, but are not operated in a coordinated manner. Low flow conditions (both summer and winter) persist downstream to Osborne Canyon at about RM 13.8, where large influxes of groundwater begin to contribute more than 1,000 cfs to the Crooked River on a consistent basis (Gannett et al. 2001).

Historical water temperature conditions in the Crooked River are summarized in Section 4.8, *Crooked River*, *Ochoco Creek and McKay Creek*. The Crooked River is listed as water temperature limited under Section 303(d) of the Clean Water Act for exceeding the Max 7-DADM of 17.8°C for salmon and trout rearing, as well as for multiple water quality criteria (see Table 4-12).

Bull Trout Foraging

Adult and subadult bull trout from the Metolius River populations could forage in accessible reaches of the Crooked River with water temperatures (7-DADM) of 16.0°C or less. Cold groundwater discharge beginning about RM 13.8 likely provides suitable conditions for bull trout foraging year round, and this will not change under the DBHCP. Seasonal foraging may also occur upstream as far as Bowman Dam when and where water temperatures are favorable. Winter foraging will be possible within the entire 70.5 miles, but summer foraging will be limited over much of the reach by naturally high water temperatures that will not change appreciably under the DBHCP.

The effects of the DBHCP on water temperatures in the Crooked River were estimated by Berger et al. (2019) using the CE-QUAL-W2 water temperature model and projected flows developed with the RiverWare hydrologic model (Reclamation 2019). The hydrologic predictions from 2019 used for the water temperature analysis differ slightly from the 2020 predictions described in Chapter 6 (Reclamation 2020a) due to minor changes in assumptions about the timing of Reclamation's release of storage from Prineville Reservoir for NUID and the timing of NUID's release of storage from Wickiup Reservoir. The assumptions used in the RiverWare model (Reclamation 2019, 2020a) are all within the range of allowable reservoir operations over the next 30 years, however, and both RiverWare runs are thus considered representative of conditions that could exist during implementation of the DBHCP. The differences between the model results are generally quite subtle, indicating that changes in assumptions about future management within the range of allowable options have relatively minor effects on habitat conditions in the Crooked River.

The results of water temperature modeling indicate the cooling effect of Prineville Reservoir will be preserved under the DBHCP and summer water temperatures will continue to be lower than they would otherwise be for several miles downstream of Bowman Dam (Figure 8-12). The benefits of the reservoir will be most apparent in dry years when higher demand for irrigation water results in release of more water and flows downstream of the reservoir are higher. In extremely dry years, however, the demand for water can exhaust availability in the reservoir and flows can become very low (with associated high water temperatures) by late summer. The seemingly counterintuitive increase in water temperatures immediately downstream of Bowman Dam in a wet year (1993) compared to other years is due to that fact that most of the storage in Prineville Reservoir in the spring of 1993 came during a storm event late in the winter. This late inflow overwhelmed the cold water that had been in the reservoir through the winter and resulted in warmer overall temperatures for reservoir outflow.

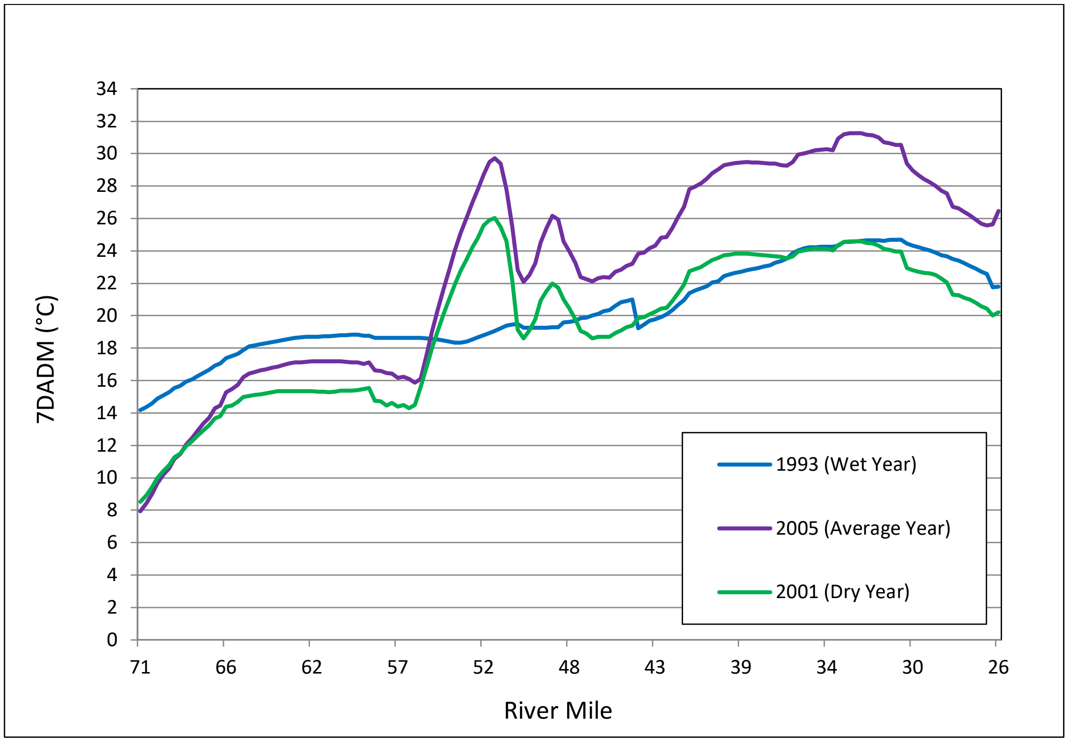


Figure 8-12. Longitudinal profile of predicted 7-day average of daily maximum temperature (7-DADM) in the Crooked River between Bowman Dam (RM 70.5) and Smith Rock (RM 27) in late July under Phase 3 of the DBHCP. Source: Berger et al. 2019**.**

The 13-mile reach from Bowman Dam (RM 70.5) to the Crooked River Diversion (RM 57) will remain below 7-DADM of 16.0°C year round (Figure 8-13) due to the cooling effect of the reservoir. Downstream of the Crooked River diversion, however, the 7-DADM will regularly exceed 16.0°C from May through September, thereby precluding bull trout foraging in most years. In some years the 7-DADM may remain below 16.0°C from the Crooked River diversion to Hydromet Station CAPO (a distance of 9 miles) for portions of the summer, depending on the timing of releases of cold irrigation water from Prineville Reservoir. NUID is expected to purchase up to 10,000 acre-feet of stored water from Prineville Reservoir when the water is available and the District's other sources of water are insufficient. During the early years of DBHCP implementation, water is expected to be regularly available from NUID's other main source of water (Wickiup Reservoir). Consequently, the need to release water from Prineville Reservoir will be less and flows in the 43 miles between the reservoir and the NUID pumps will be less. The lower flow will result in increased water temperatures. Conversely, when the availability of Wickiup Reservoir storage is reduced in later phases of DBHCP implementation, NUID is expected to call for the Prineville Reservoir water more often, and this will reduce the temperature of the water. The benefits of the call for water by NUID will vary depending on the timing of the call. In the hydrologic modeling conducted by Reclamation (2019), it was assumed the call will come earlier in the irrigation season as the availability of Wickiup Reservoir storage decreases in later stages of implementation. This accounts for the differences in summer water temperature between DBHCP phases that can be seen at RM 48 (Figure 8-14). This effect diminishes downstream of RM 48 as the water temperature in the river approaches equilibrium regardless of flow. At RM 28 (Figure 8-15) the difference between DBHCP phases is much reduced.

Overall, the only reaches of the Crooked River with water that is reliably at or below 16.0°C during the summer will be the 13 miles between Bowman Dam and the Crooked River Diversion and the reach between Osborne Canyon and Lake Billy Chinook. Significant discharge of groundwater begins at the lower end of Osborne Canyon at about RM 13.8 (Gannett et al. 2001) and this has a cooling effect on the river. At some point between RM 13.8 and Lake Billy Chinook (RM 6.5) the river becomes consistently cool enough to support summer use by bull trout.

Bull trout use of the 13-mile reach below Bowman Dam is less certain, however, because it will be separated from the lower reach by roughly 48 miles of river with water temperatures well above the tolerance range for bull trout. Fish that enter the upper reach during the winter could possibly remain through the summer, but movement between the lower cool reach and the upper cool reach is unlikely to occur from May through September.

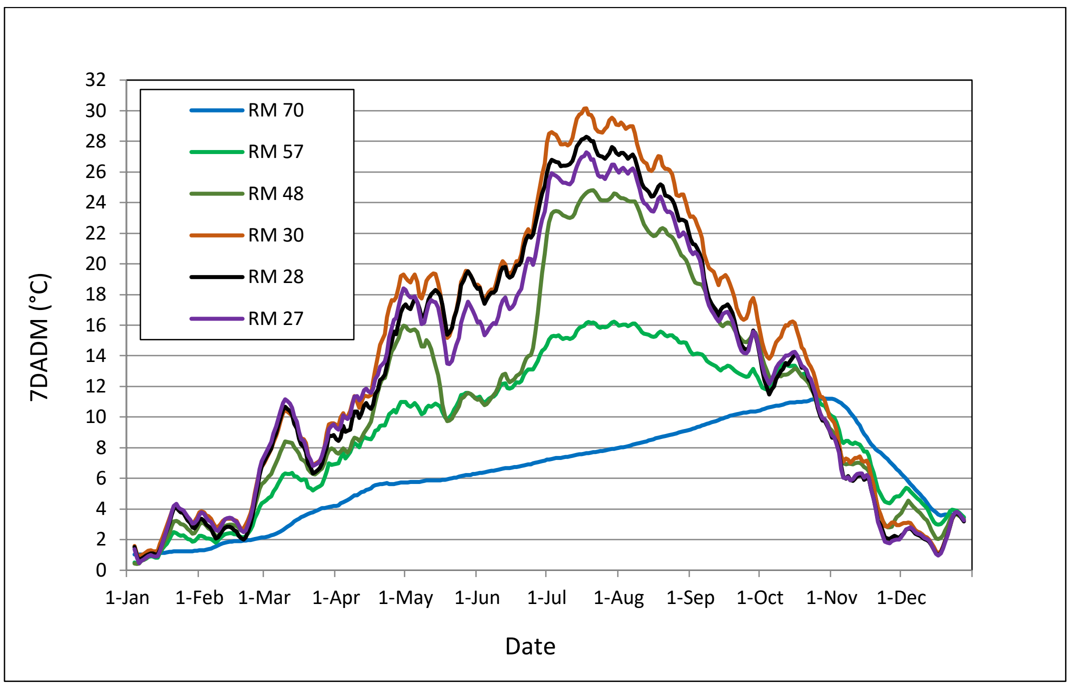


Figure 8-13. Predictions of the 7-day average of daily maximum temperature (7-DADM) in in the Crooked River between Bowman Dam (RM 70.5) and Smith Rock (RM 27) in an average flow year under Phase 3 of the DBHCP. Source: Berger et al. 2019.

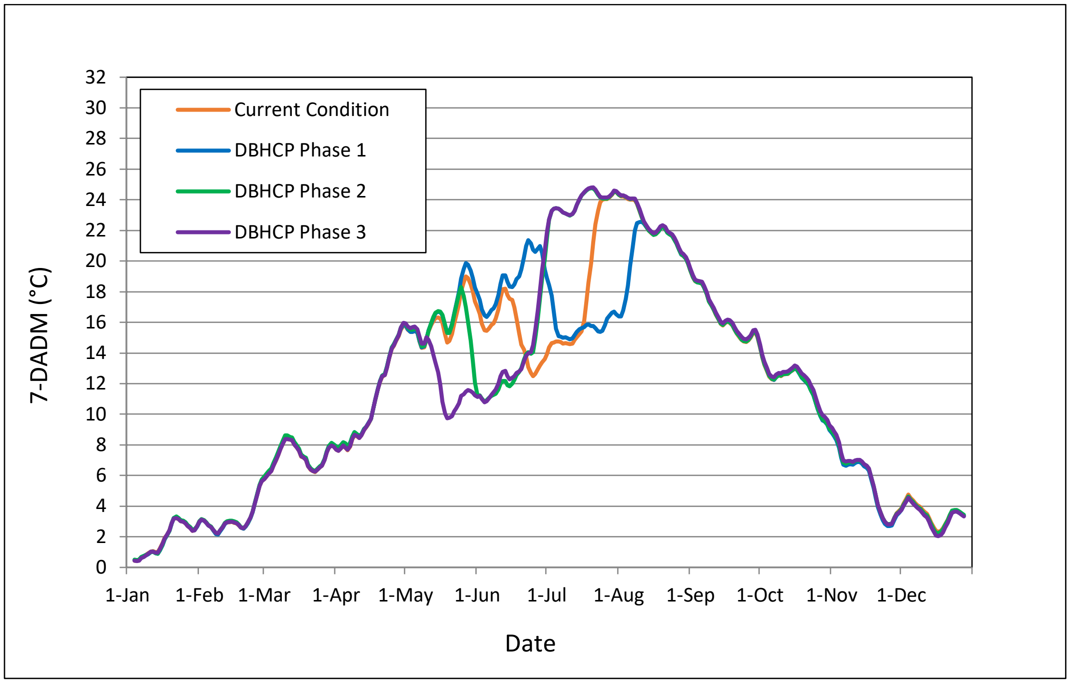


Figure 8-14. Predictions of the 7-day average of daily maximum temperature (7-DADM) under current conditions and the DBHCP in the Crooked River at Hydromet Station CAPO (RM 48) during an average flow year (2005). Source: Berger et al. 2019.

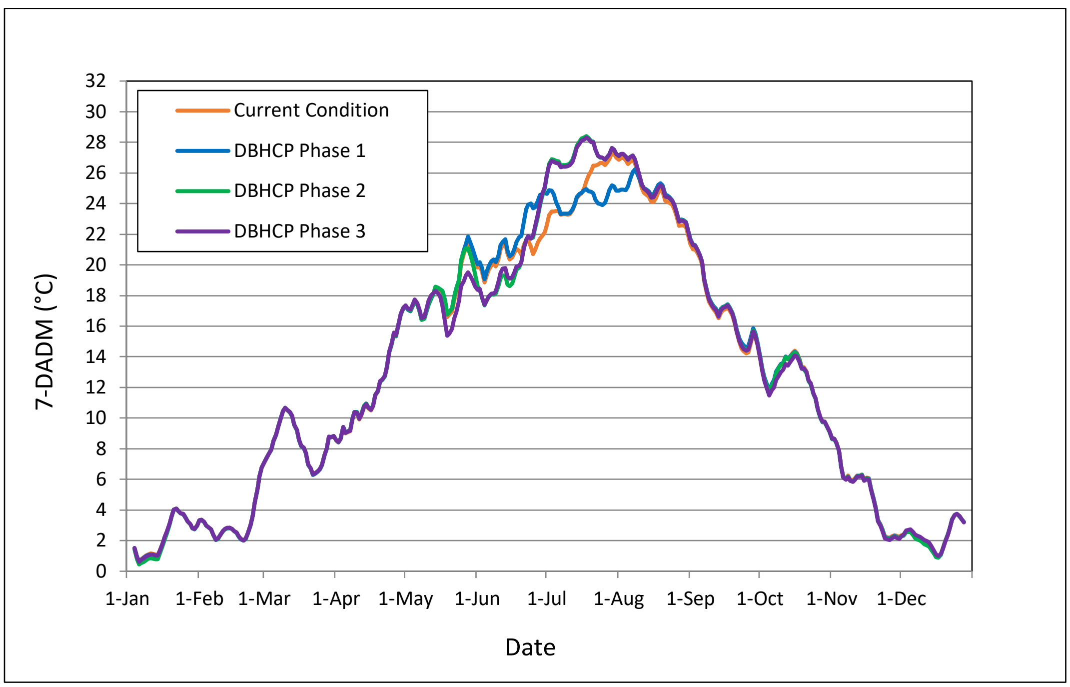


Figure 8-15. Predictions of the 7-day average of daily maximum temperature (7-DADM) under current conditions and the DBHCP in the Crooked River at the NUID pumps (RM 28) during an average flow year (2005). Source: Berger et al. 2019.

Bull Trout Spawning, Incubation and Rearing

Bull trout are not known to spawn or rear in the Crooked River and they are not expected to do so during the term of the DBHCP. Juvenile use of the Crooked River is also unlikely due to the distance from spawning habitat in the Metolius River subbasin and the availability of ample habitat closer to the Metolius River in Lake Billy Chinook. The covered activities will have no effect on bull trout spawning, incubation or juvenile rearing in the Crooked River.

Net Effect on All Life Stages of Bull Trout in the Crooked River

The overall effect of the DBHCP on bull trout in the Crooked River will be neutral or slightly positive. Bull trout use of most of the Crooked River is limited by naturally high water temperatures, and these will not change appreciably under the DBHCP. Adults and subadults may currently forage year round in the Crooked River upstream to Osborne Canyon (RM 13.8), and this will not change as a result of the DBHCP. Upstream of about RM 13.8, however, the river is naturally too warm for bull trout much of the year and this will not change.

During the winter, water temperatures will be suitable for bull trout foraging and migration from the mouth of the river to Bowman Dam (RM 70.5) and small numbers of adults and subadults may move upstream that entire distance. The DBHCP will help ensure a minimum flow of 50 cfs in this reach during the winter, but the dominant effect on winter habitat conditions in the Crooked River will be the use of uncontracted storage in Prineville Reservoir made available for fish and wildlife use by the Crooked River Collaborative Water Security and Jobs Act of 2014 (Crooked River Act). Use of the fish and wildlife water is controlled by Reclamation, and the DBHCP is based on the assumptions that Reclamation will use uncontracted storage and the City of Prineville's 5,100 acre-feet of mitigation storage to maintain at least 50 cfs in the lower Crooked River during the winter, and OID will help ensure that 50 cfs is present in dry winters when the uncontracted storage and 5,100 acre-feet are not enough. Based on Reclamation's recent use of the fish and wildlife water, however, it is likely that a large percentage will be reserved for winter flows and there will be considerably more than 50 cfs in the lower river in most years.

The City of Prineville sewage effluent treatment discharge is not anticipated to have adverse effects on bull trout. All effluent discharges will provide slight increases in instream flow, which will have positive effects on fish habitat. Discharges directly to the Crooked River will occur only during the fall, winter and early spring (November 1 through April 30) when water temperatures in the river are well below the upper thresholds for bull trout. Furthermore, direct discharges will occur at dilution rates of at least 15:1 and thus will have negligible potential to increase or decrease river water temperature.

8.1.3.2 Ochoco Creek

Overview

The recent construction of a fish ladder at Opal Springs Dam allows bull trout to travel up the Crooked River and access lower Ochoco Creek as far as Ochoco Dam at RM 11.2. Naturally high water temperatures in Ochoco Creek preclude the presence of bull trout during the summer, but seasonal foraging by adults and subadults from the Metolius River populations is a possibility during cooler months of the year. There is no evidence that bull trout utilized Ochoco Creek historically (i.e., before Opal Springs Dam was constructed), so the following analysis is based solely on the possibility that bull trout might occur there in the future.

Flows in the lower 11 miles of Ochoco Creek are determined by the storage, release and diversion of irrigation water. The historical hydrology of Ochoco Creek is presented in Section 4.8, *Crooked River*, *Ochoco Creek and McKay Creek*. The effects of the DBHCP on Ochoco Creek hydrology appear in Section 6.5.4.4, *Effects of DBHCP Measures CR-2 on the Hydrology of Ochoco Creek*. The storage of water in Ochoco Reservoir during the winter decreases median flows in lower Ochoco Creek compared to unregulated conditions (see Figure 6-64). The DBHCP will not result in a substantial change in median flows from historical conditions, but it will increase minimum flows. On occasions in the past, the flow in Ochoco Creek dropped to as low as 0 cfs when water was being stored in Ochoco Reservoir or diverted at multiple locations downstream of the reservoir. The DBHCP will eliminate extremely low flows by establishing minimum flows of 3 to 5 cfs (Table 8-3). All diversion structures on Ochoco Creek covered by the DBHCP have screens to prevent entrainment of juvenile salmonids and passage to allow volitional upstream and downstream movement.

Table 8-3. Minimum flows in Ochoco Creek required under Conservation Measure CR-2.

Stream Reach	Minimum Instream Flow Target	
	Irrigation Season	Storage Season
Ochoco Dam (RM 11.2) to D-2 Drain Confluence (RM 6.3)	5.0 cfs	3.0 cfs
D-2 Drain Confluence (RM 6.3) to mouth	5.0 cfs	5.0 cfs

Historical water temperature conditions in Ochoco Creek are summarized in Section 4.8, *Crooked River*, *Ochoco Creek and McKay Creek.* The summer cooling effect of Ochoco Reservoir on lower Ochoco Creek will continue under the DBHCP. As indicated by historical data, the 7-DADM immediately downstream of Ochoco Dam (Figure 8-16) will remain below 16.0°C until late summer in most years. Water will warm rapidly as it moves downstream, however, and the 7-DADM will consistently exceed 16.0°C near the mouth of the creek from June through September (Figure 8-17).

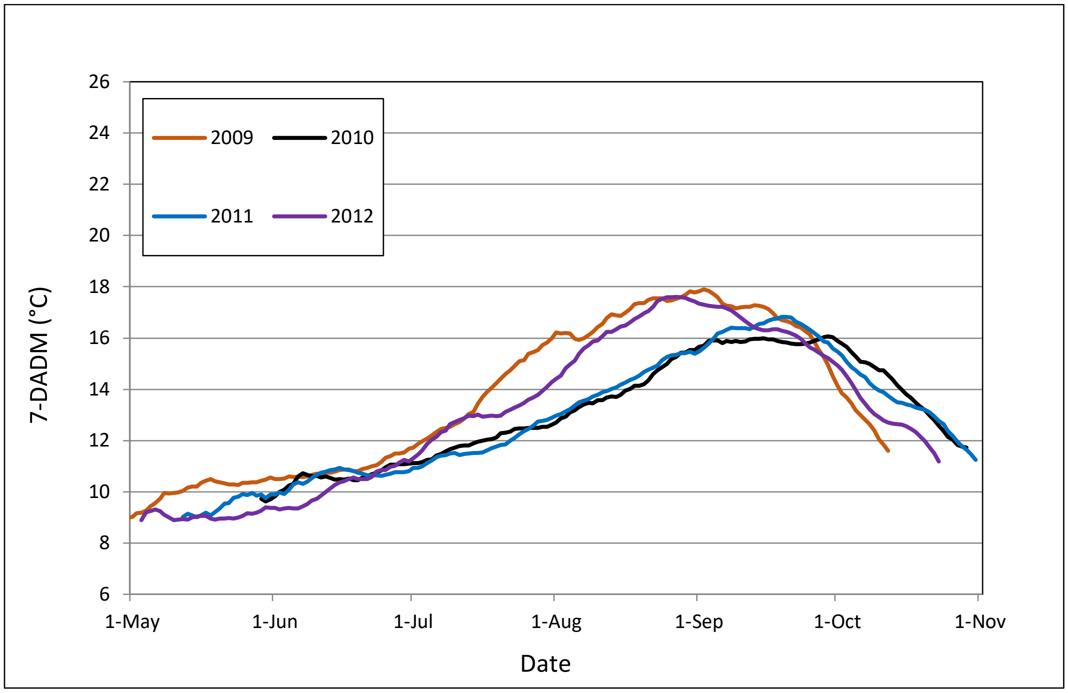


Figure 8-16. Seven-day averages of daily maximum water temperatures (7-DADM) in Ochoco Creek downstream of Ochoco Reservoir (RM 11.0) during the irrigation season. Source: CRWC 2014.

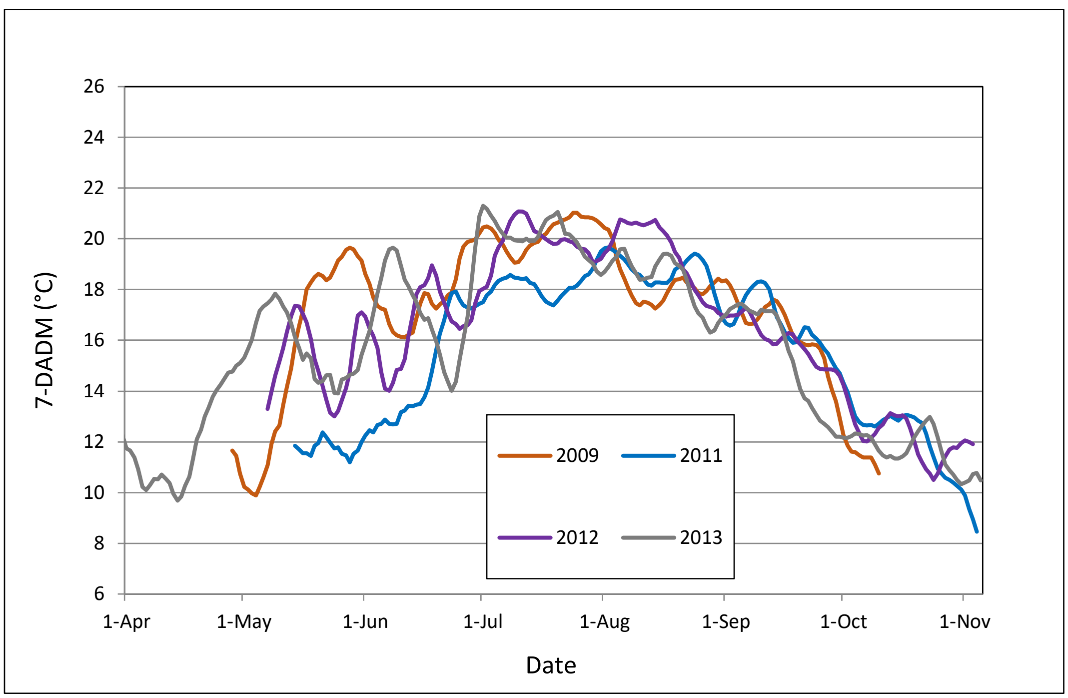


Figure 8-17. Seven-day averages of daily maximum water temperatures (7-DADM) in Ochoco Creek at RM 0.7 during the irrigation season. Source: CRWC 2014.

Bull Trout Foraging

Water temperature conditions will be favorable for bull trout foraging throughout the lower 11 miles of Ochoco Creek from October through April under the DBHCP. At other times of year the 7-DADM may remain below 16.0°C for a short distance downstream of Ochoco Dam, but bull trout will be prevented from accessing this area by several miles of thermal barrier in lower Ochoco Creek and the Crooked River. If bull trout enter Ochoco Creek during the winter and remain in the cooler reach below the dam through the summer, they will still encounter 7-DADM temperatures in excess of 16.0°C by September in at least some years. These conditions are not conducive to consistent or long-term use of Ochoco Creek by foraging bull trout from May through September. It is far more likely that bull trout residing in Lake Billy Chinook will migrate up the Crooked River in late fall or winter when water temperatures are suitable, and some of these may enter lower Ochoco Creek to forage until waters warm again in April. The maintenance of at least 3 cfs in the creek during the winter will provide habitat for the small numbers of bull trout that may move into the creek.

Bull Trout Spawning, Incubation and Rearing

Bull trout are not known to spawn or rear in the Crooked River subbasin and they are not expected to do so during the term of the DBHCP. Juvenile bull trout rearing in Ochoco Creek is also considered highly unlikely. The covered activities will have no effect on bull trout spawning, incubation or juvenile rearing in Ochoco Creek.

Net Effect on All Life Stages of Bull Trout in Ochoco Creek

The overall effect of the DBHCP on bull trout in Ochoco Creek will be neutral. Very small numbers of bull trout are expected to enter Ochoco Creek, and this use would be limited to the winter. The DBHCP will increase minimum winter flows in Ochoco Creek from historical conditions, but the number of bull trout expected to benefit from these flows is quite small. If bull trout choose to forage in Ochoco Creek during the winter, the DBHCP will not prevent or discourage this.

8.1.3.3 McKay Creek

Overview

Bull trout that migrate up the Crooked River will have access to the lower 19.6 miles of McKay Creek. As with much of the Crooked River subbasin, naturally high water temperatures in McKay Creek will preclude the presence of bull trout during the summer. Adult and subadult bull trout with access to McKay Creek could potentially forage there during the cooler months of the year, but other life stages of bull trout are not expected to utilize McKay Creek at any time of year. There is no evidence that bull trout utilized lower McKay Creek historically (i.e., before Opal Springs Dam was constructed) and the following analysis is based on the assumption that bull trout might occur there in the future.

Irrigation activities covered by the DBHCP influence flows in McKay Creek from RM 5.8 (Jones Dam) to the mouth. During the irrigation season water can be diverted from the creek into OID's three main canals and/or spilled into the creek from one of the canals for conveyance downstream to another. The net result of diversion, spilling and conveyance is flows in the lower 5.8 miles of McKay Creek from April through September that are generally higher than flows immediately upstream, but variable from point to point. There is no irrigation storage on McKay

Creek and no diversion outside the irrigation season. Consequently, flows and temperatures in McKay Creek are not affected by the covered activities from October through March. All diversions covered by the DBHCP on McKay Creek are screened to prevent the entrainment of juvenile salmonids and provided with volitional upstream and downstream passage.

The historical hydrology of McKay Creek is presented in Section 4.8, *Crooked River*, *Ochoco Creek and McKay Creek*. The effects of the DBHCP on McKay Creek hydrology appear in Section 6.5.5.3, *Effects of DBHCP Measures CR-3 on the Hydrology of McKay Creek*. Historical data on flows in lower McKay Creek are unavailable. In lieu of historical flows, natural (unregulated) flows in the lower creek were synthesized from historical records for the upper watershed and OWRD estimates of monthly 50 and 80 percent exceedance flows (R2 and Biota Pacific 2014). Unregulated flows were then compared to projected minimum flows under the DBHCP without and with the McKay Creek Water Switch (Figure 8-18). This comparison shows that minimum flows under the DBHCP will meet or exceed unregulated minimum flows throughout the irrigation season. As the McKay Creek Water Switch described in Conservation Measure CR-3 is implemented, minimum flows during the irrigation season may be substantially higher. It is important to note, however, that increased minimum flows associated with the McKay Creek Water Switch will be the result of OID allowing natural flows reaching Jones Dam at RM 5.8 to pass through to the mouth of the creek. If natural flows at Jones Dam are low, as they often are by early summer, the minimum flow in lower McKay Creek may be supported only by water released into the creek by OID, which would result in 5 cfs at the mouth of the creek.

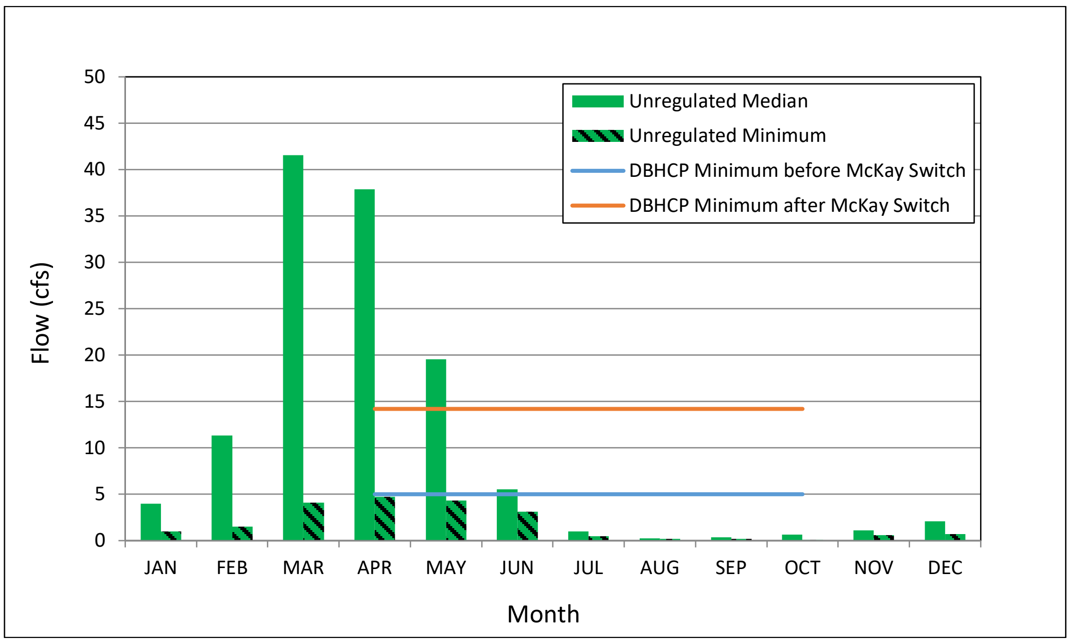


Figure 8-18. Daily average flows at the mouth of McKay Creek for unregulated and DBHCP conditions. Source: R2 and Biota Pacific 2014.

Historical water temperature conditions in McKay Creek are summarized in Section 4.8, *Crooked River*, *Ochoco Creek and McKay Creek*. Historical records of water temperature suggest a moderate and variable change in water temperature over the 5.8 miles of McKay Creek that are affected by covered irrigation activities. During the irrigation season, water upstream of OID

(Figure 8-19) is relatively warm. At the same time, water exiting the District at the mouth of McKay Creek (Figure 8-20) varies from 4°C warmer to 2°C cooler. From October through March, irrigation activities have no effect on water temperatures and the creek is cool or cold.

Bull Trout Foraging

The DBHCP will have minimal effect on bull trout foraging in McKay Creek. Naturally high water temperatures in McKay Creek as well as in several miles of the Crooked River upstream and downstream of McKay Creek from June through September will continue to preclude the presence of bull trout during these months. From October through March, when water temperatures in McKay Creek and the Crooked River may be conducive to bull trout foraging, the creek will be free flowing and will not be affected by the covered irrigation activities in any way. At the beginning of the irrigation season in April and May, portions of lower McKay Creek may remain below 16.0°C and foraging adult and subadult bull trout may remain in the creek. Minimum flows in April and May under the DBHCP will exceed unregulated minimums, but will be less than unregulated medians (Figure 8-18) and could limit the usable area of foraging habitat for bull trout that remain in the creek. By late May, natural warming of the creek will cause bull trout to move to cooler waters in the lower Crooked River until fall.

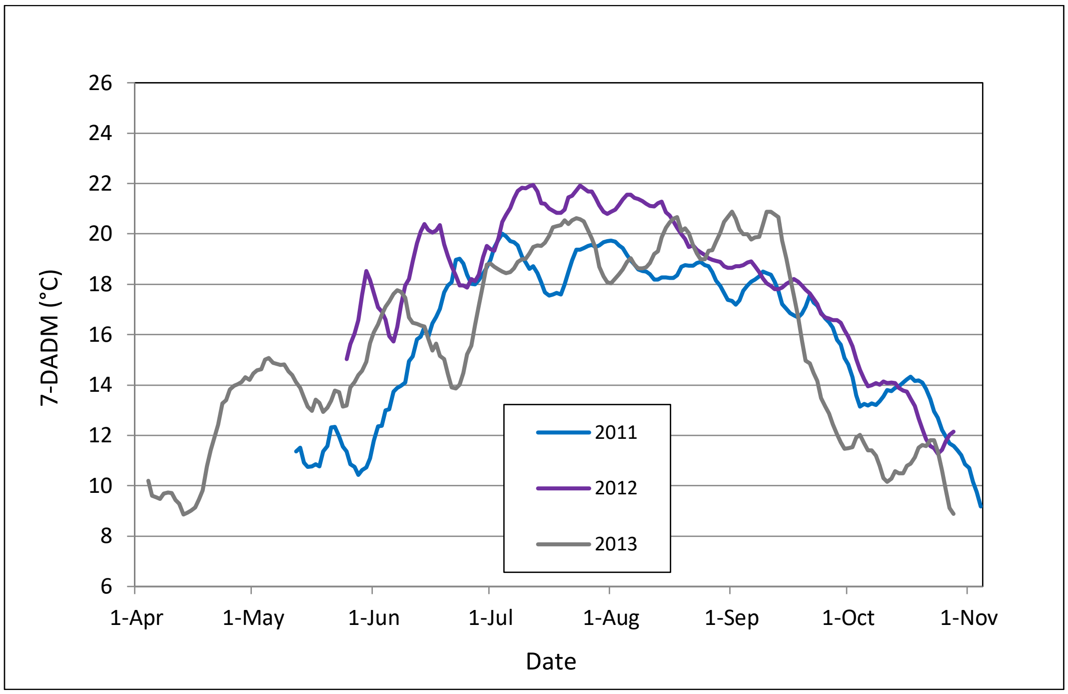


Figure 8-19. Seven-day averages of daily maximum water temperatures (7-DADM) in McKay Creek below Allen Creek (RM 8.3) during the irrigation season.
Source: CRWC 2014.

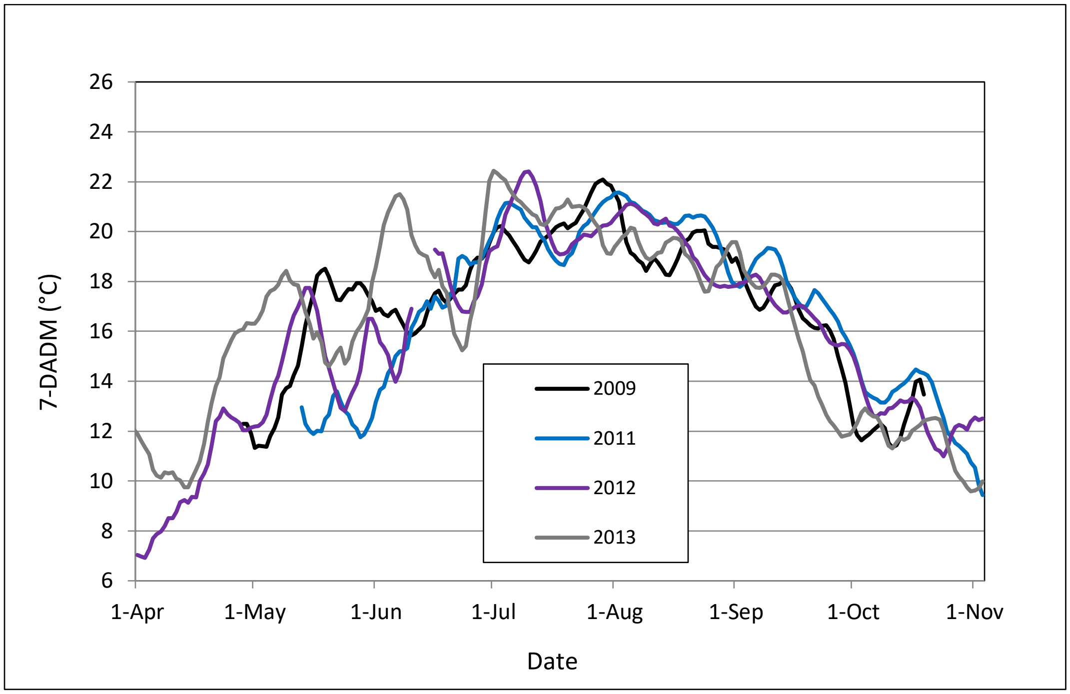


Figure 8-20. Seven-day averages of daily maximum water temperatures (7-DADM) in McKay Creek at US Route 26 (RM 0.4) during the irrigation season.
Source: CRWC 2014.

Bull Trout Spawning, Incubation and Rearing

Bull trout are not known to spawn or rear in the Crooked River subbasin and they are not expected to do so during the term of the DBHCP. Juvenile rearing in McKay Creek is also considered unlikely. The covered activities will have no effect on bull trout spawning, incubation or juvenile rearing in McKay Creek.

Net Effect on All Life Stages of Bull Trout in McKay Creek

The overall effect of the DBHCP on bull trout in McKay Creek will be neutral. Bull trout use of McKay Creek is expected to be limited to small numbers of adults and subadults during the winter. Summer water temperatures conditions in the creek are naturally too warm for bull trout. The covered irrigation activities alter flows in McKay Creek during the summer, but the creek is unaffected by the covered activities during the winter when bull trout could be present.

8.1.4 Lake Billy Chinook

Overview

Bull trout from the Metolius River subbasin populations utilize Lake Billy Chinook for foraging and migration (Ratliff et al. 1996). Adult, subadult and juvenile bull trout at least 2 years old are present in the reservoir year round. Adults and subadults (and possibly age 2+ juveniles) also pass through the reservoir when traveling to winter foraging habitats in Whychus Creek, the Middle Deschutes River and the Crooked River subbasin. Bull trout do not spawn in Lake Billy Chinook or migrate to the reservoir during their first year of life (Ratliff 1992).

Lake Billy Chinook is a hydroelectric reservoir operated as run-of-river (i.e., outflow is approximately equal to inflow on a daily basis). The covered irrigation activities collectively alter inflow to the reservoir, but reservoir volume and water surface elevation are kept constant through operation of Round Butte Dam. The DBHCP will increase inflow to the reservoir compared to historical conditions in all months, as indicated by predicted outflows near Madras (Figure 8-21). During the storage season (October through March) the majority of this increase will originate from the Upper Deschutes River and will be the result of higher minimum flows below Wickiup Reservoir (see Conservation Measure WR-1). During the peak of the irrigation season (May through August) the increase from historical to DBHCP flows is the result of conserved water projects in the Upper Deschutes basin since 2001 that increased the minimum flow at RM 159 from 109 cfs to 143 cfs (see Section 8.1.1, *Middle Deschutes River*). As indicated in Figure 8-5, the increase in surface flow from historical levels between Bend and Lake Billy Chinook during the summer has resulted in an increase in water temperature (7-DADM) of about 0.5°C where the river enters the reservoir. The current (and DBHCP) Max 7-DADM where the Deschutes River enters Lake Billy Chinook is still expected to be less than 16.0°C, however, and water temperatures within the reservoir are expected to remain within the preferred range for bull trout foraging.

Three irrigation returns also contribute flow to Lake Billy Chinook directly at a combined rate of roughly 1.3 cfs during the irrigation season (see Section 3.5.5.6, *Return Flow*). In the driest month of the year (September) the three returns represent less than 0.03 percent of the daily flow through the reservoir, and are not anticipated to have measurable effects on flow, water temperature or water quality.

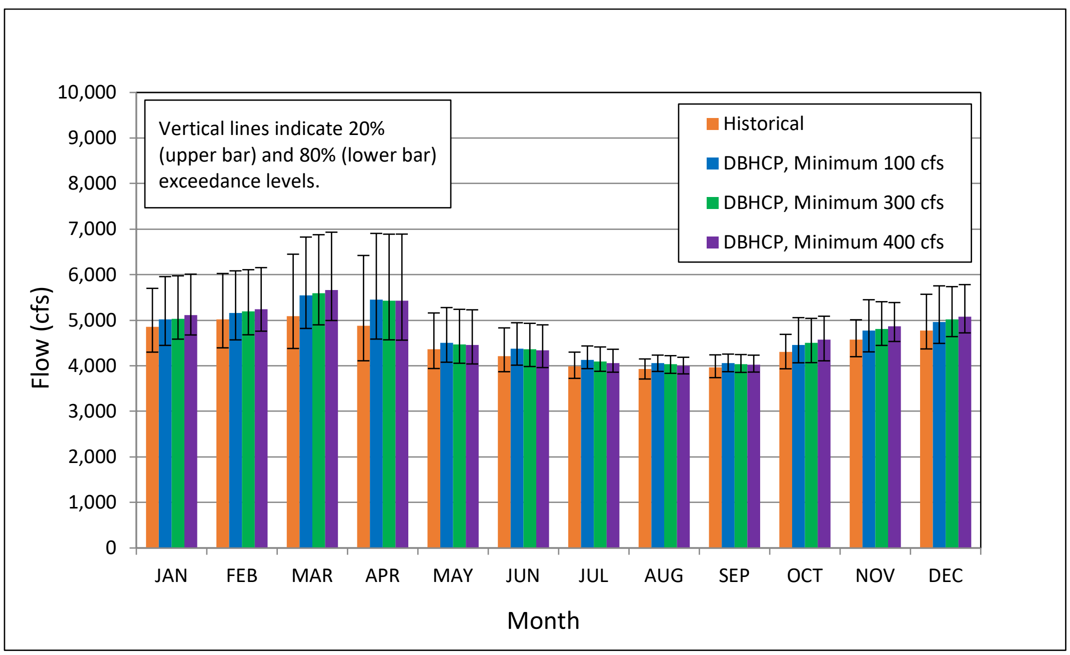


Figure 8-21. Monthly medians of daily average flows in the Deschutes River near Madras (RM 100) from 1981 through 2018. Sources: OWRD 2020d, Reclamation 2020a.

Bull Trout Foraging, Migration and Overwintering

The DBHCP is not anticipated to have an adverse effect on habitat for bull trout foraging, migration and overwintering in Lake Billy Chinook. The total area and location of suitable bull trout habitat within the reservoir will not change under the DBHCP. The increases in reservoir inflow under the DBHCP will occur mostly during the fall, winter and early spring (October through April) when they will have minimal effects on water temperature within the reservoir.

Bull Trout Spawning, Incubation and Rearing

Bull trout do not spawn in Lake Billy Chinook. The covered activities will have no effect on bull trout spawning, incubation or early juvenile rearing in the reservoir.

Net Effect on All Life Stages of Bull Trout in Lake Billy Chinook

The overall effect of the DBHCP on bull trout in Lake Billy Chinook will be neutral. The DBHCP is not expected to improve or degrade habitat for bull trout in the reservoir or impact the population of bull trout residing there.

8.1.5 Lower Deschutes River

Overview

Bull trout that spawn and rear in Warm Springs River and Shitike Creek forage in and migrate through the Lower Deschutes River as adults, subadults and juveniles. Adults and subadults from the Metolius River populations have also been detected in the Lower Deschutes River in recent years due to the installation of fish passage facilities at Pelton Round Butte Project. Bull trout do not spawn in the mainstem of the Lower Deschutes River.

The only covered activities within the Lower Deschutes River are three small irrigation returns with a combined flow of less than 20 cfs between RM 90 and RM 98 (see Table 3.7), but the covered irrigation activities upstream of Lake Billy Chinook reduce the lower river's flows year round. The storage of water in reservoirs in the Upper Deschutes and Crooked River subbasins reduces flows during the winter and the diversion of water at multiple locations reduces flows in the summer.

Historical hydrology and water temperature conditions in the Lower Deschutes River are presented in Section 4.6, *Lower Deschutes River*. As required by the Federal Energy Regulatory Commission (FERC) license issued in 2005, the Pelton Round Butte Project is operated as run-of-river with respect to flow and water temperature. Releases of water from the Project are controlled to maintain flows downstream of the Reregulating Dam (RM 100) within 10 percent (±) of inflows to Lake Billy Chinook (RM 120) on a daily basis, and water temperatures downstream of the Project are managed to approximate temperatures entering Lake Billy Chinook. The upstream storage and diversion of water for irrigation purposes reduce flows into Lake Billy Chinook year round, but the relative effects of the covered activities on the Lower Deschutes River are reduced by the substantial groundwater discharge and tributary inflow to the Deschutes River between Bend and Lake Billy Chinook and the Crooked River below US Highway 97. Since 1981, flows immediately downstream of the Pelton Round Butte Project at RM 100 have rarely dropped below 3,500 cfs and the seasonal difference in flow has typically been less than 25 percent (Figure 8-21). Water temperatures at RM 100 (Figure 8-22) are consistent with temperatures flowing into Lake Billy Chinook (Figure 8-4), and the 7-DADM at

RM 100 remains below 16.0°C year round. Farther downstream, however, the general lack of shade and limited groundwater discharge cause the river to warm. Near Moody (RM 1.4) the 7-DADM regularly exceeds 16.0°C from May through September (Figure 8-23). Bull trout use of the Lower Deschutes River is most likely limited to those months and those locations with suitable water temperatures. For several miles downstream of Madras, temperatures remain favorable for adult and subadult foraging year round. Closer to the mouth of the river, bull trout use is restricted to the cooler months of October through April when temperatures are below 16.0°C.

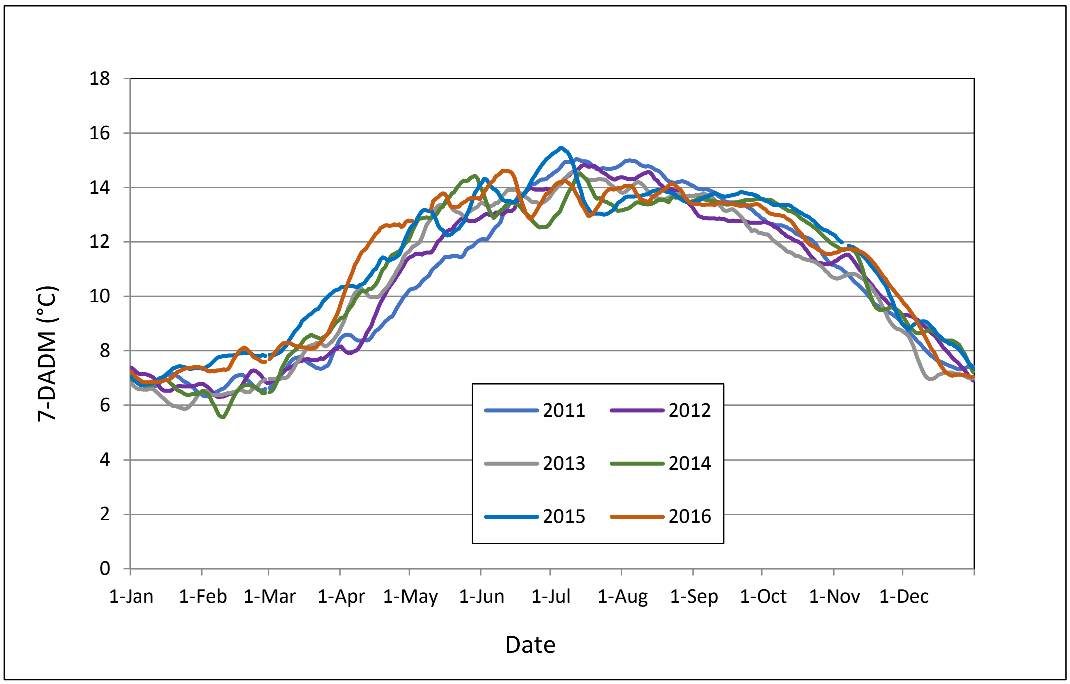


Figure 8-22. Seven-day averages of daily maximum water temperatures (7-DADM) in the Lower Deschutes River near Madras, Oregon (USGS Gage 14092500) from 2011 through 2016. Source: USGS 2017a.

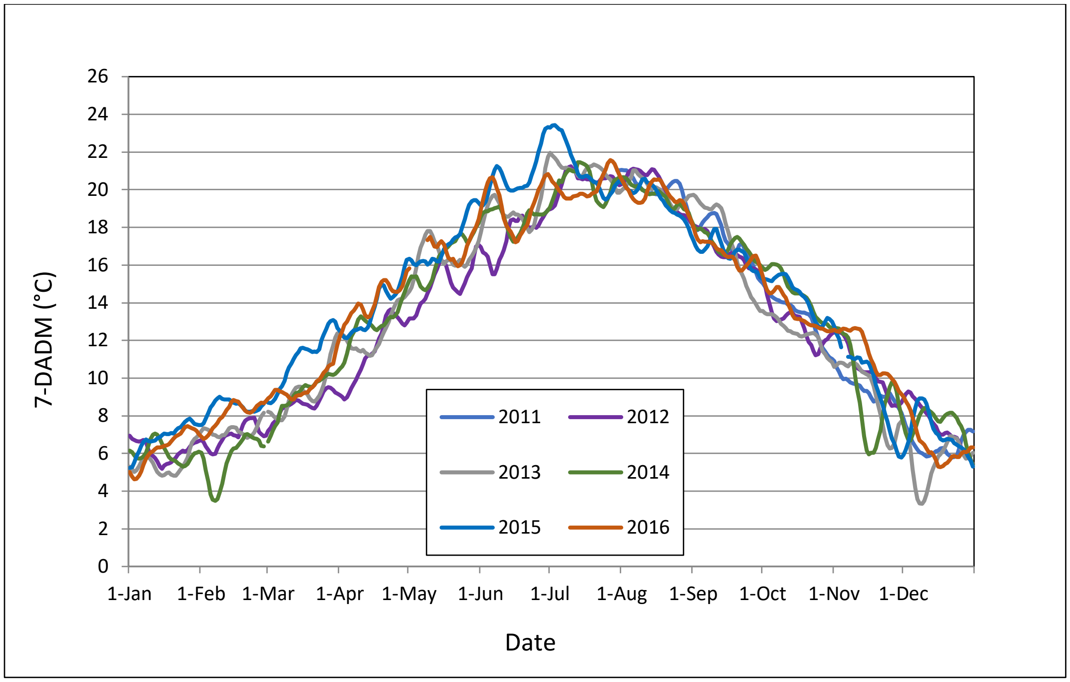


Figure 8-23. Seven-day averages of daily maximum water temperatures (7-DADM) in the Lower Deschutes River at Moody, near Biggs, Oregon (USGS Gage 14103000) from 2011 through 2016. Source: USGS 2017b.

The Lower Deschutes River is identified as water temperature limited under Section 303(d) of the Clean Water Act for exceeding the summer Max 7-DADM of 17.8°C for salmon and trout rearing and migration from RM 46.4 to the mouth (ODEQ 2017). It is also listed as water quality limited for exceeding the Max 7-DADM of 12.8°C for salmon and trout spawning from RM 99.8 to 46.4.

Flows in the lower river under the DBHCP will be higher than historical flows in all months (Figure 8-21). Flow increases during the storage season (October through March) and early irrigation season (April) will be the result of increased flows in the Upper Deschutes River required by Conservation Measure WR-1. The largest increases will be 11 percent in March and April. Flow increases during the irrigation season are increases from historical conditions that have already occurred as the result of conservation projects. Since 2001 the minimum instream flow in the Middle Deschutes River below Bend during the peak of the irrigation season (mid-May to mid-September) has increased from 109 cfs to 143 cfs (minimum flows during shoulder seasons are less than this). Additional increases in the instream water right may occur over the next 30 years, but these will not be the result of the DBHCP and they are not reflected in the DBHCP analysis.

Increases in flow in the Middle Deschutes River during the summer since 2001 have resulted in slight increases in the temperature of water entering Lake Billy Chinook. If the reservoir continues to be managed to match incoming and outgoing water temperatures, the increases from historical to current conditions upstream of the reservoir will be mirrored in the Lower Deschutes River as well. The reason for the increase is related to the limited ability of cold groundwater discharge in the Middle Deschutes River to counteract warm surface water, as described in Section 8.1.1, *Middle Deschutes River*. The Heat Source analysis conducted for the Middle Deschutes River (Figure 8-5) indicates an increase of 0.5°C in the Max 7-DADM in July at Culver from historical to current conditions. A similar increase can be expected downstream of Lake Billy Chinook. However, the 7-DADM at Culver (and Madras) is still expected to remain below 16.0°C year round under the DBHCP.

Bull Trout Foraging, Migration and Overwintering

The DBHCP will result in a small improvement in habitat for bull trout foraging, migration and overwintering in the Lower Deschutes River. Flows will be higher in all months than they were historically (Figure 8-21) and these higher flows will provide corresponding increases in the total area of bull trout foraging habitat. Any changes in water temperature associated with the higher flows will be inconsequential to bull trout. The largest increases in flow will come in March and April when water temperatures at Madras are well below the upper threshold of 16.0°C for adult and subadult foraging and relatively insensitive to an increase or decrease in temperature that might occur with a change in flow. In July, when water temperatures at Madras are at the annual high, the recent increase in flow has increased the Max 7-DADM an estimated 0.5°C, but the 7-DADM at Madras is still expected to remain below 16.0°C year round.

Bull Trout Spawning, Incubation and Rearing

Bull trout are not known to spawn or rear prior to the age of two in the Lower Deschutes River (Brun and Dodson 2001, USFWS 2002) and they are not expected to do so during the term of the DBHCP. The covered activities will have no effect on bull trout spawning, incubation or early juvenile rearing in the Lower Deschutes.

Net Effect on All Life Stages of Bull Trout in the Lower Deschutes River

The overall effect of the DBHCP on bull trout in the Lower Deschutes River will be slightly positive. The total area of usable habitat in the lower river will increase slightly, and water temperatures will remain within the preferred range for adult and subadult bull trout foraging.

8.1.6 Summary of Effects on Bull Trout

The effects of the DBHCP on bull trout are summarized in Table 8-4. The DBHCP will have a positive effect on bull trout, but the magnitude of effect will be small due to the relatively low numbers of bull trout affected by the covered activities. USFWS (2004) concluded that operation of the federal and interrelated non-federal reservoirs in the Upper Deschutes and Crooked River subbasins (Wickiup, Crane Prairie, Prineville and Ochoco reservoirs) and the diversion of water at federal facilities (North Unit Main Canal and Crooked River Diversion) are not likely to adversely affect bull trout. In reaching this conclusion they noted that although the irrigation activities reduce flows in the Middle Deschutes, Lower Deschutes and Lower Crooked rivers, these reductions are insignificant because substantial discharge of cold groundwater downstream of the irrigation activities provides adequate habitat for bull trout. The irrigation activities covered by the DBHCP include one non-federal reservoir (Crescent Lake) and a number of non-federal diversions not specifically identified in the USFWS 2004 assessment; however, the flow conditions evaluated in 2004 were the result of all federal and non-federal irrigation activities upstream of Lake Billy Chinook when USFWS concluded that adequate flows remained to support the physical and biological features essential to the conservation of the bull trout.

Table 8-4. Summary of the effects of the DBHCP on bull trout.

Affected Stream Miles	Effect on Bull Trout			
	Adverse	Not Adverse	Beneficial	Overall
Whychus Creek – 26.0 miles	√	√		Neutral or Slightly Positive
Deschutes River – 132.2 miles		√	√	Positive or Slightly Positive
Crooked River – 70.5 miles	√	√		Slightly Positive
McKay Creek – 5.8 miles	√	√		Neutral
Ochoco Creek – 11.2 miles	√	√		Neutral
TOTAL – 245.7 miles				Neutral to Slightly Positive

Flows in the Middle Deschutes and Lower Deschutes have increased since 2004, and they will increase further under the DBHCP. These increases are expected to improve conditions for bull trout. The lower Crooked River will benefit from the concurrent implementation of the DBHCP and the Crooked River Act to increase flows during the winter when bull trout may be present.

Despite the large numbers of bull trout in Lake Billy Chinook and the Metolius River subbasin, covered waters in other tributaries to the reservoir receive relatively low levels of bull trout use due to their distances from the nearest breeding populations in the Metolius River subbasin (Ratliff et al. 1996), warm summer water temperatures, and blockages to migration. This situation is not expected to change in the future, regardless of the DBHCP. Bull trout may utilize more of the Crooked River during the fall and winter in the future because passage has been provided at Opal Springs Dam, but the extent of this use is uncertain because the Crooked River is naturally too warm for bull trout much of the year. The Deschutes Basin is considered a stronghold for bull trout under current conditions, primarily due to the large population supported by the Metolius River, and any attempts to improve bull trout habitat conditions upstream of Lake Billy Chinook will have limited effect, positive or negative, on the conservation and recovery of the species.

Larger numbers of bull trout utilize Lake Billy Chinook and modest numbers inhabit the Lower Deschutes River, but the relative effects of irrigation activities on the hydrology of these waters are small compared to groundwater discharge and surface inflow to the reservoir from other tributaries like the Metolius River. As noted by USFWS (2004) the existing flows are sufficient to support those bull trout life stages that are present, and additional flows would not likely show significant change in these conditions.

8.1.7 Effects of the DBHCP on Critical Habitat for the Bull Trout

USFWS (2010) designated the following six stream reaches on the covered lands as critical habitat within Bull Trout Critical Habitat Unit 6 (Lower Deschutes Unit).

- The mainstem Deschutes River from the Columbia River to about RM 68, with the exclusion of lands under the management of the Confederated Tribes of the Warm Springs Reservation.
- Trout Creek from the Deschutes River to about RM 2
- Lake Billy Chinook
- The mainstem Deschutes River from Lake Billy Chinook to Big Falls
- The Crooked River from its confluence with Lake Billy Chinook to US Highway 97
- Whychus Creek from the Deschutes River to about RM 6

Maps of these critical habitats are provided in Section 5.1.7, *Critical Habitat*.

USFWS also identified nine primary constituent elements (PCE) of critical habitat for bull trout (Table 8-5). These are, “the physical or biological features essential to the conservation of the species and that may require special management consideration or protection” (USFWS 2010). The effects of the DBHCP on bull trout critical habitat are evaluated by examining anticipated changes from current PCE conditions that may result from DBHCP implementation.

PCE 1 – Groundwater Discharge

All life stages of bull trout require cold waters, and groundwater discharge to surface waters through springs, seeps and subsurface connections is often essential to the maintenance of suitable habitat. This is especially true for bull trout waters during the fall and summer in warm and arid regions such as central Oregon. All surface waters currently utilized by bull trout on the covered lands during the summer are supported by cold groundwater discharge. These groundwater sources include multiple springs along the Deschutes River between Big Falls and Lake Billy Chinook, on Whychus Creek at Alder Springs, and on the Crooked River at Opal Springs. Lake Billy Chinook and the Lower Deschutes River also benefit from substantial inflow of cold water in the Metolius River.

The DBHCP will have no impact on groundwater discharge to bull trout critical habitat. Groundwater discharge will not be altered in any way by the covered activities or the DBHCP, and the effectiveness of groundwater discharge at maintaining cold habitat for bull trout will not be impacted except for a minor increase in water temperature in the Middle Deschutes River (see Section 8.1.1, *Middle Deschutes River*). Recent increases in instream water rights in the Middle Deschutes River have increased the flow of warm water during the summer, while cold groundwater discharge has remained the same. The result is an estimated increase of about 0.5°C in the Max 7-DADM for the Deschutes River at RM 120 over the past 10 years (Figure 8-5). Creation of additional instream water rights in the future could further increase water temperatures in the Middle Deschutes River, but these would be unrelated to the DBHCP.

Table 8-5. Primary constituent elements (PCE) of bull trout critical habitat.

PCE	Description
1	Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.
2	Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.
3	An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.
4	Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.
5	Water temperatures ranging from 2 to 15 °C (36 to 59 °F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; streamflow; and local groundwater influence.
6	In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. A minimal amount of fine sediment, generally ranging in size from silt to coarse sand, embedded in larger substrates, is characteristic of these conditions. The size and amounts of fine sediment suitable to bull trout will likely vary from system to system.
7	A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.
8	Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.
9	Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding (e.g., brook trout); or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

Source: USFWS 2010

PCE 2 – Migration Habitats

Bull trout are a highly mobile species. In the Deschutes Basin, bull trout that spawn in cold tributary streams like the Metolius River, Warm Springs River and Shitike Creek travel long distances to forage as juveniles, subadults and adults in Lake Billy Chinook and the Lower Deschutes River (CTWSRO 2011). Small numbers of adults and subadults from the Metolius River also migrate as far as the covered lands in the Middle Deschutes River, Whychus Creek and lower Crooked River to forage (Ratliff et al. 1996). Migratory movements of bull trout can be interrupted by natural features like waterfalls and man-made barriers such as dams. Because of the species' preference for cold water, migration can also be interrupted by extended reaches of warm water.

The covered activities create no physical barriers to bull trout migration in the Deschutes Basin, and none are expected to be caused by the DBHCP in the future. No storage reservoirs covered by the DBHCP occur within the reaches potentially used by bull trout, and all covered diversion structures in areas of potential use have year-round provisions for volitional fish passage.

No temperature barriers to bull trout migration exist on those portions of the covered lands occupied by bull trout under recent historical conditions, but the species could encounter temperature barriers in the future if it expands its range. In the Crooked River subbasin, naturally high water temperatures will continue to discourage bull trout migration upstream of Osborne Canyon (approximately RM 13.8) for much of the summer, even though fish passage is now provided at Opal Springs Dam. Water temperatures are currently cooler than they would be naturally for 30 miles or more downstream of Prineville Reservoir in the Crooked River and this cooling effect will continue under the DBHCP. Within much of this reach, however, peak summer water temperatures are still well in excess of 16.0°C and bull trout presence during the summer is unlikely. Below this reach, the cooling effect of Prineville Reservoir ceases, summer water temperatures are even higher, and the potential for bull trout presence is remote. Overall, bull trout migration upstream in the Crooked River subbasin will continue to be a function of natural water temperatures and will be limited to the cooler months of October through April (see Section 8.1.3.1, *Crooked River*).

In Whychus Creek, bull trout currently could be present in the lower 1.4 miles during the summer due to the cooling effect of Alder Springs. Upstream of this, however, the summer Max 7-DADM exceeds 18°C and bull trout presence is unlikely (Figure 8-11). In contrast, the 7-DADM in Whychus Creek may have remained below 16.0°C for much of the year under natural conditions. The current condition, which will continue under the DBHCP, is a substantial improvement from historical summer temperatures in Whychus Creek, but conditions will continue to be too warm for bull trout migration and foraging. Use of Whychus Creek upstream of RM 1.4, if it occurs under the DBHCP, will continue to be limited to October through April.

Bull trout migration in Lake Billy Chinook and the Lower Deschutes River will be unaffected by the covered activities and the DBHCP. Water temperatures will remain suitable for bull trout migration and foraging year round in the reservoir and for several miles downstream of Pelton Round Butte Project in the river. Closer to the mouth of the river, however, bull trout presence will likely be limited to cooler months. These conditions will not change as a result of the DBHCP.

PCE 3 – Food Base

Bull trout are opportunistic predators, feeding on insects, amphibians, and other fish, but adult bull trout prefer to eat fish. Juvenile bull trout consume insects and other smaller prey items, until they achieve a size sufficient to transition to feeding on other fish (Bjornn 1991). Stream salmonids, such as mountain whitefish (Knowles and Gumtow 1996), are common prey items for adult bull trout in riverine habitats, but kokanee salmon are the primary food of large adult adfluvial bull trout in the upper Deschutes Basin (Ratliff and Howell 1992).

The DBHCP is expected to increase the food base for bull trout through flow and temperature-related benefits to other salmonid species, particularly steelhead trout. The magnitude of effects of the DBHCP on bull trout food sources will likely be small and proportional to the predicted increase in juvenile steelhead trout production.

PCE 4 – Habitat Complexity

Complex stream habitats typically include a mix of deep pools, runs and shallow riffles, overhanging banks, woody debris, large and small course substrates, and braided stream channels. These conditions are most often found in second order to fourth order streams, or areas with limited anthropogenic influence (Reiman and McIntyre 1993). Most adult and subadult bull trout in the Upper Deschutes Basin reside in Lake Billy Chinook, feeding on pelagic populations of kokanee salmon. Habitat complexity is neither critical nor limiting for bull trout in Lake Billy Chinook. However, complex riverine habitats are necessary for spawning and young-of-year rearing.

The DBHCP is not expected to have an appreciable impact on bull trout habitat complexity. Most of the habitat occupied by spawning adult and rearing young-of-year bull trout is located in the Metolius Basin, which is outside the covered waters. Relatively short segments of the Middle Deschutes River, Crooked River and Whychus Creek may be occupied seasonally by bull trout. These areas will experience higher flows as a result of the DBHCP, which may increase the quantity of available complex habitat. However, the direct effect of the DBHCP on habitat complexity is unknown and likely small.

PCE 5 – Water Temperature

Bull trout are strongly associated with cold waters, and water temperature is typically the limiting habitat factor for bull trout distribution. Optimum water temperatures vary by life stage, with spawning and incubation being the most limiting (Table 8-1). Within the Deschutes Basin, water temperatures suitable for bull trout spawning and incubation are only found in cold, spring-fed headwater streams in the Metolius River subbasin, Warm Springs River and Shitike Creek. These life stages of bull trout do not occur on the covered lands and are not affected by the covered activities.

For purposes of the DBHCP, USFWS (2014a) has interpreted the upper threshold of suitable temperatures for juvenile bull trout rearing to be a 7-DADM of 12°C, and the upper threshold for adult and subadult foraging and migration to be a 7-DADM 16.0°C. Water temperatures below these thresholds can be found throughout the covered lands during the winter. During the summer, however, temperatures suitable for juvenile rearing are generally restricted to the headwater steams outside the covered lands where spawning and rearing occur. Adult and subadult foraging and migration are therefore the only bull trout life stages expected to occur on the covered lands year round. These life stages may be found downstream of Big Falls in the Middle Deschutes River, downstream of Alder Springs in Whychus Creek, downstream of Opal

Springs in the Crooked River, within Lake Billy Chinook, and downstream of the Pelton Reregulating Dam in the Lower Deschutes River. All of these waters are designated critical habitat for bull trout.

Water temperatures in critical habitats on the covered lands will not change significantly under the DBHCP, and those areas that are currently suitable for adult and subadult bull trout foraging and migration will remain so. All critical habitats on the covered lands will remain suitable for foraging and migration (7-DADM ≤ 16.0°C) during the winter. During the summer, portions of the critical habitat on the covered lands are currently too warm for bull trout foraging and migration, and this will not change. Conversely, those areas that currently have suitable temperatures will continue to be suitable.

In the Middle Deschutes River, critical habitat extends upstream 12 miles from Lake Billy Chinook to Big Falls. The lower 4.8 miles of this reach are cooled by groundwater discharge and remain suitable for bull trout foraging through most of the summer (Figures 8-4 and 8-5). The upper 7 miles of the reach, however, are naturally much warmer than 16.0°C, and the DBHCP will be unable to counteract the naturally high temperatures. These 7 miles will continue to be too warm for bull trout during much of the summer.

Critical habitat in Whychus Creek extends more than 4 miles upstream of Alder Springs. The Max 7-DADM downstream of the springs at RM 1.4 will continue to be warmer than 16.0°C. Upstream of the springs the creek is considerably warmer in the summer due to irrigation diversions and natural conditions (i.e., high solar radiation and limited shade). This will not change under the DBHCP. Water temperatures above the springs will continue to preclude bull trout foraging and migration during the summer, while temperatures downstream of the springs will remain suitable.

Critical habitat in the Crooked River extends 11.5 miles from Lake Billy Chinook to US Highway 97. The lower 2.3 miles of this reach are cooled by groundwater discharge that begins below Osborne Canyon at about RM 13.8, and water temperatures are often suitable for bull trout foraging year round. Upstream of RM 13.8, however, the river is naturally too warm during the summer to support bull trout. Temperatures above 16.0°C in this reach of the Crooked River are unrelated to the covered activities, and they will not be decreased as a result of the DBHCP.

Water temperatures in Lake Billy Chinook and the Lower Deschutes River are determined by the temperature of waters entering the reservoir (see Sections 8.1.4, *Lake Billy Chinook* and 8.1.5, *Lower Deschutes River*). Inflows will remain within the suitable range for bull trout foraging and migration year round under the DBHCP, and these critical habitats will not be limiting based on water temperature. The Lower Deschutes River warms naturally as it moves downstream from the Pelton Round Butte Project and it eventually becomes too warm for bull trout presence in the summer. This will not change under the DBHCP.

PCE 6 – Spawning/Rearing Substrate

Bull trout do not spawn in waters covered by the DBHCP and they are highly unlikely to do so in the future due to naturally high water temperatures. The covered activities and the DBHCP will have no effect on this primary constituent element of bull trout critical habitat.

PCE 7 – Natural Hydrograph

The hydrology of the Deschutes Basin is highly modified by the storage, release and diversion of irrigation water. The impacts of the modified hydrograph on bull trout are relatively small, however, due to the overriding constraints on bull trout presence caused by physical barriers and naturally high water temperatures. As noted by USFWS (2004), bull trout are absent from the Upper Deschutes basin. Their distribution in the Middle Deschutes basin in the winter is determined by natural barriers (e.g., Big Falls on the Deschutes River) and man-made barriers (e.g., Bowman Dam on the Crooked River). Bull trout distribution in the Middle Deschutes basin in the summer is determined by the presence of cold water, and the species is only found downstream of significant sources of cold groundwater discharge. At all times of year, their presence on the covered lands is limited due to the distance from established breeding populations in the Metolius River subbasin.

These limiting factors would exist regardless of the altered hydrology of the covered lands, and habitat conditions for bull trout in the suitable reaches would not be markedly different under a natural hydrograph. Some areas that are currently suitable for adult bull trout foraging during the summer would be less suitable under a natural flow regime. For example, summer water temperatures in the Middle Deschutes River between Big Falls and Lake Billy Chinook could be higher under a natural flow regime (Figure 8-5), which would reduce the quality of the reach for bull trout. Similarly, a natural hydrograph in the 13-mile reach of the Crooked River between Bowman Dam and the Crooked River Diversion would cause a substantial increase in summer water temperature that would render this reach unsuitable for bull trout. The reach below Bowman Dam does not currently receive bull trout use, but there is the potential for bull trout presence now that fish passage has been provided downstream at Opal Springs Dam. Under a natural hydrograph, these 13 miles of the Crooked River would be suitable for bull trout foraging only in the fall and winter. In Whychus Creek, on the other hand, a natural hydrograph with higher summer flows could reduce summer water temperatures to the point that temperature is no longer limiting bull trout presence in the summer (Figure 8-11). Other factors may limit bull trout use of Whychus Creek in the summer, however, because the creek experiences little winter use by bull trout despite suitable water temperatures. Overall, the modified hydrograph of the covered lands does not represent a significant adverse impact to PCE 7 of bull trout critical habitat.

PCE 8 – Water Quality

The covered activities and the DBHCP are not expected to impact water quality in critical habitats for the bull trout. Portions of designated critical habitat on the covered lands are listed under Section 303(d) of the Clean Water Act as water quality limited for water temperature, flow modification, habitat modification, biological criteria, dissolved oxygen (DO), pH, total dissolved gas (TDG), E. coli and chlorophyll *a*. The specific reaches of the covered lands that are impaired for these water quality criteria are identified in Chapter 4, *Current Conditions of the Covered Lands and Waters*. Four of the criteria (water temperature, flow modification, DO and TDG) have direct bearing on the quality for habitat for bull trout and could influence the presence of the species in affected reaches. Water temperature and flow (hydrology) are addressed as PCE 5 and PCE 7, respectively. The following discussion of effects on PCE 8 is therefore limited to DO and TDG.

The Middle Deschutes River, Lake Billy Chinook, Lower Deschutes River and Crooked River are identified as water quality limited for DO during salmonid spawning (Table 8-6). The DO criterion for salmonid spawning is not pertinent to critical habitat on the covered lands, however, because bull trout do not spawn in these naturally warm waters.

The Crooked River is also identified as failing to meet the minimum DO criterion of 6.5 mg/l for cool water aquatic life from the mouth to RM 124.8, but DO concentrations below this standard are found primarily upstream of Prineville Reservoir and well upstream of designated bull trout critical habitat. Water quality data summarized by Reclamation (2013) and ODEQ (2018) indicate multiple DO concentrations below 6.5 mg/l upstream of Prineville Reservoir since 2000, but only infrequent concentrations that low downstream of the reservoir. DO concentrations in the lower Crooked River meet or exceed the minimum criterion of 8.0 mg/l for cold water aquatic life year round, except during late summer when water temperatures are naturally at their highest for the year and DO concentrations have been reported to be as low as 5.9 mg/l near Terrebonne (see Figure 4-63).

Table 8-6. Bull trout critical habitats on the covered lands that are identified in Oregon's 2012 Integrated Report as water quality limited for dissolved oxygen and total dissolved gasses.

	Water Quality Parameter		
	Dissolved Oxygen (spawning)	**Dissolved Oxygen Year Round**	**Total Dissolved Gas**
Water Quality Criterion	≥ 11.0 mg/l	≥ 6.5 mg/l	≤ 110 %
Water Body	**Current Impairment**		
Middle Deschutes	yes	no	no
Whychus Creek	no	no	no
Crooked River	yes	yes	yes
Ochoco Creek	no	no	no
McKay Creek	no	no	no
Lake Billy Chinook	yes	no	no
Lower Deschutes	yes	no	no

Source: ODEQ 2017

Bull trout critical habitat extends from the mouth of the Crooked River to US Highway 197 (RM 18). The lower 13.8 miles of this reach are naturally cold year round and DO concentrations above 8 mg/l can be expected. Campbell (2014) reported DO concentrations at the mouth of the Crooked River in 2013 that never dropped below 9 mg/l. The 4.2 miles of critical habitat upstream of RM 13.8, however, experience low flows and naturally high water temperatures during the summer, and historical data indicate DO concentrations could fall below 8 mg/l during July and August of some years. This is a natural condition that occurs unrelated to the covered activities and will not change as a result of the DBHCP.

The Crooked River is also listed as water quality limited for total dissolved gasses (TDG) from RM 70.5 (Bowman Dam) to RM 51. Elevated TDG in this reach of the Crooked River is the result of high flow releases from Prineville Reservoir for flood control; this event occurs irregularly during the winter and early spring of years with high runoff in the upper Crooked River. When TDG levels are elevated, they are highest directly below Bowman Dam and they attenuate to background levels several miles downstream. Elevated TDG levels do not reach the upstream limit of bull trout critical habitat (RM 18) in the Crooked River, and thus elevated TDG has no effect on PCE 8. The elevated TDG levels are unrelated to the covered activities (operation of Bowman Dam is not a covered activity) and the DBHCP will result in no change to TDG in the Crooked River.

PCE 9 – Low Levels of Predation, Competition and Inbreeding

Predation, competition and inbreeding with bull trout are issues of concern where non-native fish species are present in bull trout habitats (USFWS 1999). Non-native brook trout (*Salvelinus fontinalis*) are present in the Deschutes Basin (Ratliff et al. 1996) and have the potential to hybridize and/or compete with bull trout in spawning areas. However, no bull trout spawning habitat occurs on the covered lands and the covered activities have no effect on the presence or absence of non-native species in bull trout spawning habitat. The Bull Trout Coastal Recovery Unit Implementation Plan (USFWS 2015) identifies no primary or secondary threats to bull trout with respect to predation, competition or inbreeding from non-native species in the Deschutes Basin. The covered activities and the DBHCP will have no effect on this primary constituent of bull trout critical habitat.

8.2 Steelhead Trout

Middle Columbia River steelhead trout *(Oncorhynchus mykiss*) inhabit the Deschutes River upstream as far as the Pelton Round Butte Reregulating Dam (RM 100). The species is currently being reintroduced to historical range upstream of the Pelton Round Butte Project in the Deschutes River, Whychus Creek, Crooked River, Ochoco Creek and McKay Creek. The ongoing reintroduction anticipates that steelhead will eventually migrate upstream of Lake Billy Chinook to spawn and rear young in the Deschutes River upstream to Big Falls (RM 132.2), in Whychus Creek upstream to a natural barrier at RM 37.1, in the Crooked River upstream to Bowman Dam (RM 70.5), in Ochoco Creek upstream to Ochoco Dam (RM 10.5) and in McKay Creek upstream to a natural barrier at RM 19.6 (Figure 8-24). As of 2020, those steelhead downstream of Pelton Reregulating Dam are listed as threatened under the ESA and steelhead in the reintroduction area upstream of Pelton Round Butte Project are designated non-essential experimental until 2025. Anticipated steelhead presence in the Middle Deschutes River is summarized by life stage and season in Table 8-7. Designated critical habitat for steelhead within the covered lands includes the mainstem Lower Deschutes River and Trout Creek.

Steelhead downstream of the Pelton Round Butte Project are affected to varying degrees by all covered activities that modify flow in the Upper Deschutes River and its tributaries. Steelhead upstream of the hydroelectric project are affected by covered activities within the individual reaches. The following analysis of effects is organized into six geographic areas that contain all affected reaches (Figures 8-25 and 8-26; Table 8-8; Middle Deschutes River, Whychus Creek, Crooked River Subbasin, Lake Billy Chinook, Lower Deschutes River and Trout Creek (a tributary to Lower Deschutes River).

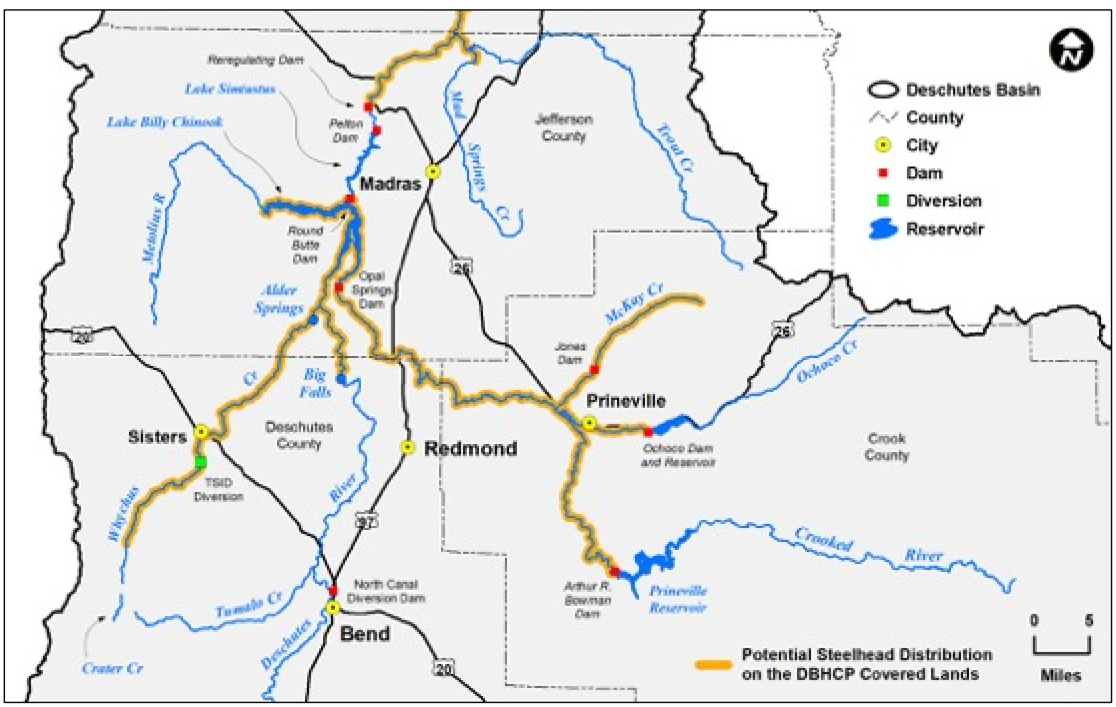


Figure 8-24. Waters covered by the DBHCP that are currently or potentially accessible to steelhead.

Table 8-7. Seasonal presence and water temperature suitability for steelhead trout in the Upper Deschutes Basin.

Life History Stage	Season[1/]	Water Temperature Suitability (°C)				
		Preference	Avoidance	Stress/ Disease	Delay	Lethal
Adult Migration[2/]	Oct-Mar	10.0 – 12.8	< 7.2; > 14.4	ND	> 21.0	> 23.9
Spawning[3/]	Mar-May	4.0 – 12.0	< 3.9; > 9.4	ND	ND	> 21.0
Incubation[4/]	Mar-Jun	5.6 – 11.1	ND	> 15.0	ND	ND
Juvenile Rearing[5/]	All Year	< 14.0	> 19.0	> 22.0	ND	ND
Outmigration[6/]	Apr-Jun	ND	ND	ND	12.0 – 13.6	ND

Notes:

1) NPCC 2004; PGE and CTWSRO 2016, 2017, 2018, 2019
2) McCullough et al. 2001
3) USEPA 2001b
4) Bell 1990; USEPA 2001b
5) USEPA 2001b
6) McCullough et al. 2001

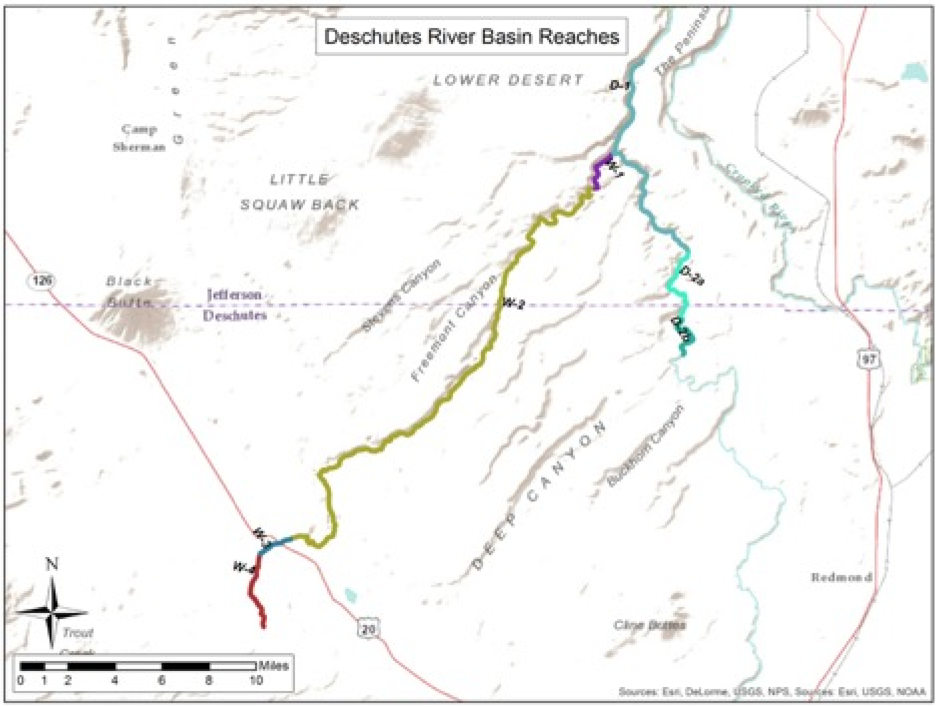


Figure 8-25. **Reaches of the Middle Deschutes River and Whychus Creek designated for the analysis of effects of the DBHCP on covered fish species.**

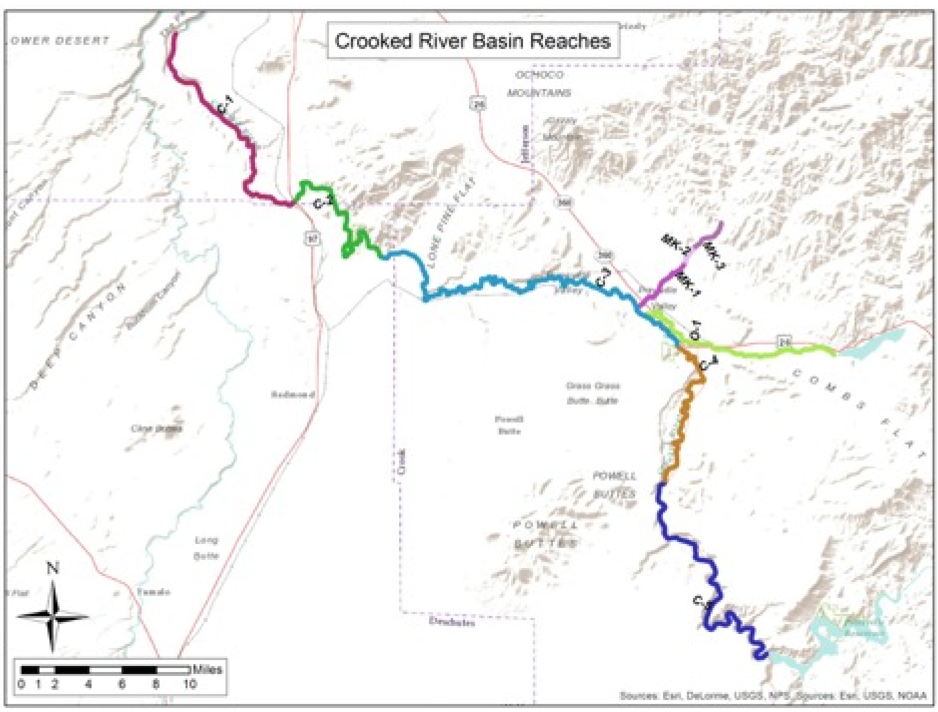


Figure 8-26. **Reaches of the Crooked River, Ochoco Creek and McKay Creek designated for the analysis of effects of the DBHCP on covered fish species.**

Table 8-8. Reaches of the Deschutes Basin designated for the analysis of effects of the DBHCP on covered fish species.

Stream	Reach	Map Code	Upstream (RM)	Downstream (RM)	Length (miles)
Deschutes River	Big Falls to RM 130	D-2b	132.2	130.4	1.8
	RM 130 to Steelhead Falls	D-2a	130.4	127.7	2.7
	Steelhead Falls to Lake Billy Chinook	D-1	127.7	120.0	7.7
Whychus Creek	TSID Diversion to City of Sisters	W-4	24.2	22.2	2.0
	Within City of Sisters	W-3	22.2	20.2	2.0
	City of Sisters to Alder Springs	W-2	20.2	1.6	18.6
	Alder Springs to Mouth	W-1	1.6	0.0	1.6
Crooked River	Bowman Dam to Crooked River Diversion	C-5	70.5	56.5	14.0
	Crooked River Diversion to US Route 26	C-4	56.5	48.0	8.5
	US Route 26 to NUID Pumps	C-3	48.0	27.6	20.4
	NUID Pumps to US Route 97	C-2	27.6	18.4	9.2
Ochoco Creek	Ochoco Dam to RM 6.3	UPPER	11.2	6.3	4.9
	RM 6.3 to Mouth	LOWER	6.3	0.0	6.3
McKay Creek	Jones Dam to Dry Creek	MK-3	5.8	3.9	1.9
	Dry Creek to Reynolds Siphon	MK-2	3.9	3.2	0.7
	Reynolds Siphon to Mouth	MK-1	3.2	0.0	3.2

The effects of the DBHCP on steelhead in all six geographic areas occur indirectly through the changes in hydrology and water quality described in detail in Chapter 6, *Habitat Conservation*. Direct effects can also occur through entrainment and blockage to migration at covered irrigation diversions within the occupied and potentially occupied reaches. The conservation measures described in Chapter 6 have been designed to address both indirect and direct effects of the covered activities on steelhead and other covered species.

Changes to hydrology resulting from the covered activities and interrelated federal activities are variable by season and by location. The storage and release of water at irrigation reservoirs affect flows in covered waters downstream of those reservoirs (Deschutes River, Crooked River and Ochoco Creek) on a year-round basis. In general, downstream flows are reduced by irrigation storage in the fall and winter and increased by the release of storage in the spring and summer. The diversion of irrigation water, on the other hand, affects downstream flow mostly during the irrigation season (spring and summer). The exceptions to this are stock water runs that occur periodically during the winter on the Deschutes River and Whychus Creek. The effects of these variable changes in flow and associated water quality on steelhead are also variable. Reductions in flow caused by storage and diversion of water generally have negative effects on steelhead, while releases of stored water have neutral or positive effects. These differences in effect are discussed in detail for each of the six geographic areas.

The effects of the covered activities on covered fish species are determined by comparing historical conditions on the covered lands to future conditions under the DBHCP. For consistency with hydrologic analyses presented in Chapter 6, *Habitat Conservation,* historical conditions are defined as conditions that existed from 1981 through 2018 and future DBHCP conditions are those that will occur during DBHCP implementation beginning in 2021. In most cases, historical conditions are the same as current conditions (i.e., conditions immediately prior to DBHCP implementation), but in some cases current conditions are different (i.e., improved) from average or median historical conditions due to conservation actions, such as irrigation canal piping, that occurred progressively over the 11 years of DBHCP development. These early conservation actions cannot be attributed directly to the DBHCP because they occurred prior to federal approval of the DBHCP, but they are a product of the DBHCP development process and have resulted in improved conditions for covered species. Habitat improvements associated with early conservation actions will be identified in the following analysis and distinguished from the effects of the DBHCP.

Natural (also called unregulated) conditions are discussed briefly for some geographic areas to describe the natural habitat potential of those affected reaches, but not as a basis for comparison of the effects of the DBHCP. Natural conditions are not used as the basis for comparison because they are no longer achievable after 100 years or more of land use change in the basin, and because in certain locations irrigation activities have been beneficial to covered species and a return to natural conditions would be undesirable. Natural conditions are important to note, however, because they provide insights into the natural potential of the covered lands to support the covered species. In many cases, the conservation benefits of the DBHCP are limited by the natural potential of the covered lands.

8.2.1 Middle Deschutes River

Overview

The analysis of effects of the DBHCP on steelhead in the Middle Deschutes River is limited to the 12.2 miles of river currently or potentially occupied by the species between Big Falls (RM 132.2) and Lake Billy Chinook (RM 120.0) (Figure 8-25; Table 8-8). There are no irrigation storage reservoirs, diversions or return flows within this reach; the effects of the covered activities are limited to changes in flow resulting from the storage, release and diversion of water in the Deschutes River and its tributaries more than 30 miles upstream.

Historical hydrology and water quality of this reach are described in Section 4, *Upper and Middle Deschutes River*. The first 2 miles of the reach below Big Falls are heavily influenced by upstream irrigation activities; flows are generally low in the summer due to irrigation diversions and low in the winter due to irrigation storage. In contrast, flows in the remaining 10 miles of the reach are higher because of groundwater discharge and surface tributary inflow that reduce the relative effects of upstream irrigation activities. Instream water rights that were established as a result of conserved water projects (i.e., irrigation canal piping) prior to 2020 provide a minimum flow of 143 cfs for this reach during the peak of the irrigation season (mid-May to mid-September). Flows at the upstream end of the reach are typically at or modestly above the allowable minimum during the summer, while flows at the downstream end of the reach exceed 500 cfs in most months (see Figure 4-5). The instream minimum flows are part of the current condition, but they are not fully reflected in average or median historical conditions because many of the conserved water projects occurred after 2010.

The DBHCP will not alter flows in this reach during the irrigation season, as indicated by projected daily average flows upstream at RM 160 (Figure 8-27). The *DBHCP, Minimum 100 cfs* flows for April through September shown in Figure 8-27 reflect current conditions, and these are greater than historical flows because they include the benefits of early conservation actions since 2010. Irrigation season flows in this reach could continue to increase from current conditions over the next 30 years if there are additional conserved water projects, but these are not reflected in Figure 8-27 or included in this analysis because they would be unrelated to the DBHCP.

During the storage season (October through March) flows in the Middle Deschutes River will increase as a result of the DBHCP because fall and winter flows below Wickiup Dam (Hydromet Station WICO) will increase. As with irrigation season flows, the *DBHCP, Minimum 100 cfs* flows for October through March shown in Figure 8-27 reflect current conditions because the requirement to maintain a minimum flow at WICO is already being implemented. In the future, as the required minimum flow at WICO increases, the winter flow in the Middle Deschutes River will also increase. Additional benefit will be derived from Measure DR-1, which will prevent stock water diversions from reducing flows downstream of Bend to less than 250 cfs from November through March.

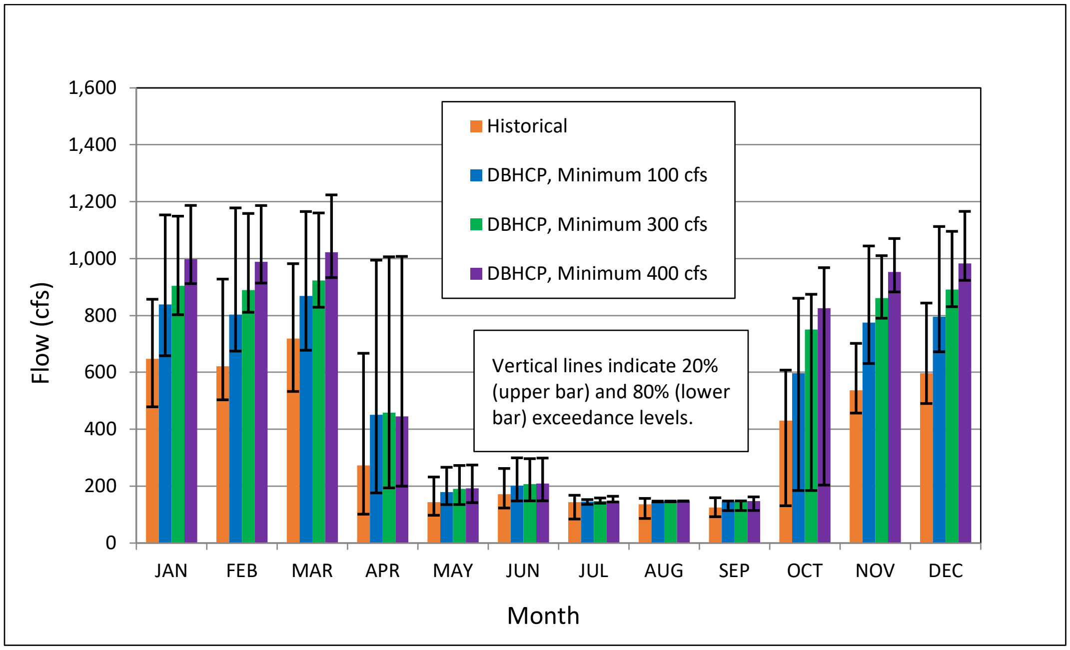


Figure 8-27. Monthly medians of daily average flows in the Deschutes River below the confluence with Tumalo Creek (RM 160) for historical and DBHCP projected conditions. Sources: OWRD 2020a, 2020b; Reclamation 2020a.

Water temperatures at the upstream and downstream ends of the Middle Deschutes River from 2011 through 2016 are presented in Figures 8-28 and 8-29. Temperatures within this reach are not expected to change as a result of the DBHCP. Summer temperatures reflect the large influx of cool groundwater between RM 130 and RM 120, and peak temperatures at the downstream end of the reach can be as much as 7°C cooler than at the upstream end. In 2013, the 7-DADM at Lower Bridge (RM 133) was consistently above 18°C from late June through late September and the peak in 7-DADM in July was over 24°C (see Chapter 4 - Figure 4-13). In contrast, the 7-DADM at Culver (RM 120) never reached 18°C and it exceeded 16°C only briefly. The Middle Deschutes River is listed as water temperature limited under Section 303(d) of the Clean Water Act for exceeding the maximum 7-DADM of 18°C for salmon and trout rearing and migration. The reach is also listed as water quality limited for dissolved oxygen during salmonid spawning (January 1 to May 1) and for flow modification.

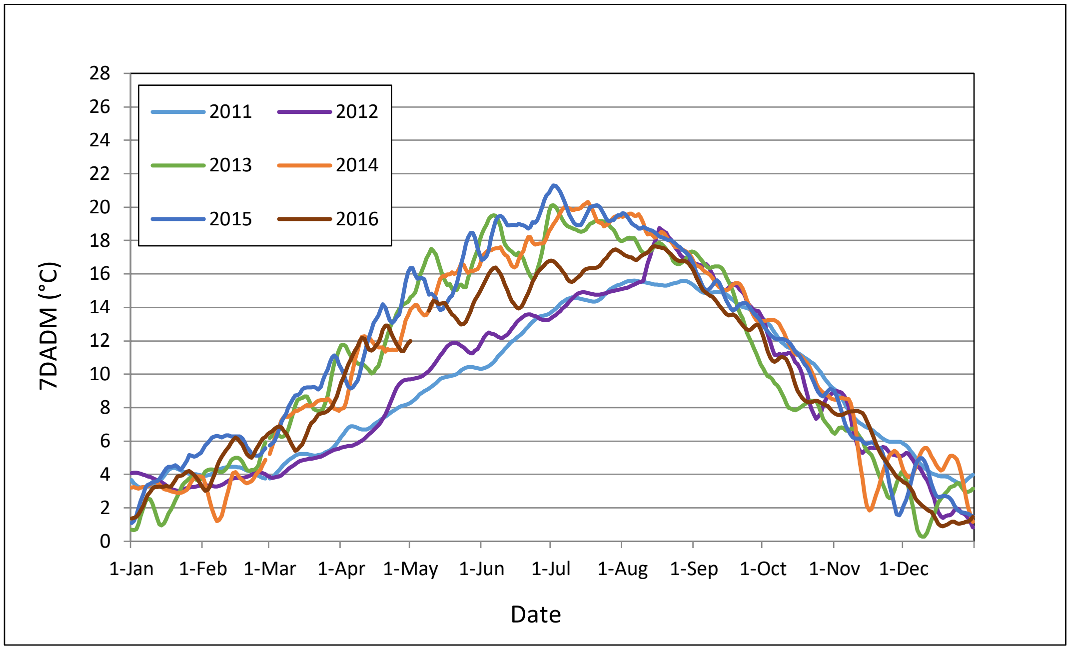


Figure 8-28. Seven-day averages of daily maximum water temperatures (7-DADM) in the Deschutes River below Bend (RM 164) from 2011 through 2016. Source: Reclamation 2017.

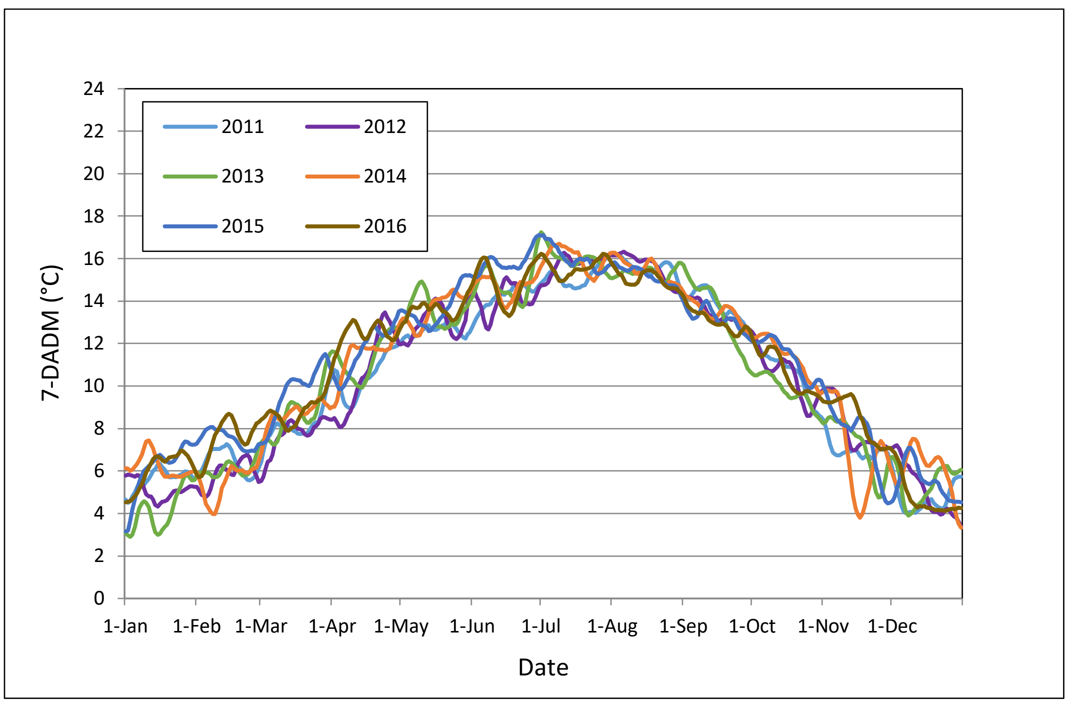


Figure 8-29. Seven-day averages of daily maximum water temperatures (7-DADM) in the Deschutes River near Culver (RM 120) from 2011 through 2016. Source: USGS 2019.

Steelhead Adult Migration

Since 2012, adult steelhead collected below the Pelton Round Butte Project have been radio-tagged and released into Lake Billy Chinook during their upstream migration (Hill and Quesada 2013; Hill et al. 2014; Wymore et al. 2015; Burchell et al. 2016; Burchell and Hill 2017; Burchell 2018). Movements of these fish are tracked using both fixed and mobile radio receivers, providing information about locations that are used by adult spawners. Results indicate steelhead returns are higher in the Crooked River subbasin than the Deschutes or Metolius Rivers (Table 8-9). While these data provide some insight into the distribution of steelhead spawners in the basin, it is difficult to make inferences about migration conditions from the few adult fish that are passed upstream annually.

Upstream migration of adult steelhead is influenced by numerous hydrologic, environmental, and physical factors. In regulated river systems, migration can be impeded by changes in flow and other management practices that influence channel depth or water temperature and create physical or thermal barriers to fish movement. For steelhead, a minimum channel depth of 8.4 inches is required for adult upstream passage (CDFW 2017) and preferred temperature range is 10.0 to 12.8 °C. Migration is likely to be delayed if water temperatures exceed 21°C (Table 8-7).

Recent water temperatures in the Middle Deschutes River (2011 through 2016) are within the preferred range for adult migration in October, but well below the preferred range from November through March (Figures 8-28 and 8-29). It is unclear how cooler temperatures would adversely affect migration and holding conditions, since most literature derives preferred temperature conditions from populations inhabiting warmer rivers (Appendix A-4). However, because DBHCP measures are not expected to appreciably alter temperatures in this area, migration conditions in the Middle Deschutes River under the DBHCP are not likely to be affected relative to historical conditions.

Predicted changes in riffle depth within three reaches of the Middle Deschutes River were examined to assess the potential for physical barriers to steelhead movement under DBHCP flows (Appendix A-4). Average riffle depths for the DBHCP are consistently predicted to increase from historical conditions during the steelhead migration period of October through March (Figure 8-30). Additionally, the predicted average riffle depths exceed the minimum depth threshold under all flow conditions and all phases of DBHCP implementation. Adult steelhead are therefore not expected to encounter physical barriers during their upstream migration in the Middle Deschutes River from Lake Billy Chinook to Big Falls.

Table 8-9. Results of monitoring of returning adult summer steelhead captured at Pelton Round Butte Project fish trap from 2012 through 2017.

Year	Number of Fish Captured at Pelton Fish Trap	Number of Fish Tagged & Released Upstream	Proportion Detected Following Release					
			Deschutes River	Whychus Creek	Metolius River	Crooked River	McKay Creek	Ochoco Creek
2012[1/]	133	72	0.03	0.01	0.00	0.13	0.14	0.00
2013[2/]	50	50	0.02	0.00	0.10	0.20	0.04	0.00
2014[3/]	93	93	0.04	0.04	0.06	0.28	0.04	0.01
2015[4/]	45	45	0.07	0.04	0.16	0.40	0.04	0.04
2016[5/]	30	30	0.10	0.00	0.03	0.03	0.03	0.00
2017[6/]	30	28	0.11	0.00	0.30	0.11	0.04	0.00

Notes:

[1/] Hill and Quesada 2013

[2/] Hill et al. 2014

[3/] Wymore et al. 2015

[4/] Burchell et al. 2016

[5/] Burchell and Hill 2017

[6/] Burchell 2018

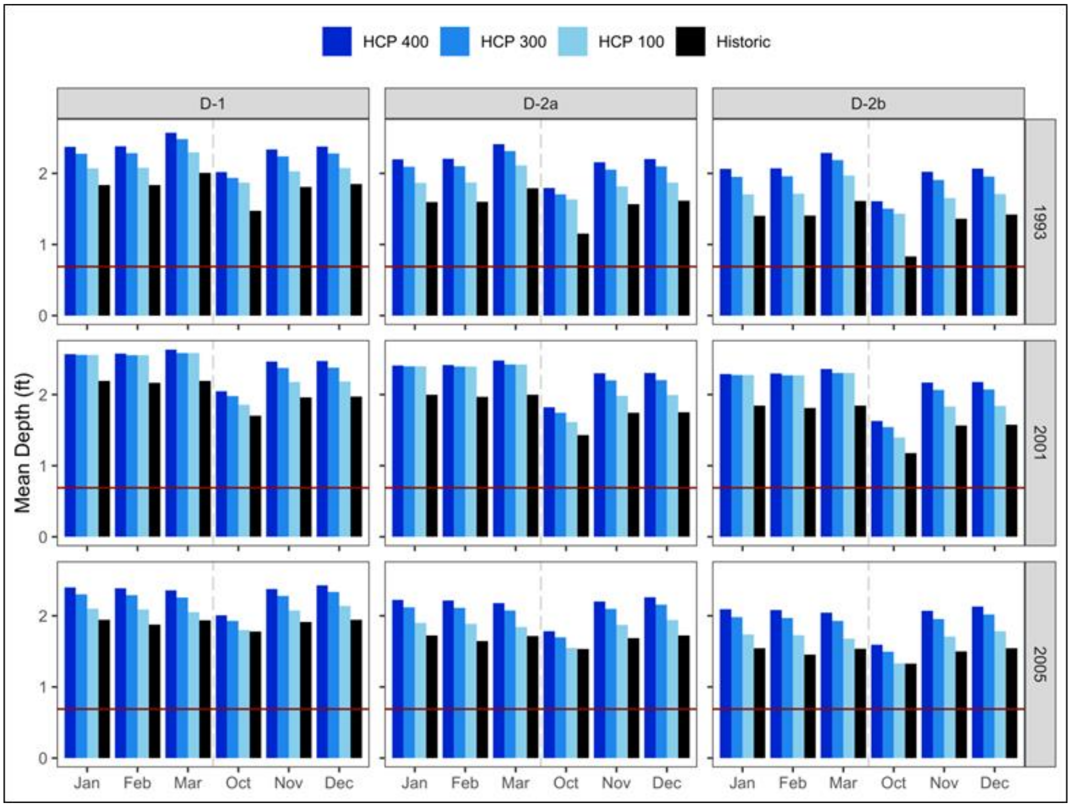


Figure 8-30. Estimated average riffle depth in the Middle Deschutes River during the steelhead migration period (horizontal line indicates minimum depth required for passage) during three sample years. Source: See Appendix A-4.

Steelhead Spawning

Steelhead enter spawning areas weeks or months before they spawn and they require instream or overhead cover to avoid disturbance and predation. Cover can include overhanging vegetation, undercut banks, submerged vegetation, submerged objects such as logs and rocks, floating debris, deep water, turbulence and turbidity (Giger 1973). Prior to spawning, female steelhead dig a shallow depression (*redd*) where they will deposit ova. Once fertilized, the female will backfill with coarse substrate. Females typically choose redd locations in cool, clear streams in shallow pool tailouts and in the transition areas between riffles and other slower velocity habitat types with suitable gravel size, depth and water velocity. Intermittent streams can be used for spawning if flows are maintained long enough to allow emergent fry to disperse downstream before the dry conditions in the late summer or fall. Typical steelhead spawning habitat requirements are described in Table 8-10. Further, females generally prefer locations with uniform water velocity and course sediment that will allow a steady supply of water between 4 and 12°C (Table 8-7).

Table 8-10. Spawning habitat criteria used to assess impacts of the DBHCP on steelhead.

Habitat Characteristic	Criteria	Source
Water Depth	≥ 0.24 m (9.5 in.)	Smith 1973
	0.21 m (8.26 in.)	Orcutt et al. 1968
Fines Composition	< 5% in redd	Raleigh et al. 1986
	< 25%	Platts and Partridge 1983
Substrate Size	0.5 to 4 inches in diameter	Raleigh et al. 1986
Velocity	1 to 3 feet per second (fps)	Raleigh et al. 1986

Source: Burke et al. 2010.

Water temperatures in the Middle Deschutes River downstream of Big Falls (RM 132) are within the preferred temperature range for steelhead spawning from March 1 through mid-April, but exceed 12°C by late April in many years and can exceed 18°C in some years. Historical water temperatures at RM 164 are provided in Figure 8-28. Little cooling occurs between RM 164 and Steelhead Falls (RM 130.4), so the temperatures provided in Figure 8-28 are generally indicative of temperatures in Reach D-2b. Downstream of this, cold groundwater discharge reduces water temperature in Reaches D-2a and D-1 during the spring and summer (Figure 8-5), but temperatures likely still exceed 12°C by mid-April under natural conditions. Salmonids encountering temperatures greater than 13°C prior to or during spawning can experience negative effects to gametes that reduce fertilization and embryo survival rates (Bry 1981; Hokanson et al. 1977). Under the thermal conditions described above, much of the Middle Deschutes River below Big Falls would not be suitable for steelhead spawning during mid-April through May in most years. DBHCP measures are not expected to appreciably alter temperatures in this area, and therefore are not expected to improve or further impair spawning relative to the historical condition.

Direct observations of site selection by spawning steelhead in the Middle Deschutes River are limited because there have been relatively few returning adult fish. However, ODFW's Aquatic Inventory Program (AIP) has resulted in the collection of data throughout the Deschutes Basin that are useful for identifying potential steelhead spawning habitat (Burke et al. 2010). In 2016, Portland General Electric used the HabRate model in conjunction with recently collected AIP data to rank the quality of habitat for summer steelhead in the basin (Spateholts and Wymore 2017). The model indicated *good* quality spawning habitat for summer steelhead is extremely limited in the basin. Between the Deschutes, Crooked and Metolius River basins, approximately 10 km (6.2 miles) of *good* spawning habitat was estimated for summer steelhead, most of which was identified in Whychus Creek.

Flows in the Middle Deschutes River are predicted to increase modestly between March and May under the DBHCP (Figure 8-31) and this is likely to improve spawning habitat from historical conditions. Despite this, HabRate model results ranked steelhead spawning conditions in the Deschutes River as *fair*, and a modest flow increase predicted for the DBHCP is not likely to change overall spawning habitat suitability ranking.

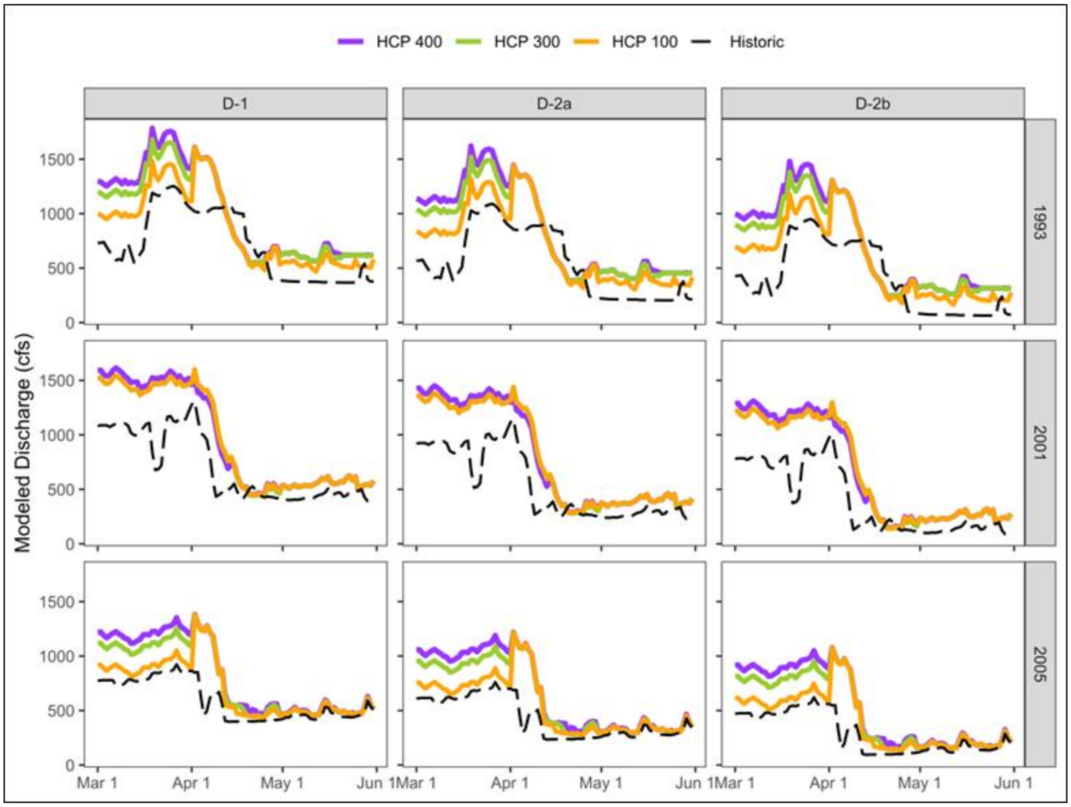


Figure 8-31. Modeled average discharge in the Middle Deschutes River during the steelhead spawning period during three sample years. Source: See Appendix A-4.

Steelhead Egg Incubation

Figures 8-28 and 8-29 suggest the Middle Deschutes River is suitable for steelhead egg incubation from March 1 through mid-April, when the 7-DADM is less than 15°C, but water temperatures can exceed the optimal range by early April in many years. The best available water temperature data for Reach D-2b (Figure 8-28) suggest water temperatures can exceed 15°C and become stressful for incubating eggs by May in some years. Downstream in Reaches D-2a and D-1, where spring discharge cools the water, temperatures remain optimal for most of the incubation period. The 7-DADM measured in Reach D-1 only exceeded 15°C in June for some years (Figure 8-29), but mean temperatures were likely well below levels that would affect the development of embryos. These conditions will not change under the DBHCP.

The stressful temperatures in Reach D-1 could have negative effects on steelhead embryos. As temperatures increase, the metabolic demands of growing embryos also increase and they require more dissolved oxygen. However, the capacity of water to hold dissolved oxygen diminishes with increased temperature. At temperatures greater than 15°C hatching can be delayed, resulting in smaller size-at-emergence and elevate mortality in steelhead embryos.

Steelhead Summer Rearing

Juvenile steelhead rearing capacity under DBHCP flows in the Middle Deschutes River was assessed using the Unit Characteristic Methodology (UCM) described by Cramer and Ackerman (2009) and adapted to the Deschutes Basin by Courter et al. (2014). The UCM-Flow analysis is used to quantify changes in the amount of available habitat across a range of flows and predict how those changes will influence juvenile fish densities (fish/m2). The DBHCP analysis relied on local habitat data to estimate habitat conditions and model carrying capacity (the maximum number of fish that can be supported by available habitat) for predicted flows. The UCM approach is based on the assumption that the bottleneck for total fish production in steelhead streams is low summer/fall flow and associated high water temperatures that coincide with the presence of rearing juveniles (Cramer and Ackerman 2009). Low summer flows in the Middle Deschutes River are currently less than natural flows, and they are not expected to change from current conditions under the DBHCP (Table 8-11). Habitat features used to estimate rearing densities were channel unit composition, surface area, water depth, substrate, cover and water temperature. The density of fish in each channel unit type (pool, riffle, run, etc.) was based on empirical observations of fish abundance levels in streams that are fully seeded and operating at or near capacity. These baseline density levels were then scaled by local habitat features, and then summed across channel units within each study reach. A detailed description of the UCM model calculations is provided in Spateholts (2013) and Cramer and Ackerman (2009). Details on the application of UCM to the Deschutes Basin are provided in Courter et al. (2014).

A number of trends are apparent in the UCM analysis results (Table 8-12). Current/DBHCP minimum flows provide higher total predicted rearing capacity than historical minimum flows (which are lower than current flows) and natural flows (which are considerably higher than current flows). Within the three reaches, however, the trends are inconsistent. In Reach D-1 the highest estimated capacity is for historical minimum flows, in Reach D-2a the highest estimated capacity is for current minimum flows, and in Reach D-2b the highest estimated capacity is for natural flows. This seemingly inconsistent trend is due to the effects of flow on water depth and temperature. At low flows, an increase in flow and associated water depth over riffle habitat will improve conditions for rearing juveniles. As flows increase, water eventually becomes too deep and too fast and juvenile salmonid rearing conditions deteriorate. This accounts for the major trend of increased capacity from historical to current conditions, but decreased capacity at natural flows.

The irregular trend within reaches is related to the counteracting effects of surface flow and groundwater discharge on summer water temperatures in the Middle Deschutes River. Peak summer temperatures (Max 7-DADM) for historical, current and natural flows were estimated with the HeatSource model (Watershed Sciences and MaxDepth Aquatics 2008). Results are presented in Figure 8-32). Natural flows are cooler than historical and current flows at the upstream end of Reach D-2b (RM 132) and these cool waters provide better conditions for juvenile steelhead rearing. Because natural flows are higher, however, they are cooled less by the groundwater discharge that begins at about RM 130.5, and natural flows are warmer than historical flows downstream in Reaches D-2a and D-1. The result is lower rearing capacity in these downstream reaches under natural flows. Since Reaches D-1 and D-2a make up 85 percent of the analysis area, the lower rearing capacity under natural flows in these reaches counteracts the increased capacity in Reach D-2b and gives the natural flow scenario the lowest overall capacity.

Overall, the differences in total predicted juvenile rearing capacity between flow scenarios for the Middle Deschutes are relatively small given the range of flows that was evaluated. Due to uncertainty in predictions of carrying capacity, the most appropriate application of these values is to make relative comparisons between flow scenarios rather than predictions of absolute fish numbers in the river. In this context, the DBHCP is not expected to result in a significant change in steelhead rearing capacity in the Middle Deschutes River from historical or natural conditions.

Table 8-11. Averages (and ranges) of flow and maximum weekly average temperature (MWAT) used for UCM analysis of steelhead carrying capacity in the Middle Deschutes River.

Flow Condition	Middle Deschutes River Reach D-1		Middle Deschutes River Reach D-2a		Middle Deschutes River Reach D-2b	
	Flow (cfs)	MWAT (°C)	Flow (cfs)	MWAT (°C)	Flow (cfs)	MWAT (°C)
Historical Minimum	467 (310-579)	14.5 (14-16)	304 (247-310)	15.4 (15-16)	164 (146-174)	19.1 (19-20)
Current/DBHCP Minimum	497 (339-608)	14.6 (14-16)	334 (278-339)	15.5 (15-16)	194 (176-204)	18.9 (19-20)
ODEQ Natural	1,730 (1,502-1,903)	15.8 (15-17)	1,496 (1,439-1,502)	16.4 (16-17)	1,355 (1,338-1,366)	16.9 (n/a)

Table 8-12. Steelhead parr carrying capacity estimates for the Middle Deschutes River.

Middle Deschutes River Reach	Steelhead Parr Carrying Capacity (total fish per reach)		
	Historical Minimum Flow	Current/DBHCP Minimum Flow	ODEQ Natural Flow
D-1	28,254	28,076	18,975
D-2a	12,115	12,376	11,821
D-2b	8,758	10,041	14,295
TOTAL	**49,127**	**50,493**	**45,091**

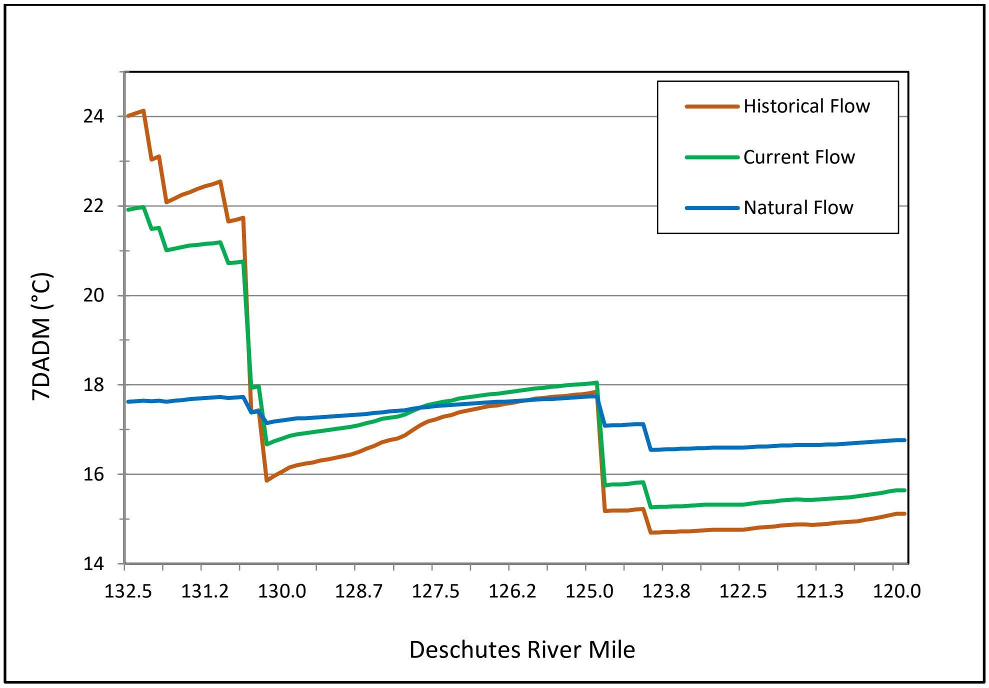


Figure 8-32. Heat Source predictions of the annual maximum of the 7-day average of daily maximum water temperatures (Max 7-DADM) for the Deschutes River between Big Falls (RM 132.2) and Lake Billy Chinook (RM 120.0).

Steelhead Winter Rearing

Median winter flows in the Middle Deschutes River will be consistently higher under the DBHCP than they were historically (Figure 8-27). Unlike trends for summer rearing habitat, higher flows are positively correlated with rearing capacity during the winter (Appendix A-1). Consequently, no negative impacts are anticipated from the DBHCP during steelhead winter rearing.

Steelhead Smolt Migration

In general, higher flows in the upper Deschutes Basin are expected to be positively associated with smolt survival during migration, though the precise influence of flows is somewhat uncertain (Appendix A-3). Multiple regression analysis demonstrated that flow in the Crooked and Deschutes Rivers was positively associated with hatchery steelhead smolt survival after accounting for effects of the number of stocked fish (PGE and CTWSRO 2019). Therefore, smolt survival was assumed to be linearly related to spring flow (March-June) when evaluating DBHCP flows. Although this approach is likely to overestimate the survival benefit of increased flows, especially under high flow scenarios, assuming a positive linear relationship between flow and survival provides a logical basis for making relative comparisons between flow management scenarios.

Comparison of projected DBHCP flows to current conditions does not reveal appreciable changes in the Middle Deschutes River during the steelhead trout emigration period. Therefore, flow management alternatives associated with the DBHCP should not be expected to markedly change smolt survival conditions in the Middle Deschutes Basin.

No data are available on optimal or preferred water temperatures for steelhead smolt migration, but migration travel times tend to decrease as temperatures warm in the spring. Reduced travel times may increase survival as the migration season progresses. However, once temperatures reach about 16°C, piscivorous fish species become more active and risk of predation becomes much higher for smolts. As indicated in Figures 8-28 and 8-29, weekly maximum water temperatures (7-DADM) in the Middle Deschutes River during the period of smolt migration (April through June) can range from 5.0 to 20.0 °C, depending on the water year. Fortunately, the majority of the smolts in the Middle Deschutes River should be downstream before temperatures reach 16°C in most years. Temperatures are not expected to change under the DBHCP and therefore temperature-related effects on smolts are not expected to change.

Net Effect on All Life Stages of Steelhead in the Middle Deschutes River

The potential for reintroduced steelhead to successfully spawn and rear in the Middle Deschutes will not change appreciably as a result of the DBHCP, and this portion of the basin will continue to be capable of contributing to the reintroduction effort. The DBHCP is expected to have no adverse effect on migrating adult steelhead in the Middle Deschutes River. Spawning habitat availability is historically limiting in the Middle Deschutes River and modest increases in flow under the DBHCP are likely to provide minor improvements from historical conditions. Developing embryos may be negatively impacted by slightly higher water temperatures caused by higher flows than occurred historically, particularly in May and June. The bulk of steelhead summer rearing is supported by Reaches D-1 and D-2a, which have slightly higher estimated rearing capacity under the current/DBHCP condition than the historical condition. For steelhead smolts, temperatures during outmigration are not expected to change under the DBHCP.

8.2.2 Whychus Creek

Overview

Steelhead that are transported above Pelton Round Butte Project have access upstream in Whychus Creek to a natural barrier at RM 37.1. The covered lands extend upstream in Whychus Creek to RM 26 to include a small diversion operated by one TSID patron, but the vast majority of TSID's effects on flow and water temperature occur downstream of the District's main diversion at RM 24.2. The area of analysis for steelhead in Whychus Creek is therefore the 24.2 miles from the TSID diversion to the mouth. There are no storage reservoirs on Whychus Creek, and no covered activities other than the TSID main diversion at RM 24.2 and the patron diversion at about RM 26. Water is diverted from March through November, but diversion rates are highest during the peak irrigation season of April to October.

The historical hydrology of Whychus Creek is described in Section 4.5, *Whychus Creek*. The effects of the DBHCP on hydrology are presented in Section 6.4.3.4, *Effects of DBHCP Measure WC 1 on Whychus Creek Hydrology*. Natural flow in Whychus Creek varies considerably on a seasonal basis, with peak flows during spring snowmelt and winter storms, and low flows in late summer. Historically, irrigation diversions substantially reduced summer flows in the lower 24 miles of the creek. In recent years, however, conserved water projects by TSID and others have resulted in instream water rights of over 31 cfs. The new instream rights are reflected in DBHCP flows at Sisters (Figure 8-33), although flows at Sisters are consistently lower than flows immediately below the TSID diversion, where the water right is measured, due to channel losses and irrigation diversions between the two points. The net effect of the new instream rights is that median and 80 percent exceedance minimum flows in the lower 24 miles of Whychus Creek will be higher throughout the irrigation season considerably greater than they were historically (Figure 8 33). The apparent decreases in median flows in Whychus Creek during March, October and November under the DBHCP are the result of TSID diversions in these months being artificially low for recent historical conditions (2000 through 2017) due to canal piping projects that prevented TSID from diverting water. These reduced diversions increased the historical stream flows shown in Figure 8-33. Now that piping is completed, TSID will return to its normal practice of diverting water from March through November and Whychus Creek flows will return to levels similar to those that occurred prior to 2000.

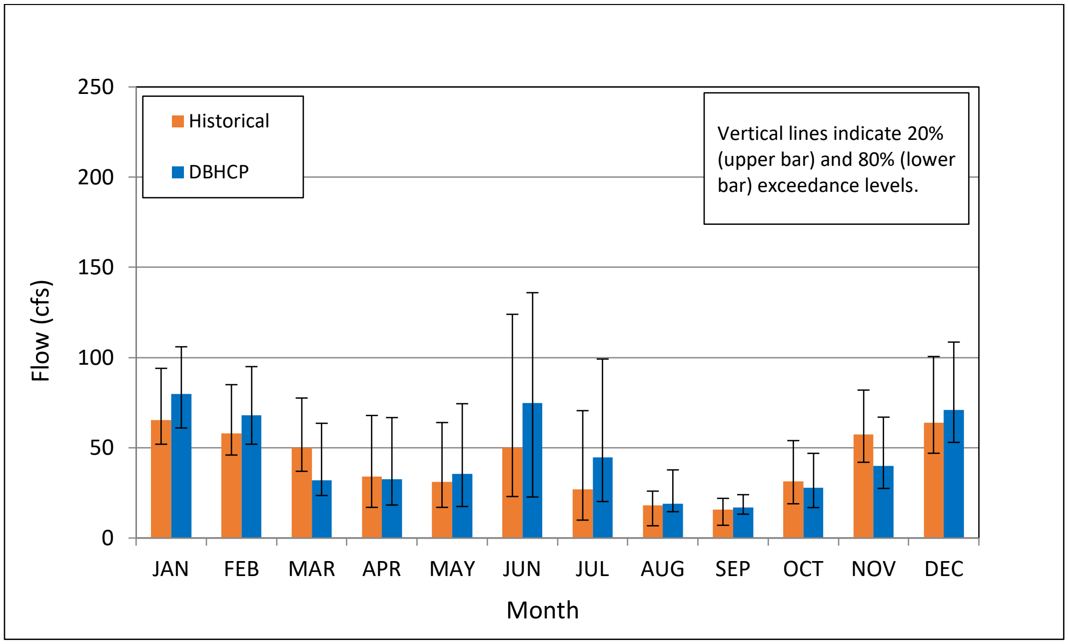


Figure 8-33. Monthly medians of daily average flows for historical conditions (reported) and DBHCP conditions (projected) in Whychus Creek at Sisters (OWRD Gage 14076050). Sources: OWRD 2020c; Reclamation 2020a.

Historical water temperature conditions in Whychus Creek are summarized in Section 4.5, *Whychus Creek* and water temperature conditions under the DBHCP are described in 6.4.3.5, *Effects of DBHCP Measure WC-1 on Whychus Creek Water Temperature*. Summer temperatures generally increase with downstream distance until a cooling effect is provided by groundwater discharge at Alder Springs (RM 1.4). Peak summer temperature (Max 7-DADM) has generally been less than 18°C upstream and immediately downstream of the TSID diversion at RM 24.2 (Figures 8-34 and 8-35), but frequently over 18°C downstream from the diversion to Alder Springs (Figure 8-36), particularly in years of low instream flow. Downstream of Alder Springs (Figure 8-37) peak summer temperatures characteristically remain below 16°C. Summer water temperatures have decreased over the past decade due to the establishment of instream water rights, but 7-DADM temperatures as high as 24.1°C were reported at RM 6.0 in 2015. Water temperatures under natural, historical and DBHCP conditions were compared using a regression equation developed by Mork and Houston (2016) to predict 7-DADM for the warmest portion of the creek (RM 6.0) at the warmest time of year (July). The new instream water right of 31.18 cfs below the TSID diversion, which equates to an estimated 23.18 cfs at Sisters, will result in a Max 7-DADM at RM 6.0 in July of 20.42°C (Table 8-13). The DBHCP minimum flow of 20 cfs below the TSID diversion (estimated 12 cfs at Sisters) will result in a Max 7-DADM at RM 6.0 of 22.1°C. Whychus Creek is listed as water temperature limited under Section 303(d) of the Clean Water Act for exceeding the year-round maximum 7-DADM of 18°C for salmon and trout rearing and migration from the mouth to RM 40.3 (ODEQ 2017).

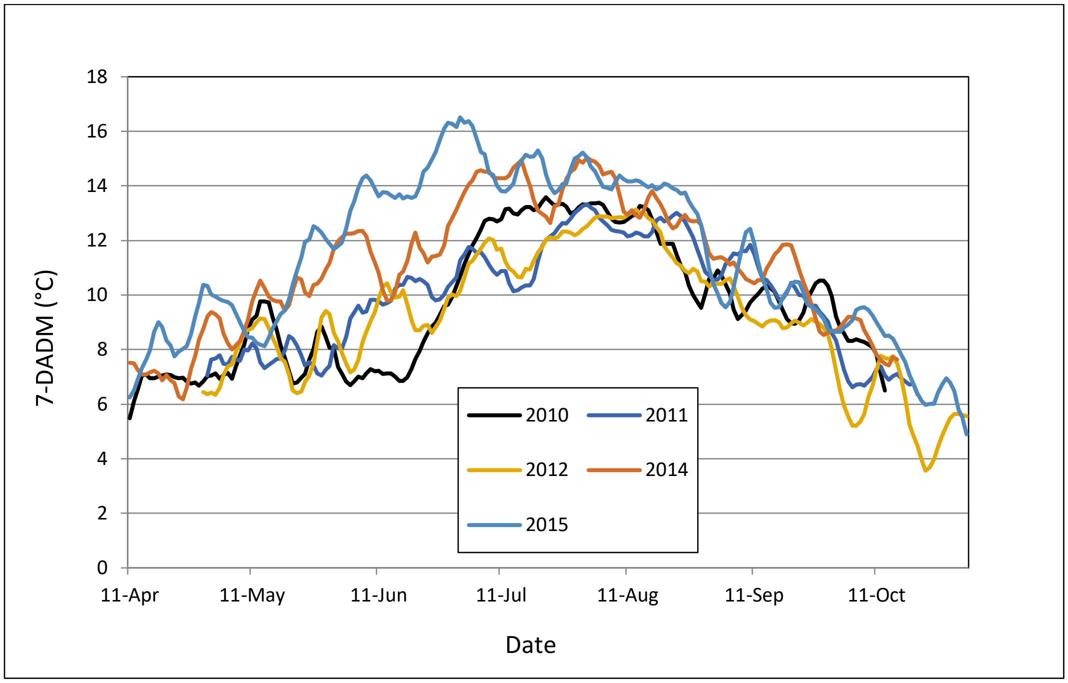


Figure 8-34. Seven-day averages of daily maximum water temperatures (7-DADM) in Whychus Creek upstream of Three Sisters Irrigation District Diversion at OWRD Gage 14075000 during the irrigation season. Source: UDWC 2016.

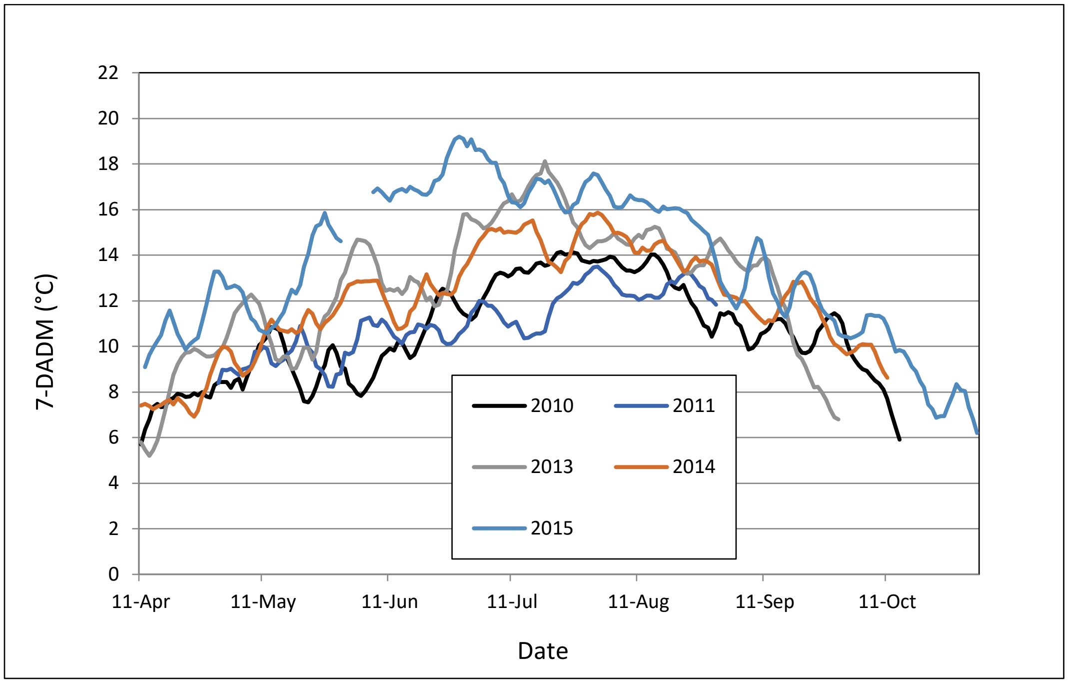


Figure 8-35. Seven-day averages of daily maximum water temperatures (7-DADM) in Whychus Creek downstream of Three Sisters Irrigation District Diversion at Forest Road 4606 during the irrigation season. Source: UDWC 2016.

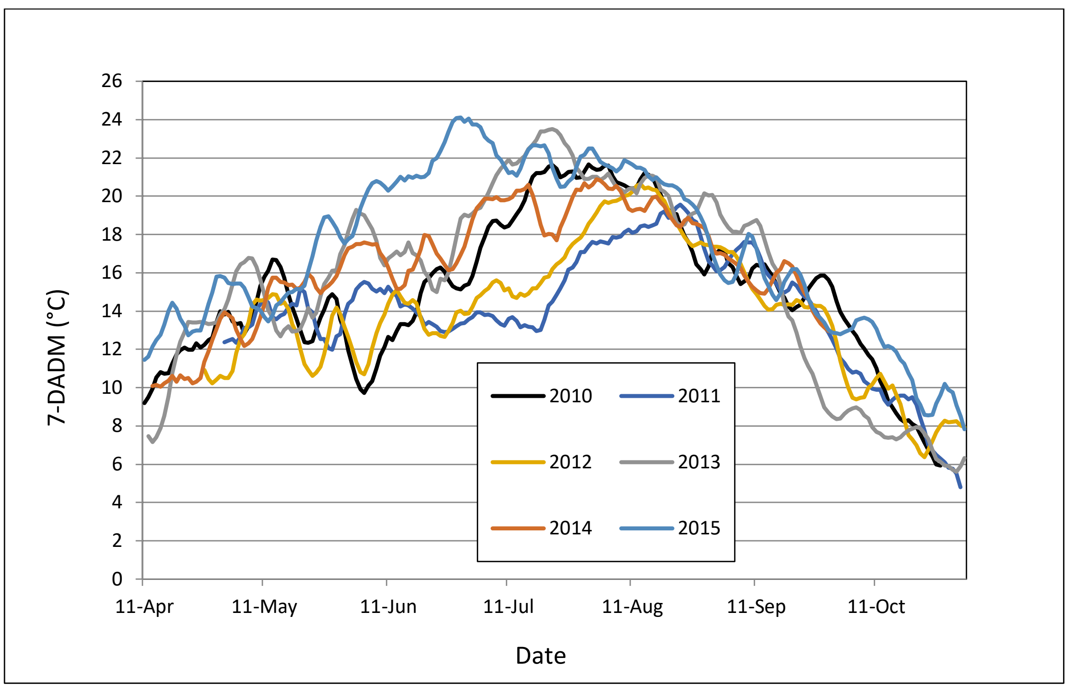


Figure 8-36. Seven-day averages of daily maximum water temperatures (7-DADM) in lower Whychus Creek at Forest Road 6360 (approximate RM 6.00) during the irrigation season. Source: UDWC 2016.

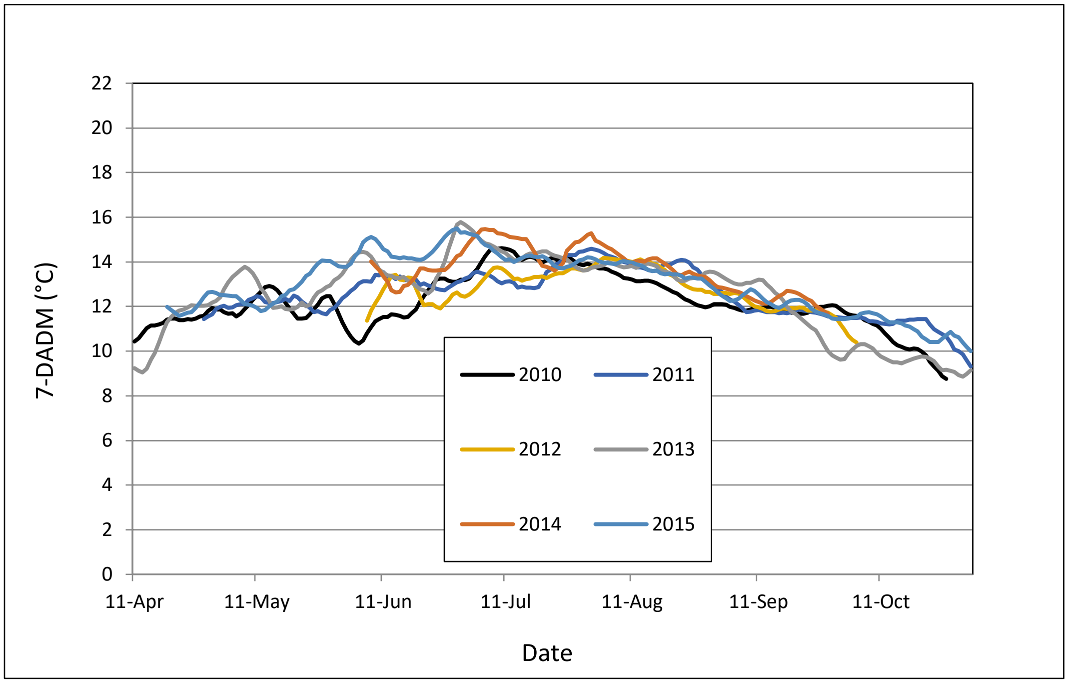


Figure 8-37. Seven-day averages of daily maximum water temperatures (7-DADM) in Whychus Creek near the mouth (RM 0.25) during the irrigation season. Source: UDWC 2016.

Table 8-13. Predicted 7-day average of daily maximum water temperature (7-DADM) at River Mile 6.0 in Whychus Creek under historical and future (DBHCP) conditions.

Flow Condition	Flow at OWRD Gage 14076050 in Sisters, OR	7-DADM at River Mile 6.0
Unregulated (Natural) Median Flow	155 cfs	15.56°C
Unregulated (Natural) Minimum Flow	71 cfs	17.56°C
Historical Median Flow	27 cfs	20.03°C
Historical Minimum Flow	2 cfs	26.68°C
DBHCP Median Flow	45 cfs	18.72°C
DBHCP Instream Water Right Flow	23.18 cfs	20.42°C
DBHCP Minimum Flow	12 cfs	22.10°C

Note:

[1] The instream water rights of 31.18 cfs and minimum flow of 20 cfs described in Conservation Measure WC-1 are both measured directly downstream of the TSID diversion at RM 24.2. Channel losses estimated between the TSID diversion and Gage 14076050 at Sisters are assumed to reduce instream flow by 8 cfs during July.

Steelhead Adult Migration

Since 2012, adult steelhead collected below the Pelton Round Butte Project have been radio-tagged and released into Lake Billy Chinook during their upstream migration from October through March (Hill and Quesada 2013; Hill et al. 2014; Wymore et al. 2015; Burchell et al. 2016; Burchell and Hill 2017; Burchell 2018). Only a small proportion of these fish have been observed in Whychus Creek (Table 8-9), making it difficult to draw conclusions about migration conditions from the few adult fish passed upstream annually.

Upstream migration of adult steelhead is influenced by numerous hydrologic, environmental and physical factors. In regulated river systems, migration can be impeded by changes in flow and other management practices that influence channel depth or water temperature and create physical or thermal barriers to fish movement. For steelhead, a minimum channel depth of 8.4 inches (0.70 foot) is required for adult upstream passage (CDFW 2017) and preferred temperature range is 10.0 to 12.8°C. Migration is likely to be delayed if water temperatures exceed 21°C (Table 8-7).

The DBHCP is not expected to affect water temperatures in Whychus Creek during adult migration, so historical trends in water temperature provide insight into future conditions. For most of the winter, much of the lower 22 miles of creek remains below 7°C, which is in the avoidance range for steelhead (Table 8-7). October water temperatures downstream of the TSID diversion are warmer than above the diversion (Figures 8-34 and 8-35), but still below the typical range for migration. It is unclear how cooler temperatures would adversely affect migration and holding conditions since most literature derives preferred migration temperature conditions from observations of fish migrating through warmer rivers (Appendix A-4) and adult summer steelhead are known to reside in freshwater throughout the winter. Relatively consistent water temperatures during the irrigation season at Alder Springs (RM 1.4) result in water temperatures within the preferred range for migration at the mouth of Whychus Creek for most of October (Figure 8-37). Nevertheless, the DBHCP measures are not expected to appreciably alter temperatures in Whychus Creek during the adult migration period, and therefore are not expected to affect migration conditions.

The relationships between flow and riffle channel depth in the covered waters were determined through HEC-RAS hydrologic modeling (Appendix A-4). The results for steelhead in Whychus Creek are illustrated in Figure 8-38. Under the DBHCP, the estimated monthly median flow in Whychus Creek at Sisters (boundary of Reaches W-3 and W-4) will range from 28 cfs in October to 80 cfs in January (Figure 8-33). The minimum flow at Sisters when TSID is diverting water will be 12 cfs. Whychus Creek will accumulate flow downstream of Sisters from surface tributaries and groundwater discharge, and by the time it reaches the mouth (Reach W-1) the minimum flow of 12 cfs will have increased to at least 50 cfs. The relationship between flow and riffle depth provided in Figure 8-38 indicates Reach W-1 will have sufficient depth for steelhead migration when the flow below the TSID diversion is 20 cfs (and the flow at Sisters is 12 cfs), but Reaches W-2 and W-3 will need about 30 cfs (roughly the instream water right) below the diversion to reach sufficient depths for adult migration and Reach W-4 will need the flow below the diversion to be at least 35 cfs. Median flows in Whychus Creek from November through February (Figure 8-33) should be sufficient for adult steelhead migration in most years, but median flows at the beginning and end of migration (October and March) will be routinely below the required water depth. This suggests that adult steelhead will find suitable water depths for migration during years of high flow, but less than preferred depths during October and March of median flow years and during all months of dry years, particularly when the flow at Sisters is 12 cfs.

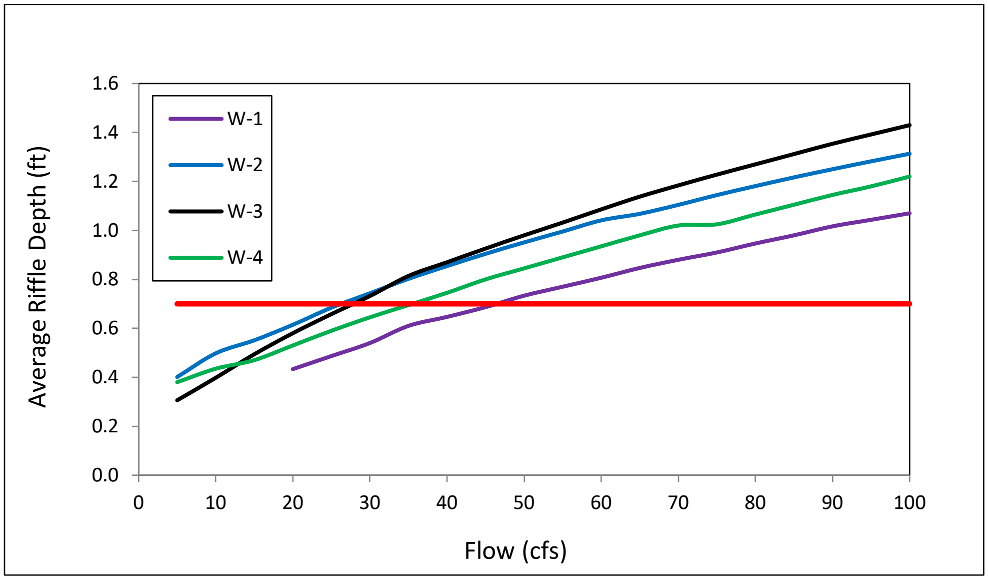


Figure 8-38. Relationship between flow and riffle depth in Whychus Creek Analysis Reaches W-1 through W-4 based on HEC-RAS hydraulic modeling. Horizontal red line indicates minimum depth for steelhead adult migration (0.70 foot). Source: See Appendix A-4.

Steelhead Spawning

HabRate modeling conducted by Spateholts and Wymore (2017) suggested that *good* steelhead spawning habitat was only available in Whychus Creek near the City of Sisters. Steelhead spawning in Whychus Creek is expected to occur from March through May (Table 8-7).The DBHCP is not expected to result in a significant change in water temperatures from historical conditions during steelhead spawning. Data presented in Figures 8-34 through 8-37 indicate historical 7-DADM values of 6 to 19°C during steelhead spawning. At the warmest location in the creek (RM 6.0) the 7-DADM has been quite variable from year to year, but has generally been above 12°C for most of April and May (Figure 8-36). Upstream of this, at Forest Road 4606, the 7-DADM has stayed below 12°C for the spawning period in most years (Figure 8-35). Near the mouth of the creek, where the influence of cool groundwater discharge is most apparent, water temperatures has still exceeded 12°C for much of May (Figure 8-37). These data suggest spawning habitat may be temperature impaired in the lower sections of Whychus Creek, supporting the HabRate model predictions that good habitat is only available upstream of Sisters. This is not expected to change under the DBHCP.

Minimum water depth for steelhead spawning is 0.79 foot. Median flows in Whychus Creek from March through May will range from 32 to 35 cfs at Sisters (Figure 8-33). At these flows, pool tailouts and runs are expected to provide sufficient depth for spawning in all reaches. Steelhead spawning habitat area will likely be greatest in Reach W-1 because of additional inflow.

Steelhead Egg Incubation

As temperatures increase, so do the metabolic demands of growing embryos, requiring more dissolved oxygen. The capacity of water to hold dissolved oxygen diminishes with increased temperature, and at temperatures > 15°C this can delay hatching, cause smaller size at emergence and elevate mortality in steelhead embryos. The DBHCP may result in minor cooling of Whychus Creek in June compared to past conditions, but recent historical data suggest water temperatures will still exceed the optimum for steelhead incubation by late April in the reaches below the TSID diversion (Figure 8-35 through 8-37). In lower Whychus Creek, water temperatures in some water years exceed the stress tolerance for developing embryos (15°C).

Steelhead Summer Rearing

Summer rearing potential for steelhead in Whychus Creek was evaluated by applying a fish capacity model developed in the Crooked River Basin (Appendix A-1) to site-specific water temperatures and flow conditions in Whychus Creek. The Crooked River Basin provided a contemporary data-driven model relating fish abundance to habitat features, and due to its proximity to Whychus Creek, it was considered the best available data for this assessment. Juvenile rearing capacity was estimated for three different flow scenarios (historical, DBHCP and natural) originally developed for the ODEQ Heat Source model (Watershed Sciences and MaxDepth Aquatics 2008). Scenarios with the lowest temperatures were generally associated with higher rearing capacity values (Table 8-14). Overall, the DBHCP instream water right of 31.18 cfs below the TSID diversion is estimated to provide an 86 percent increase in juvenile steelhead rearing capacity relative to historical flows. Rearing capacity in Whychus Creek will be less than this when the instream flow is less than the full instream right (the allowable minimum under the DBHCP is 20 cfs below the diversion), but available data are insufficient to model the minimum flow for the entire creek or determine how frequently it will occur. The historical flow scenario shown in Table 8-14 assumed a flow of 21.84 cfs below the TSID diversion, but this water did not have an associated instream right and flows in downstream reaches were allowed to drop below 10 cfs in the model. Under the DBHCP, a flow of 20 cfs below the TSID diversion (12 cfs at Sisters) will be protected from diversion in all reaches of Whychus Creek and the resulting steelhead summer rearing capacity will be higher than the estimate for historical flows in Table 8-14.

Table 8-14. Estimated steelhead summer rearing capacity and predicted habitat characteristics in Whychus Creek.

Reach	Scenario	Rearing Capacity		Mean Density (fish/ft^2)	Mean Flow (cfs)	MWAT (°C)
		95th Quantile	Median			
W-1	Historical	23,490	22,318	0.16734	61.45	15.25
	Current/DBHCP	13,257	12,379	0.08911	87.86	15.91
	Natural	24,873	23,665	0.14668	224.00	13.29
W-2	Historical	832	330	0.00053	9.00	23.04
	Current/DBHCP	13,993	11,275	0.01440	35.40	18.49
	Natural	170,992	161,065	0.16001	171.60	13.15
W-3	Historical	232	131	0.00317	3.31	20.92
	Current/DBHCP	20,772	19,594	0.29706	29.54	14.82
	Natural	14,713	13,724	0.15835	165.70	11.76
W-4	Historical	44,583	41,143	0.17081	21.84	15.40
	Current/DBHCP	80,313	75,653	0.27905	30.16	14.14
	Natural	88,392	83,526	0.17391	166.3	11.61
TOTAL	**Historical**	**69,137**	**63,922**			
	Current/DBHCP	**128,335**	**118,901**			
	Natural	**298,970**	**281,980**			

Steelhead Winter Rearing

Winter rearing potential for steelhead in Whychus Creek was not quantitatively evaluated. In general, winter rearing capacity is positively correlated with flow (Appendix A-1). Median flows in Whychus Creek under the DBHCP will be higher than historical flows from December through February and slightly lower than recent historical flows in October and March (Figure 8-33). Overall, the instream right of 31.18 cfs and minimum flow of 20 cfs below the TSID diversion will eliminate extremely low winter flows, and this is expected to have a positive effect on winter rearing conditions for steelhead. The diversion of water has much less effect on peak water temperature in the winter than it does in the summer, and diversions from Whychus Creek during the winter are not expected to result in water temperatures outside the preferred range for rearing juvenile steelhead (< 14°C).

Steelhead Smolt Migration

As noted for the Middle Deschutes River, higher flows in the upper Deschutes Basin are expected to be positively associated with smolt survival during migration (Appendix A-3). Comparison of current/DBHCP flows to historical flows in Whychus Creek indicates that median flows at Sisters will decrease a very small amount (1 cfs) at the beginning of steelhead trout emigration in April, and increase from 4 to 25 cfs in May and June (Figure 8-33). This could have a small positive effect on smolt migration.

No data are available on optimal or preferred water temperatures for steelhead smolt migration, but migration travel times tend to decrease as temperatures warm in the spring.

However, once temperatures reach about 16°C, piscivorous fish species also become more active and risk of predation becomes much higher for smolts. As indicated in Figures 8-34 through 8-37, weekly maximum water temperatures in Whychus Creek during the period of smolt migration (April through June) can range from 5.0 to 20.0 °C depending on the water year and stream reach. However, the majority of the smolts in Whychus Creek should be downstream before temperatures reach 16°C. Temperatures are not expected to change under the DBHCP and therefore temperature-related effects on smolts are predicted to be minimal.

Net Effect on All Life Stages of Steelhead in Whychus

The DBHCP will represent an improvement for steelhead trout in Whychus Creek compared to historical conditions. Much of this improvement will be the result of instream water rights that have been created over the past 10 years. Consequently, conditions for steelhead in Whychus Creek under the DBHCP will be much the same as current (2020) conditions. The primary improvement for steelhead from historical conditions will be increased summer flows and associated increases in juvenile summer rearing habitat (Table 8-14). The estimated summer rearing capacity under the DBHCP is as much as 86 percent higher than it was historically. Conditions for other life stages (adult migration, spawning, incubation, winter rearing and smolt emigration) will remain constant or improve slightly as a result of the DBHCP. To the extent that none of these other life stages is limiting for the population overall in Whychus Creek, the total number of steelhead produced by the creek should be measurably greater than it was prior to 2010.

8.2.3 Crooked River Subbasin

8.2.3.1 Crooked River

Overview

A primary goal of the ongoing Upper Deschutes reintroduction program is to provide steelhead access to the lower Crooked River from the mouth (Lake Billy Chinook) to Bowman Dam (Prineville Reservoir). This entire 70.5-mile reach is affected to varying degrees by Reclamation's storage and release of water in Prineville Reservoir. Portions of the lower 56 miles are also affected by diversion of water at OID's Crooked River Diversion (RM 56.5) and NUID's Crooked River Pumps (RM 27.6). Eleven irrigation returns covered by the DBHCP between RM 49.4 and RM 11.9 also affect flows in the Crooked River (see Chapter 3 for a summary of all covered activities on the Crooked River). Reclamation's operation of Prineville Reservoir affects downstream flows year round; flows are reduced along the entire 70.5 miles during the storage season (October to March) and increased in portions of the 70.5 miles during the irrigation season (April to September). The diversions covered by the DBHCP reduce flows during the irrigation season. Irrigation returns contribute to instream flow year round, but the majority of return flow occurs during the irrigation season and for a month or more afterward. Return flows reach the river through named and unnamed surface tributaries as well as shallow groundwater discharge. The river is also affected by multiple irrigation diversions and returns that are unrelated to the DBHCP, including 34 small OID patron pumps between RM 49.8 and RM 38.4. The Crooked River Diversion and Crooked River pumps are screened to prevent entrainment of juvenile salmonids and are designed to allow unimpeded upstream and downstream movement of fish.

The historical hydrology of the Crooked River is presented in Section 4.8, *Crooked River, Ochoco Creek and McKay Creek*. The effects of the DBHCP on Crooked River hydrology appear in Section 6.5.3.3, *Effects of DBHCP Measures CR-1 on the Hydrology of the Crooked River*. Natural flows in the Crooked River have a very strong seasonal component (see Figure 4-45). Inflow to Prineville Reservoir (unregulated flow) typically peaks at 2,000 cfs or more during spring snowmelt and drops to nearly zero in late summer. Winter and spring storms in some years can also produce sudden increases to reservoir inflow. Flows downstream of the reservoir (regulated flows) are determined by natural conditions, reservoir operations and irrigation diversions. Flows in the lower Crooked River are generally low in the winter due to natural conditions (low reservoir inflow) and irrigation storage of runoff events, but variable in the summer due to the complex combination of releases, diversions and returns. The 13.5 miles of river between Bowman Dam and Crooked River Diversion have consistent flows of 200 cfs or more during the summer due to the conveyance of irrigation water from the reservoir to the diversion. Downstream of Crooked River Diversion, the flow is considerably less and more variable due to the multiple diversions and returns that respond to common weather conditions in a largely independent manner. Low flow conditions (both summer and winter) persist downstream to about RM 13.8, where large influxes of groundwater begin to contribute more than 1,000 cfs to the Crooked River on a consistent basis (Gannet et al. 2001).

Historical water temperature conditions in the Crooked River are summarized in Section 4.8, *Crooked River*, *Ochoco Creek and McKay Creek*. The cooling effect of Prineville Reservoir is expected to continue under Reclamation's management, concurrent with DBHCP implementation, and summer water temperatures downstream of Bowman Dam will continue to be several degrees cooler than they would otherwise be (Figures 8-39 through 8-44). Nevertheless, water temperatures will continue to exceed preferred ranges for salmonids at times downstream of the Crooked River Diversion (RM 56.5). The Crooked River is listed as water temperature limited under Section 303(d) of the Clean Water Act for exceeding the 7-DADM of 17.8°C for salmon and trout rearing, as well as for multiple other water quality criteria (see Table 4-12).

The water temperature predictions in Figures 8-39 through 8-44 were developed by Berger et al. (2019) using the CE-QUAL-W2 water temperature model and projected flows developed with the RiverWare hydrologic model (Reclamation 2019).The hydrologic predictions from 2019 used for the water temperature analysis differ slightly from the 2020 predictions described in Chapter 6 (Reclamation 2020a) due to minor changes in assumptions about the timing of Reclamation's release of storage from Prineville Reservoir for NUID and the timing of NUID's release of storage from Wickiup Reservoir. The assumptions in the RiverWare modeling (Reclamation 2019, 2020a) are all within the range of allowable reservoir operations over the next 30 years, however, and both RiverWare runs are thus considered representative of conditions that could exist during implementation of the DBHCP. The differences between the model results are generally quite subtle, indicating that changes in assumptions about future management within the range of allowable options have relatively minor effects on habitat conditions in the Crooked River.

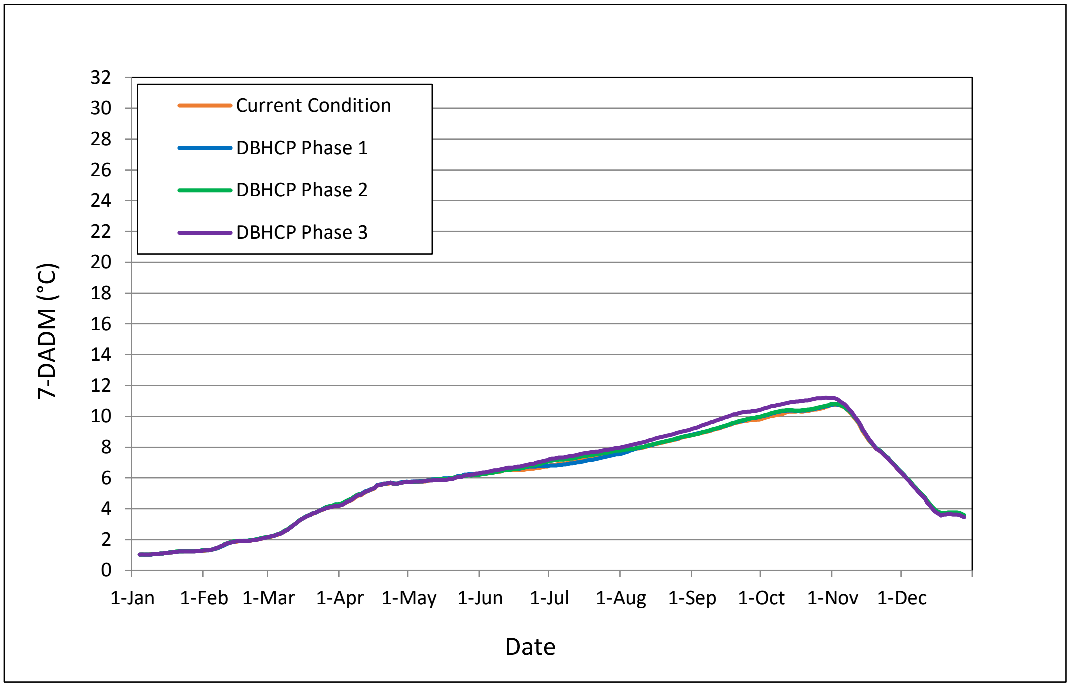


Figure 8-39. Predictions of the 7-day average of daily maximum temperature (7-DADM) under current conditions and the DBHCP in the Crooked River below Bowman Dam (RM 70.5) during an average flow year (2005). Source: Berger et al. 2019.

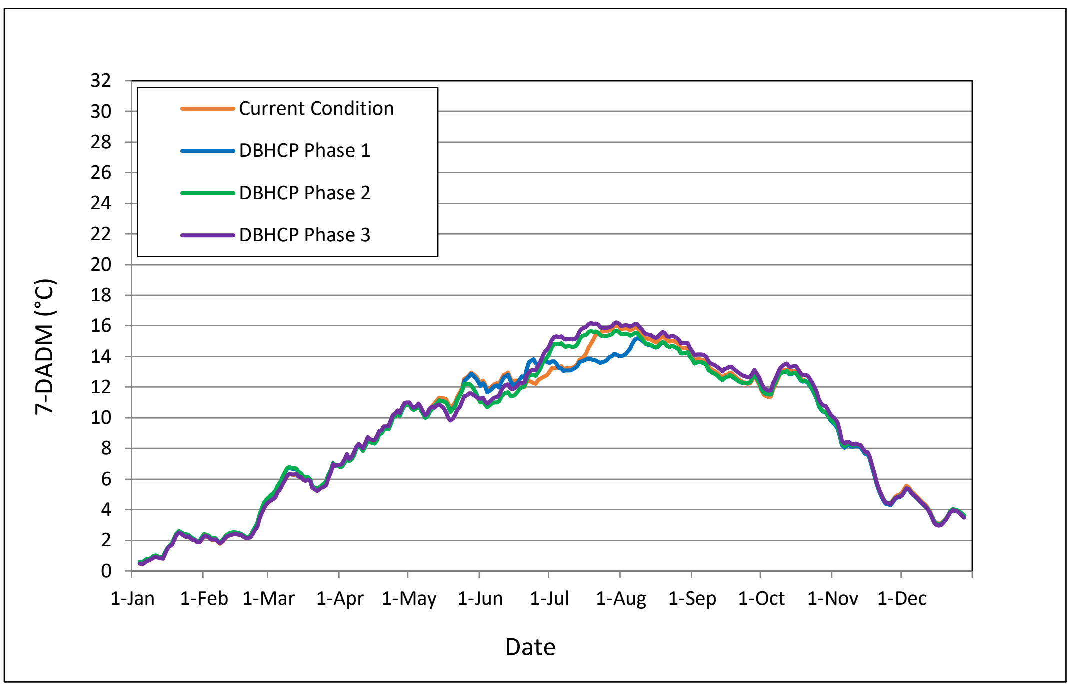


Figure 8-40. Predictions of the 7-day average of daily maximum temperature (7-DADM) under current conditions and the DBHCP in the Crooked River at the Crooked River Diversion (RM 57) during an average flow year (2005). Source: Berger et al. 2019.

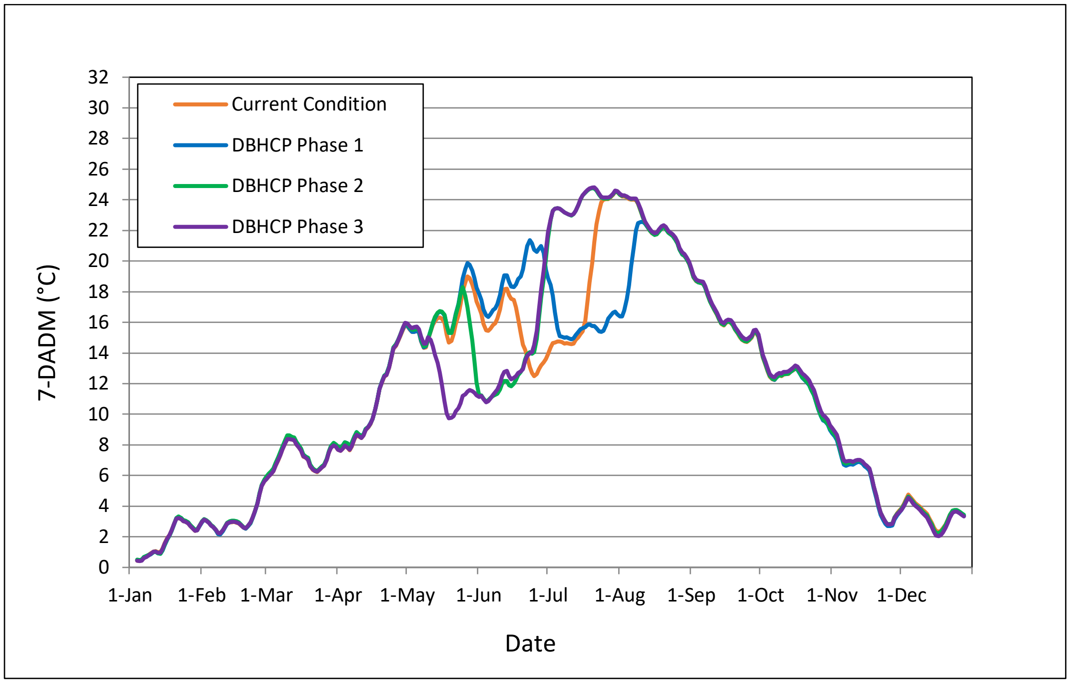


Figure 8-41. Predictions of the 7-day average of daily maximum temperature (7-DADM) under current conditions and the DBHCP in the Crooked River at Hydromet Station CAPO (RM 48) during an average flow year (2005). Source: Berger et al. 2019.

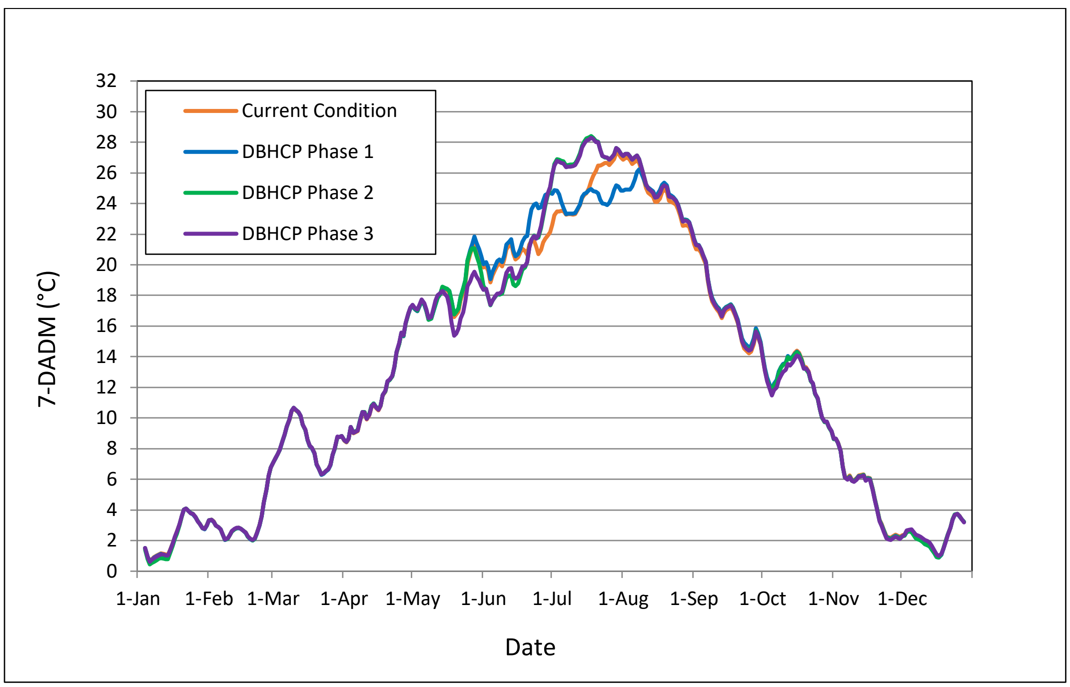


Figure 8-42. Predictions of the 7-day average of daily maximum temperature (7-DADM) under current conditions and the DBHCP in the Crooked River at the NUID pumps (RM 28) during an average flow year (2005). Source: Berger et al. 2019.

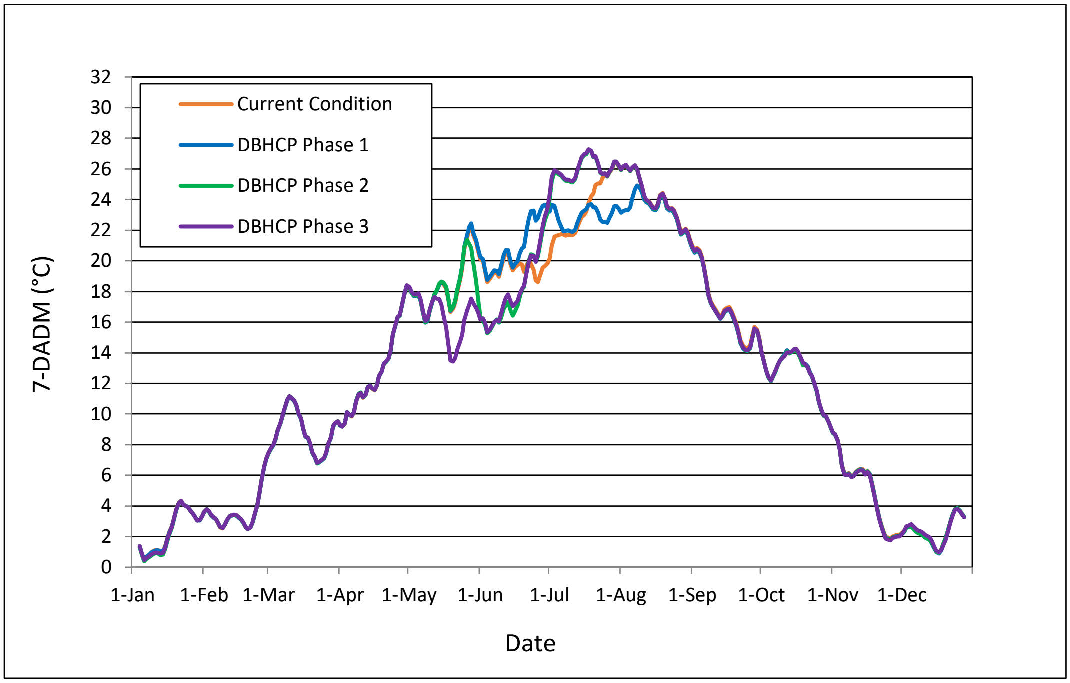


Figure 8-43. Predictions of the 7-day average of daily maximum temperature (7-DADM) under current conditions and the DBHCP in the Crooked River at OWRD Gage 14087300 (RM 27) during an average flow year (2005). Source: Berger et al. 2019.

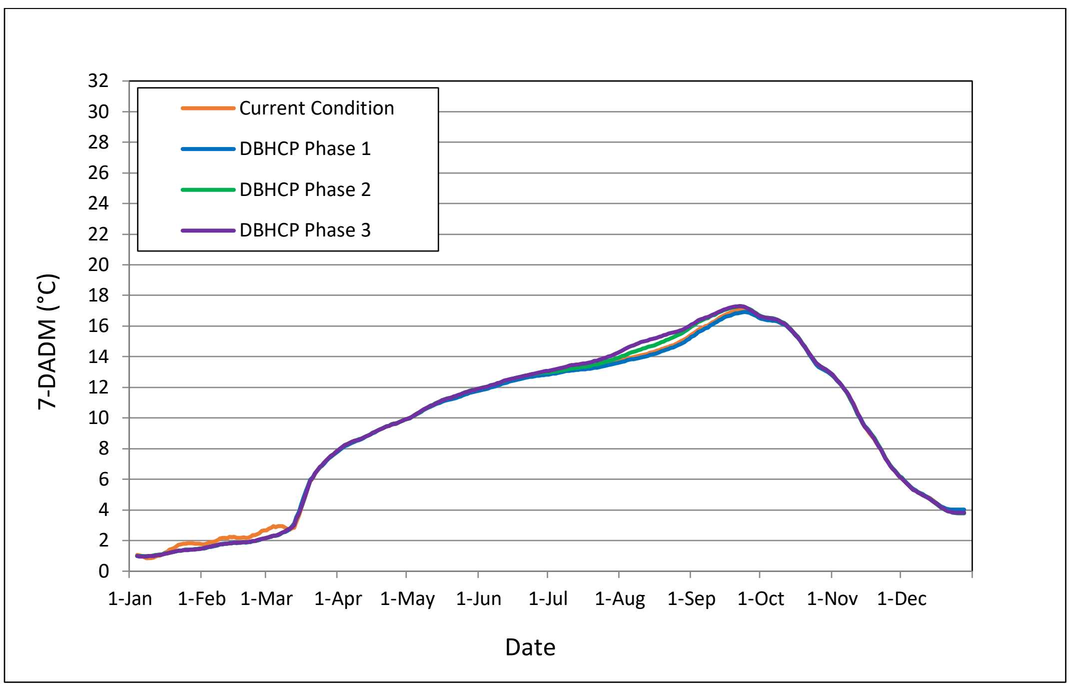


Figure 8-44. Predictions of the 7-day average of daily maximum temperature (7-DADM) under current conditions and the DBHCP in the Crooked River below Bowman Dam (RM 70.5) during a wet flow year (1993). Source: Berger et al. 2019.

Steelhead Adult Migration

A notable proportion of returning adult steelhead that are captured at the Pelton fish trap and released into Lake Billy Chinook are subsequently detected in the Crooked River subbasin (Table 8-9), but total numbers are still relatively small and it is difficult to make site-specific inferences about preferred migration conditions. Upstream migration can be impeded by changes in flow and other management practices that influence channel depth or water temperature and create physical or thermal barriers to fish movement. For steelhead, a minimum channel depth of 0.70 foot is required for adult upstream passage (CDFW 2017) and the preferred water temperature range is 10.0 and 12.8°C. Migration is likely to be delayed if water temperatures exceed 21°C (Table 8-7). Avoidance by migrating adults has not been reported until temperatures exceed 14.4°C.

Predicted water temperatures for the DBHCP shown in Figures 8-39 through 8-43 indicate that during an average flow year in the Crooked River (2005), water temperatures will be below 12.8°C for all of the steelhead adult migration period, with the exception of early October. While some October temperatures in some areas may reach 14°C, they will remain below the avoidance range. Similar trends are expected to occur in years of higher and lower than average flow (Berger et al. 2019), although a year with high reservoir inflow late in the winter (1993) resulted in higher than average water temperatures in Prineville Reservoir and the lower Crooked River that persisted well into October (Figure 8-44), indicating that natural runoff conditions have the potential to overwhelm the cooling effect of the reservoir and increase water temperatures throughout the lower river simultaneous with high flows.

Predicted average monthly temperatures during the steelhead migration period are not expected to change under the DBHCP, with minor exceptions (Figure 8-45). In years like 2001 (dry), average temperatures under the DBHCP are predicted to decrease slightly in Reaches C-3 and C-4 during November and December. In years like 1993 (wet) and 2005 (average), the DBHCP is not likely to affect migrating steelhead since predicted temperatures are nearly identical to current conditions.

Predicted changes in average riffle depth corresponding to the Reclamation (2019) flow predictions used by Berger et al. (2019) were examined to determine if and where physical barriers to adult steelhead migration were likely to occur during DBHCP implementation (Appendix A-4). Comparison of modeled riffle depths does not reveal large changes relative to current conditions in years like 2005, but average riffle depths are predicted to increase slightly from current conditions in years when winter flows are naturally low like 1993 and 2001 (Figure 8-46). As a result, the frequency of riffle depths below the preferred minimum of 0.70 foot will decrease under the DBHCP (Table 8-15). These increases in average riffle depths are likely to benefit migrating steelhead by reducing the potential for physical barriers.

Taken together, predicted flow and temperature conditions in the Crooked River suggest that in certain years the DBHCP measures are likely to reduce the number of physical barriers to adult steelhead migration in the lower reaches, and will have an inconsequential effect on water temperature.

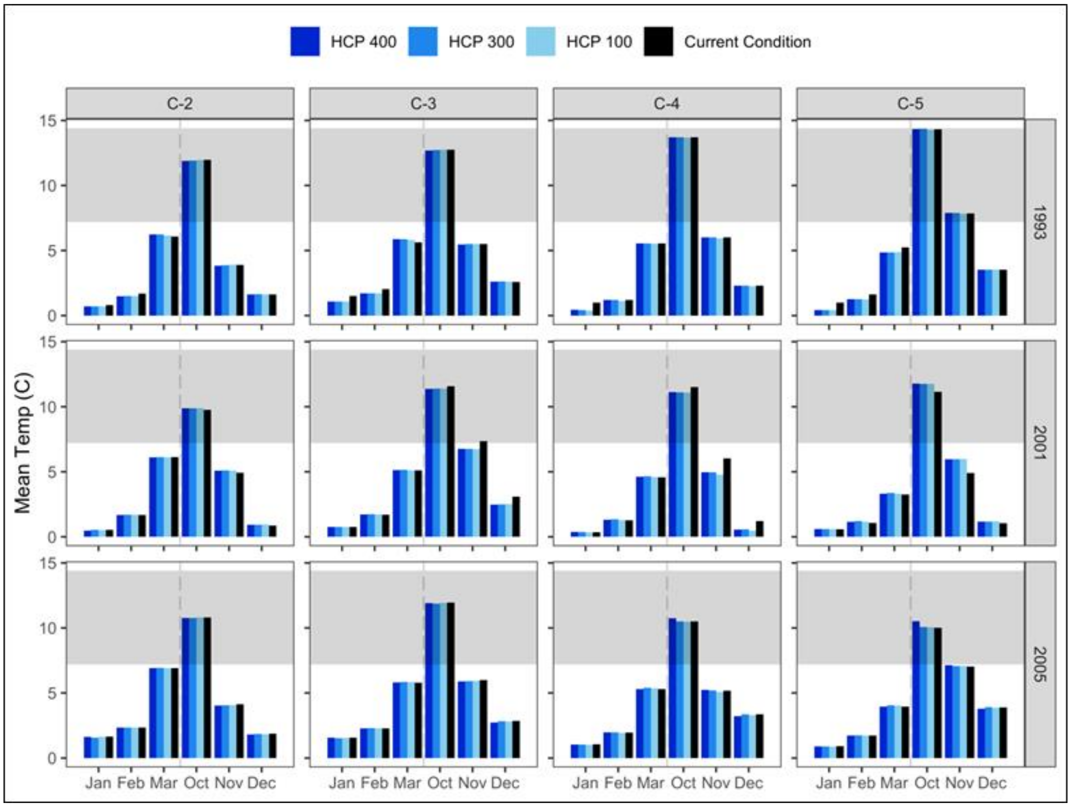


Figure 8-45. Estimated average temperature in the Crooked River during the steelhead migration period. A grey shaded area indicates the range in temperatures assumed to be associated with optimum conditions for summer steelhead migration during three sample years Source: See Appendix A-4.

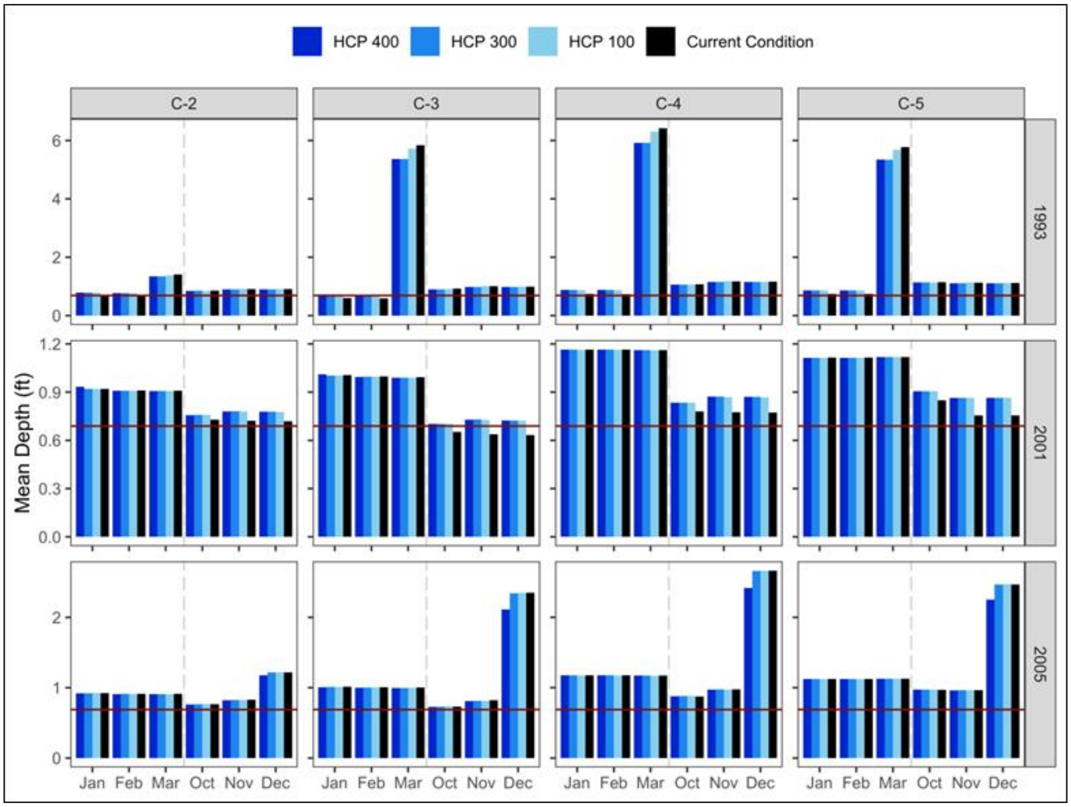


Figure 8-46. Estimated average riffle depth in the Crooked River during the steelhead migration period. A horizontal red line indicates minimum depth required for passage. Source: See Appendix A-4.

Table 8-15. Number of weeks when modeled average riffle depths were below the threshold required for upstream passage (0.70 foot; CDFW 2017) during the steelhead migration period.

Year	Month	Reach	Number of Weeks with Average Riffle Depth < 0.7 Feet			
			Current Condition	HCP 100	HCP 300	HCP 400
1993	Jan	C-2	3	0	0	0
		C-3	4	0	0	0
	Feb	C-2	4	0	0	0
		C-3	4	0	0	0
	Mar	C-2	1	0	0	0
		C-3	1	0	0	0
2001	Oct	C-3	4	2	2	2
	Nov	C-3	4	0	0	0
	Dec	C-3	4	0	0	0
2005	Oct	C-3	2	2	2	2

Steelhead Spawning

Steelhead abundance remains low in the Crooked River, so there are few direct observations on how adults select spawning sites. Therefore, HabRate modeling conducted by Spateholts and Wymore (2017) was utilized to assess spawning conditions. Most of the potential spawning areas in the Crooked River were ranked as *fair* and *poor*, but *good* summer steelhead spawning habitat was identified near Opal Springs.

Steelhead that spawn in the Crooked River will be seeking water temperatures between 4.0 and 12.0°C from March through May. The entire lower Crooked River is expected to remain below 12.0°C through mid-April under all flow conditions and all phases of DBHCP implementation (Figures 8-39 through 8-44), but temperatures will likely exceed 12°C in May in some reaches and under some flow conditions. Upstream of the Crooked River Diversion, water temperatures may approach 16°C during May in years like 1993 when water temperatures in Prineville Reservoir were elevated (Figure 8-47). Downstream of the Crooked River diversion, water temperatures will regularly exceed 12°C by early May, and this is expected to limit spawning habitat conditions. Water temperatures above 12°C from May through September are a natural condition in the Crooked River that is ameliorated in certain reaches only by the presence of Prineville Reservoir and the release of cold water it enables during normally hot months. Prior to construction of the reservoir, steelhead would likely have completed spawning before the naturally high water temperatures occurred in May.

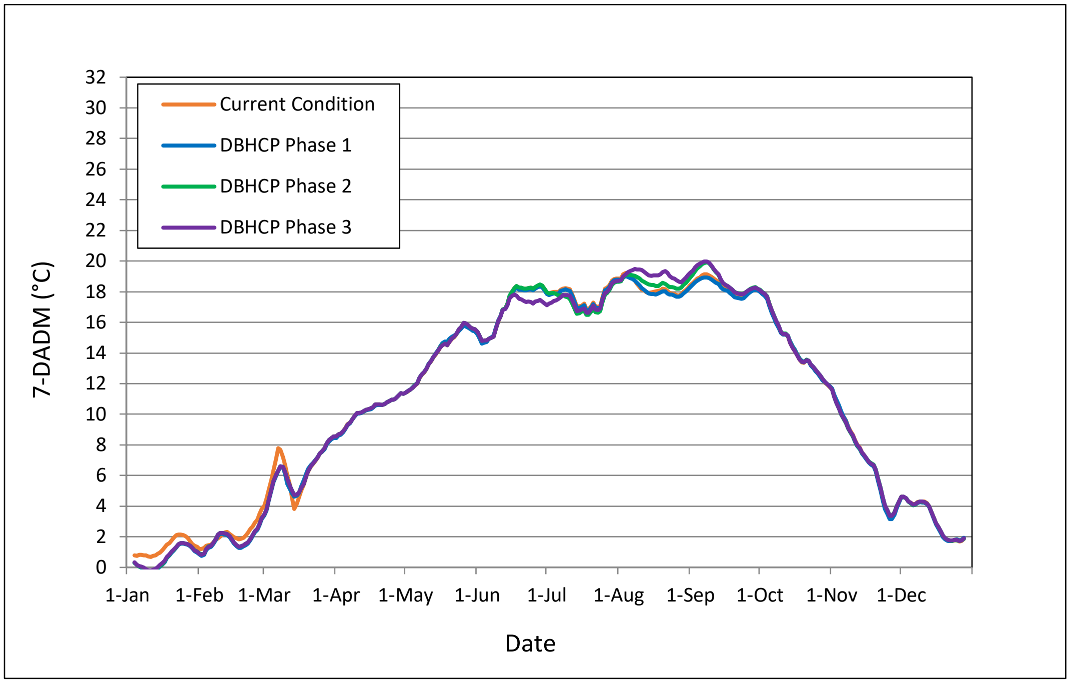


Figure 8-47. Predictions of the 7-day average of daily maximum temperature (7-DADM) under current conditions and the DBHCP in the Crooked River at the Crooked River Diversion (RM 57) during a wet flow year (1993). Source: Berger et al. 2019.

The predicted maximum water temperatures for March through May under the DBHCP are comparable to or lower than current conditions, and thus the DBHCP will maintain current conditions for steelhead spawning habitat (Figures 8-39 through 8-44). In an average water year (2005) during Phase 3 of DBHCP implementation, the maximum water temperatures in late May and early June may decline between RM 48 (Figure 8-41) and RM 27 (Figure 8-43), thereby providing a net benefit to spawning steelhead. Overall, water temperature modeling for the lower Crooked River (Berger et al. 2019) indicates that while modifications to flow can affect water temperatures, the extent to which temperatures can be decreased is limited by local environmental conditions that cause water temperatures to be naturally high by early summer.

Similarly, a comparison of modeled DBHCP flows to current conditions did not reveal any large changes in the Crooked River during the steelhead trout spawning period (Figure 8-48). In wet (1993) and dry (2001) years, flow conditions are expected to be nearly identical to current conditions. In an average water year such as 2005, flows are predicted to increase slightly between Hydromet Stations PRVO (RM 70) and CAPO (RM 48) in late May and early June, likely increasing steelhead spawning habitat area at the end of the spawning period (March-May).

Conservation Measure CR-6 will result in a small increase in flow downstream of the NUID Pumps during the month of May in dry years by increasing the required minimum flow from 43 cfs to 50 cfs (see Chapter 6, Section 6.5.2). This will result in a small increase in spawning area, but relatively little change in water temperature. This small change in flow is not reflected in Figure 8-48 because it will occur between two analysis points (CAPO and Opal Springs).

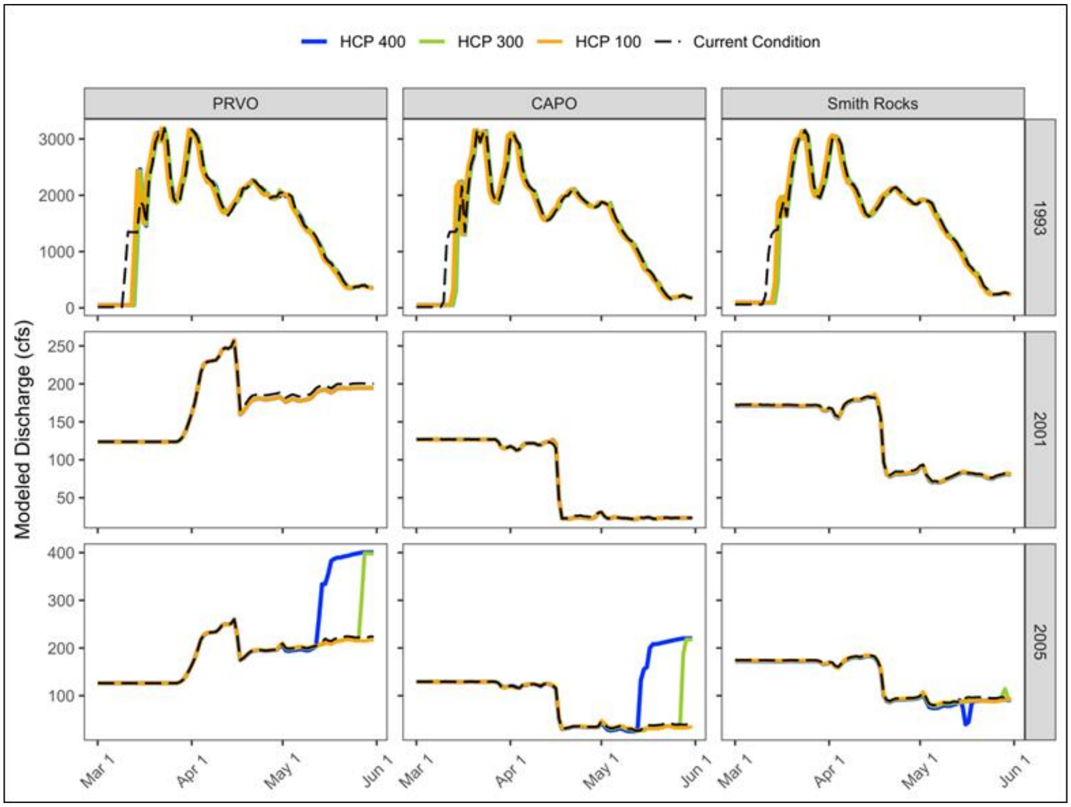


Figure 8-48. Modeled discharge during the steelhead spawning period in the lower Crooked River at Hydromet Stations PRVO (RM 70) and CAPO (RM 48), and at Smith Rock.

Steelhead Egg Incubation

Water temperatures in the Crooked River during the period of steelhead egg incubation will not change substantially as a result of the DBHCP. Temperatures upstream of the Crooked River Diversion will remain within the preferred range for incubation through mid-May, and below the threshold for stress to developing eggs (> 15°C) through June (Figure 8-40). Downstream of the Crooked River Diversion water temperatures will exceed the upper limit of the preferred range (11.1°C) by mid-April and the threshold for stress by mid-May in many years (Figures 8-41 through 8-43). The variations in water temperatures between DBHCP phases are the results of different patterns of use of the 10,000 acre-feet of water available for NUID in Prineville Reservoir. NUID typically calls for the water when its other sources (live flow in the Crooked River and the combination of live flow and storage in the Deschutes River) are not enough to meet irrigation demand. When the water is called for, it is released from Prineville Reservoir in addition to other releases and conveyed 42 miles from Bowman Dam to the NUID pumps. This conveyance increases the flow (both volume and speed of water) in these 42 miles of river and simultaneously decreases water temperature. Downstream of the NUID pumps the Crooked River is unaffected by the release of the 10,000 acre-feet, except that water directly downstream of the pumps may be cooler than it would otherwise be due to the larger thermal mass and shorter travel time for water between Bowman Dam and the pumps. Depending on the timing of NUID's need, which varies by DBHCP phase, the water can be released any time between April and September. Each phase of DBHCP implementation represents an incremental decrease in the availability of Deschutes River water for NUID, so the demand for the 10,000 acre-feet from Prineville Reservoir comes earlier in the irrigation season with each successive phase. This is most apparent in Figure 8-41, which shows that by Phase 3 of implementation NUID could be calling for the Prineville Reservoir water in mid-May. The CE-QUAL-W2 water temperature modeling results presented in Figure 8-41 suggest the 10,000 acre-feet could reduce the temperature of the lower Crooked River up to 8°C, depending on the timing of the release. The greatest reduction in temperature would come during July, when natural temperatures are at their highest. If the release occurs in May and June it can benefit steelhead egg incubation. If it comes in July and August it could benefit juvenile rearing by reducing the annual maximum temperature in the river. The magnitude of difference between the phases (i.e., the magnitude of benefit from the 10,000 acre-feet) diminishes with downstream distance (compare Figure 8-41 to Figure 8-42) because meteorological conditions in the Crooked River Canyon tend to drive surface water temperatures toward equilibrium irrespective of flow.

The small increase in required minimum flows downstream of the NUID pumps during May of dry years (see Conservation Measure CR-6) may decrease water temperatures slightly between there and Osborne Canyon. However, water temperatures within this reach will still be above 11.1°C by mid-April and above 15°C by May of most dry years even with the additional flow.

Steelhead Summer Rearing

Summer rearing potential for steelhead in the Crooked River Basin was evaluated by developing a fish capacity model that estimates juvenile fish potential. The model: 1) relates observed fish densities to habitat attributes (e.g., depth and maximum weekly average temperature); 2) estimates the changes in habitat attributes (e.g., depth, width, total area and temperature) under the DBHCP using predictive models (e.g., CE-QUAL-W2) for hydraulic area calculations and temperature changes; 3) estimates fish density under DBHCP phases by applying modeled habitat coefficients to predicted changes in habitat area and temperature; and 4) expands those predicted densities to the total available habitat to estimate fish production potential (weekly expected number of fish) within analysis reaches (Figure 8-49). The modeling approach is described in detail in Appendix A-1. The current condition and all three phases of DBHCP implementation were assessed for three hydrologic conditions representing a wet year (1993), an average year (2005) and a dry year (2001) from the historical record. Flow predictions for the analysis were derived from Reclamation (2019), and water temperature data were from Berger et al. (2019). Summer capacity was summarized on a weekly time scale (roughly mid-May to early October). The week with the lowest total capacity for each scenario is shown in Figure 8-50 and summarized in Table 8-16.

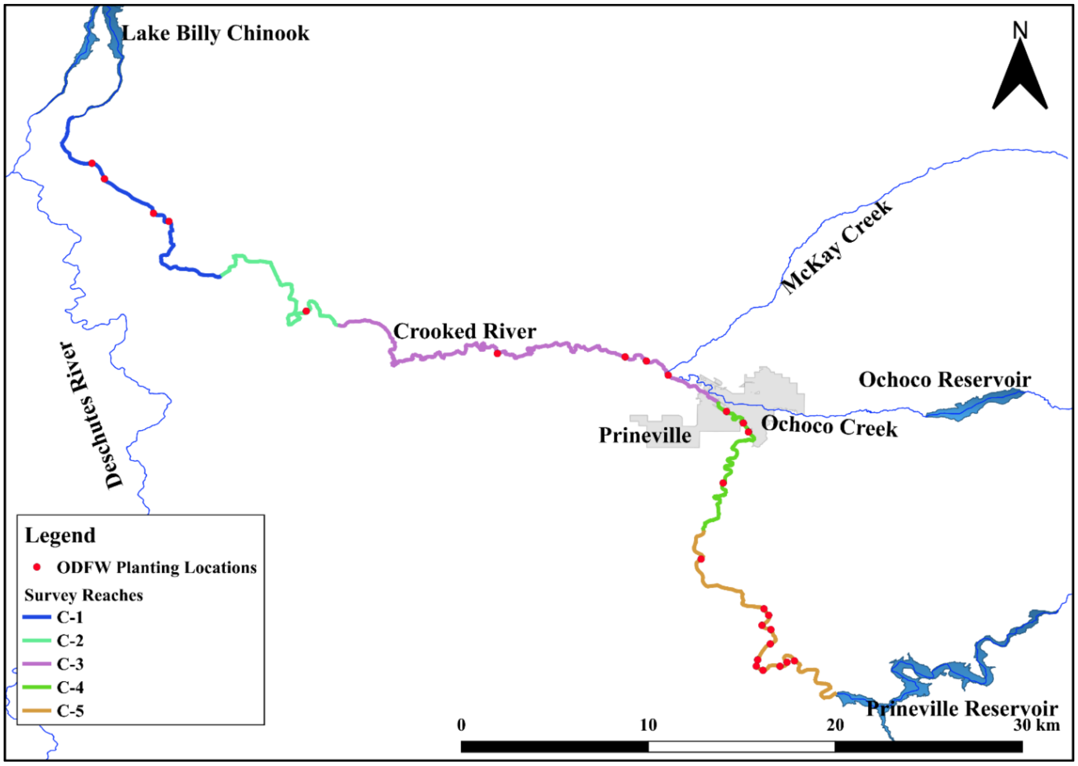


Figure 8-49. Map of the Crooked River and its tributaries showing analysis reaches for estimating juvenile rearing capacity.

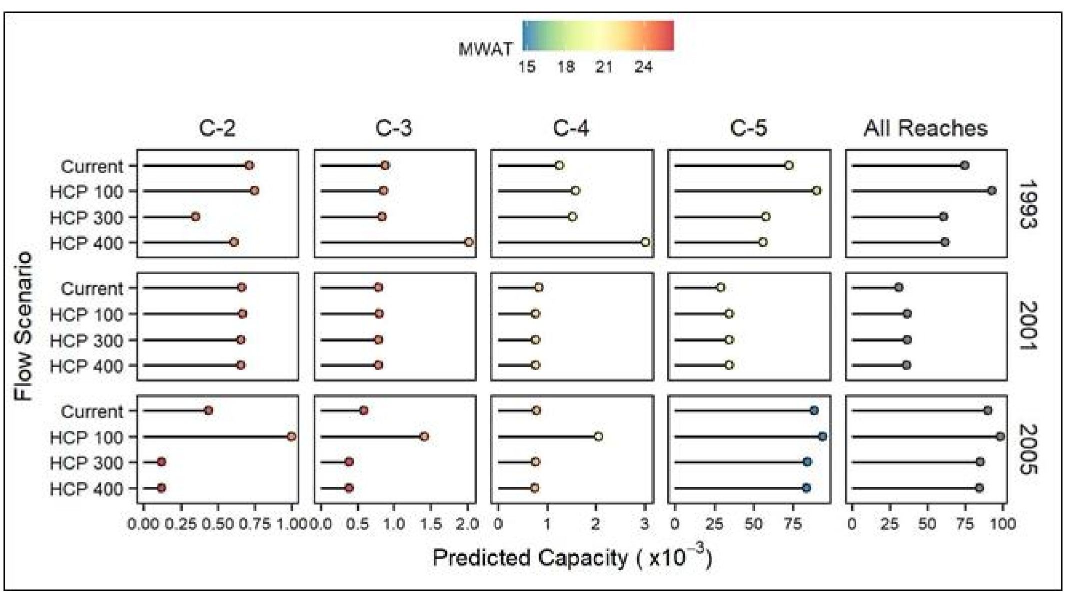


Figure 8-50. Predicted juvenile steelhead summer rearing capacity (x 1,000 fish) for Crooked River Reaches C-2 through C-5 in three historical water years. Values are the 95th quartile of Poisson distribution. Source: See Appendix A-1.

Table 8-16. Juvenile steelhead summer capacity estimates for four reaches of the mainstem Crooked River.

Water Year	Scenario	Summer Rearing Capacity (number of juvenile fish)				
		Reach C-2	Reach C-3	Reach C-4	Reach C-5	All Reaches
1993	CURRENT	717	886	1,263	72,391	75,257
	DBHCP 100	752	857	1,582	89,957	93,148
	DBHCP 300	350	835	1,523	57,822	60,530
	DBHCP 400	611	2,021	3,020	56,108	61,760
2001	CURRENT	665	782	839	29,058	31,344
	DBHCP 100	669	801	775	34,282	36,527
	DBHCP 300	660	790	774	34,631	36,855
	DBHCP 400	657	784	774	34,235	36,450
2005	CURRENT	437	590	789	88,846	90,662
	DBHCP 100	1,000	1,413	2,056	93,956	98,425
	DBHCP 300	121	385	774	84,237	85,517
	DBHCP 400	121	385	750	83,772	85,028

Crooked River Reach C-5 (Bowman Dam to Crooked River Diversion) has by far the highest overall capacity for juvenile *O. mykiss* summer rearing in all water years and all flow scenarios, primarily due to low water temperatures below the dam. Differences between flow scenarios and water years in the other reaches are variable. For water year 1993 (wet year), the DBHCP 400 scenario yields more than twice the capacity of the current condition in Reaches C-3 and C-4 due to a cooling effect of higher flows, but this increase is negligible compared to the number of fish predicted in Reach C-5 under all scenarios. In the 2001 water year (dry year), all scenarios are relatively comparable across all reaches. The 2005 water year (average year) has significant variability among scenarios in Reaches C-2, C-3 and C-4. Among those reaches, DBHCP 100 yields the highest capacity, which is driven by lower water temperatures predicted for that scenario relative to the others.

The summer capacity models were also run with set flow and temperature values to assess the sensitivity and validity of predictions (Figure 8-51). The resulting summer fish density estimates are highest at flows between 50 and 200 cfs and are inversely related to flow; this reflects the negative relationship between depth and juvenile fish abundance in the summer model (Appendix A-1). The magnitude of this relationship was highly dependent on water temperature because warmer MWAT values (e.g., 24 to 25 °C) resulted in low fish densities across all flows.

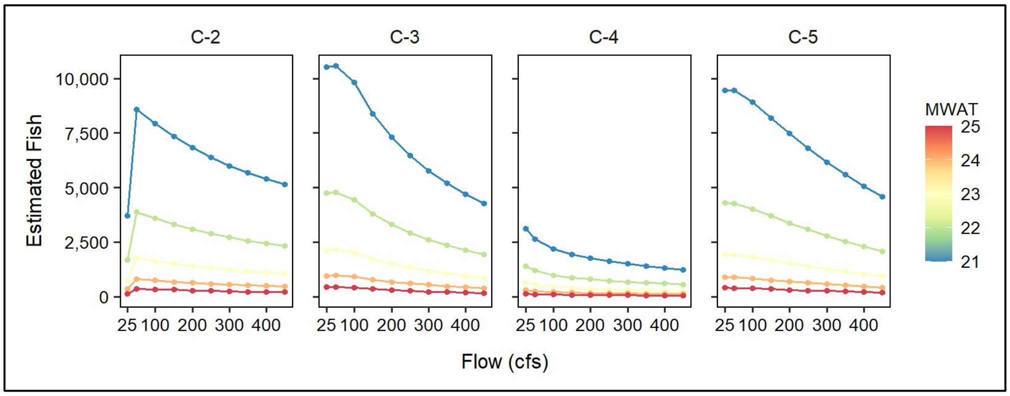


Figure 8-51. Modeled effects of flow on summer juvenile steelhead density in the Crooked River. Estimated fish numbers are the sums of median estimates for all habitat units within a reach. Source: See Appendix A-1.

A number of inferences can be drawn from the estimated capacities and the sensitivity analysis. The vast majority of fish production occurs in Reach C-5 where water temperatures remain cool throughout the summer under all flow scenarios. In Reaches C-2 through C-4, on the other hand, consistently high summer water temperatures generally negate the benefits to fish production from changing flow. Flow is estimated to be most limiting to summer rearing conditions in the Crooked River when it falls below about 50 cfs or rises above 450 cfs. Within this range, increased summer flow can decrease water temperature and increase rearing capacity, but only when the water being released from Prineville Reservoir is cool. For example, in years like 1993, when the releases from the reservoir were warm (Figure 8-47), increasing flow would have had no positive effect on rearing capacity in Reaches C-2 through C-4. In future dry years, the provision in Conservation Measure CR-6 to keep flows in Reach C-2 at or above 50 cfs will help ensure that flows remain within the optimal range for steelhead rearing. Any associated reductions in water temperature will also be beneficial to young steelhead.

Steelhead Winter Rearing

Winter rearing potential for steelhead in the Crooked River Basin was evaluated by developing a fish capacity model that estimates juvenile fish capacity similar to the summer capacity model (Appendix A-1). The primary difference between the summer and winter models is that each is based on season-specific observations of fish use and fish density in mesohabitat types. As with the summer capacity model, all three phases of DBHCP implementation and the current condition were assessed for three hydrologic conditions from the historical record (1993, 2001 and 2005). Winter capacity was summarized on a weekly time scale (roughly mid-November through December 31). The week with the lowest total capacity for each scenario is shown in Figure 8-52 and summarized in Table 8-17.

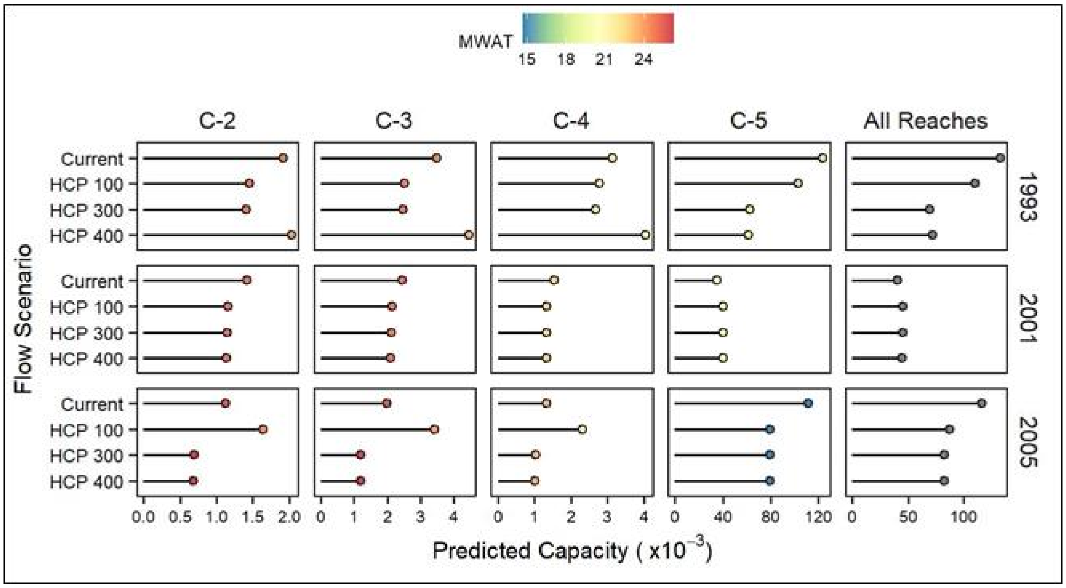


Figure 8-52. Predicted juvenile steelhead winter rearing capacity (x 1,000 fish) for Crooked River Reaches C-2 through C-5 in three historical water years. Values are the 95th quartile of Poisson distribution. Source: See Appendix A-1.

Table 8-17. Juvenile steelhead winter capacity estimates for four reaches of the mainstem Crooked River.

Water Year	Scenario	Winter Rearing Capacity (number of juvenile fish)				
		Reach C-2	Reach C-3	Reach C-4	Reach C-5	All Reaches
1993	CURRENT	1,915	3,491	3,136	123,925	132,467
	DBHCP 100	1,451	2,526	2,783	103,363	110,123
	DBHCP 300	1,416	2,481	2,668	63,111	69,676
	DBHCP 400	2,033	4,455	4,050	61,656	72,194
2001	CURRENT	1,420	2,458	1,548	35,290	40,716
	DBHCP 100	1,157	2,143	1,330	40,484	45,114
	DBHCP 300	1,152	2,121	1,332	40,529	45,134
	DBHCP 400	1,140	2,111	1,332	40,013	44,596
2005	CURRENT	1,124	1,983	1,340	111,809	116,256
	DBHCP 100	1,642	3,429	2,312	79,700	87,083
	DBHCP 300	688	1,212	1,036	79,672	82,608
	DBHCP 400	686	1,205	1,010	79,621	82,522

Estimates of winter rearing capacity are variable by reach, flow scenario and water year. As with summer rearing, the most noticeable trend is the difference between Reach C-5 and the other three reaches. The DBHCP results in lower winter capacity in Reach C-5 in wet years (1993) and average years (2005), but slightly higher capacity in dry years. The higher capacity in dry years is primarily because the current capacity is quite low and the effect of Conservation Measure CR-1 is to increase winter flow in dry years. Overall, winter rearing capacities are lower under the DBHCP for all years in Reaches C-2 through C-4. Exceptions to this are HCP 400 in a wet year (1993) and HCP 100 in an average year (2005). The reasons for these exceptions are not readily apparent; they may be the results of reservoir management assumptions used to run the hydrologic model (RiverWare) and water temperature model (CE-QUAL-W2) that supported the fish capacity modeling. As explained above, these assumptions may not fully reflect actual conditions during the implementation of the DBHCP.

The relationship between flow and the estimated number of fish in the winter is positive (Figure 8-53), but the relationship is tempered by high MWAT values from the preceding summer that can influence the distribution and survival of fish going into the winter months. The winter capacity model (Appendix A-1) was influenced by an observed correlation between summer water temperature and winter fish density. The magnitude of flow effects on winter fish capacity is significantly greater when summer thermal maximums are less than 23°C. When simulated summer water temperatures are held constant, the sensitivity analysis in Figure 8-53 indicates that increasing flow in the winter can substantially increase the number of juvenile steelhead that can be supported in all four reaches of the Crooked River.

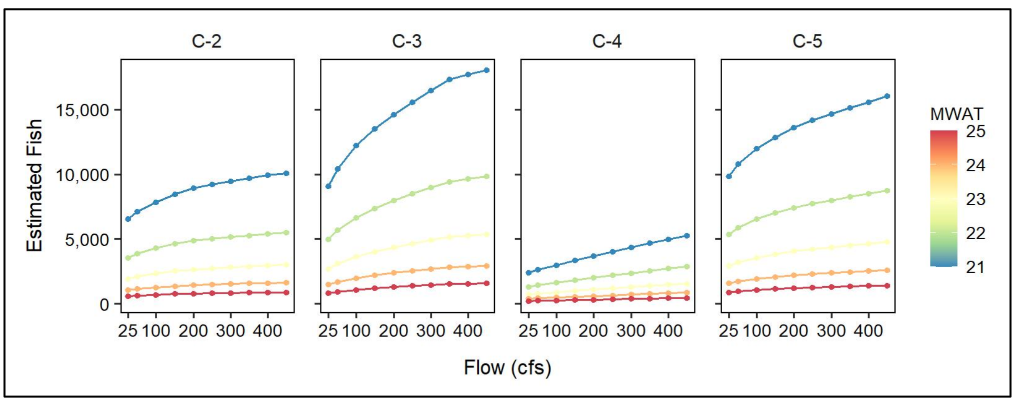


Figure 8-53. Modeled effects of flow on winter juvenile steelhead density in the Crooked River. Estimated fish numbers are the sums of median estimates for all habitat units within a reach. Source: See Appendix A-1.

Steelhead Smolt Migration

As noted for the Middle Deschutes River, higher flows in the upper Deschutes Basin are expected to be positively associated with smolt survival during migration (Appendix A-3). Comparison of modeled flow (proposed under the DBHCP) to current and historical flows indicates little change in the Crooked River due to irrigation activities during the steelhead trout emigration period. However, the use of uncontracted (fish and wildlife) storage in Prineville Reservoir by Reclamation for smolt migration pulse flows will be facilitated by provisions in Conservation Measure CR-7. Trial pulse flow releases from Prineville Reservoir during smolt migration in recent years have been found to be effective at moving the young fish downstream (PGE and CTWSRO 2019), but a key aspect of these pulses is that the full amount of water continues to flow all the way to Lake Billy Chinook. Measure CR-7 will help ensure that by eliminating the possibility for diversion of the pulses by OID and NUID. This is expected to provide a significant improvement in steelhead smolt migration compared to recent years with no pulses.

No data are available on optimal or preferred water temperatures for steelhead smolt migration, but migration travel times tend to decrease as temperatures warm in the spring. However, once temperatures reach about 16°C, piscivorous fish species also become more active and risk of predation increases. As indicated in Figures 8-39 through 8-43, predicted 7-DADM in the Crooked River during the period of smolt migration (April through June) can vary appreciably depending on the location, scenario and water year. In the some reaches below Bowman Dam, predicted temperatures for all DBHCP scenarios and the current condition are well above 16°C by May (Figure 8-42, Figure 8-43). Conversely, predicted temperatures in the reach below Bowman Dam remains cool throughout the outmigration period for all scenarios. The middle reach of the Crooked River, as measured at the CAPO gage, indicates a decline in temperature in mid-May under Phase 3 of the DBHCP compared to all other scenarios (Figure 8-41), thus suggesting an improvement to smolt survival conditions.

Net Effect on All Life Stages of Steelhead in the Crooked River

Overall conditions for steelhead in the lower Crooked River will improve modestly as a result of the DBHCP. Adult migration, spawning and summer rearing will remain largely unchanged from current conditions, while winter rearing will improve during dry water years and smolt migration will improve in all years. The winter improvements will be due in part to a shift in emphasis for the use of uncontracted (fish and wildlife) storage in Prineville Reservoir and in part to the commitment in Conservation Measure CR-1 to forego irrigation storage if needed to meet a winter minimum flow of 50 cfs. The use of uncontracted Prineville Reservoir storage, which is controlled by Reclamation with input from USFWS and NMFS, has a dominating effect on conditions for steelhead in the Crooked River. The hydraulic forecasting for the DBHCP included assumptions about future use of the uncontracted water that differ slightly from the past. With recent realization that low winter flows, particularly in the highly productive Reach C-5, can be limiting to overall steelhead production in the river, Reclamation and the Services now emphasize the use of the uncontracted water in the winter. To help further ensure the presence of suitable winter flows in dry years, the rate of irrigation storage will be reduced as necessary to maintain a flow of 50 cfs in the river when the uncontracted storage is exhausted. This shift in emphasis to the maintenance of suitable flows during the winter is expected to improve overall conditions for steelhead under the DBHCP.

Summer flows in the Crooked River are modified only slightly from historical conditions because of the realization that water temperature is the primary factor determining summer rearing conditions for steelhead, and there is limited potential to reduce water temperature from its naturally warm state. Modifications in the timing of the release of irrigation storage for NUID have the potential to lower water temperatures for several miles of the Crooked River, but the timing of these releases is determined by the availability of water for NUID from Wickiup Reservoir, and that will decrease dramatically under the DBHCP. Consequently, NUID does not have the ability to time the release of Prineville Reservoir storage for any reason other than to meet irrigation demand. The commitment by NUID to maintain a flow of 50 cfs downstream of its pumps whenever the pumps are diverting (see Conservation Measure CR-6) will produce small improvements in conditions for steelhead spawning, incubation, juvenile rearing and smolt migration between the pumps and Osborne Canyon. The additional commitment in Conservation Measure CR-7 to allow spring pulse flows to pass to Lake Billy Chinook without being diverted will substantially improve conditions for steelhead smolt migration.

The City of Prineville sewage effluent treatment discharge is not anticipated to have adverse effects on steelhead. All effluent discharges will provide slight increases in instream flow, which will have positive effects on fish habitat. Discharges directly to the Crooked River will occur only during the fall, winter and early spring (November 1 through April 30) when water temperatures in the river are well below the upper thresholds for steelhead. Furthermore, direct discharges will occur at dilution rates of at least 15:1 and thus will have negligible potential to increase or decrease river water temperature.

8.2.3.2 Ochoco Creek

Overview

Steelhead that have access to the Crooked River at Prineville will also have access to the lower 11 miles of Ochoco Creek from the mouth to Ochoco Dam. Flows in this reach are determined by the storage, release and diversion of irrigation water. The historical hydrology of Ochoco Creek is presented in Section 4.8, *Crooked River*, *Ochoco Creek and McKay Creek*. The effects of the DBHCP on Ochoco Creek hydrology appear in Section 6.5.4.4, *Effects of DBHCP Measures CR-2 on the Hydrology of Ochoco Creek*. The storage of water in Ochoco Reservoir during the winter decreases median flows in lower Ochoco Creek compared to unregulated conditions (see Figure 6-64). The release of water for conveyance from Ochoco Reservoir to Red Granary Diversion (RM 10.2), Breese Diversion (RM 7.5), North and South Infiltration Galleries (RM 5.7), Ryegrass Diversion (RM 4.7) and multiple small pumps during the summer increases median flows in the creek compared to unregulated conditions. The DBHCP will not result in a substantial change in median flows from historical conditions, but it will increase minimum flows in the creek. At times in the past the flow in Ochoco Creek has dropped to as low as 0 cfs due to storage or diversion of water. The DBHCP will eliminate extremely low flows by establishing minimum flows of 5 cfs for the irrigation season and 3 to 5 cfs for the storage season. All diversion structures on Ochoco Creek covered by the DBHCP have screens to prevent entrainment of juvenile salmonids and passage to allow volitional upstream and downstream migration.

Historical water temperature conditions in Ochoco Creek are summarized in Section 4.8, *Crooked River*, *Ochoco Creek and McKay Creek*. The cooling effect of Ochoco Reservoir on lower Ochoco Creek will continue under the DBHCP and water temperatures downstream of the reservoir will be lower than they are upstream of the reservoir. The increased minimum flow required by Conservation Measure CR-2 will reduce the potential for flows below 5 cfs during the irrigation season, but this will have minimal effect on average water temperature because flows this low were infrequent prior to the DBHCP. Historical water temperature for Ochoco Creek below Ochoco Dam (Figure 8-54) and at RM 0.7 (Figure 8-55) indicate the range of summer temperatures that can be expected under the DBHCP. A very small number of returning adult steelhead have been detected in Ochoco Creek since 2012 (Table 8-9).

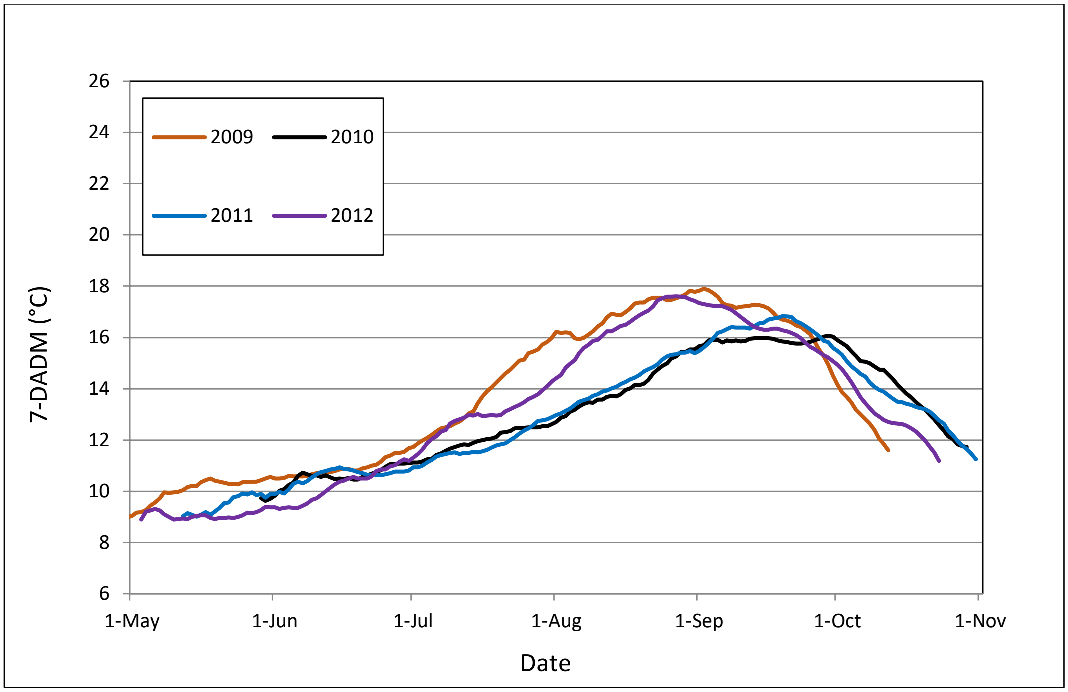


Figure 8-54. Seven-day averages of daily maximum water temperatures (7-DADM) in Ochoco Creek downstream of Ochoco Reservoir (RM 11.0) during the irrigation season. Source: CRWC 2014.

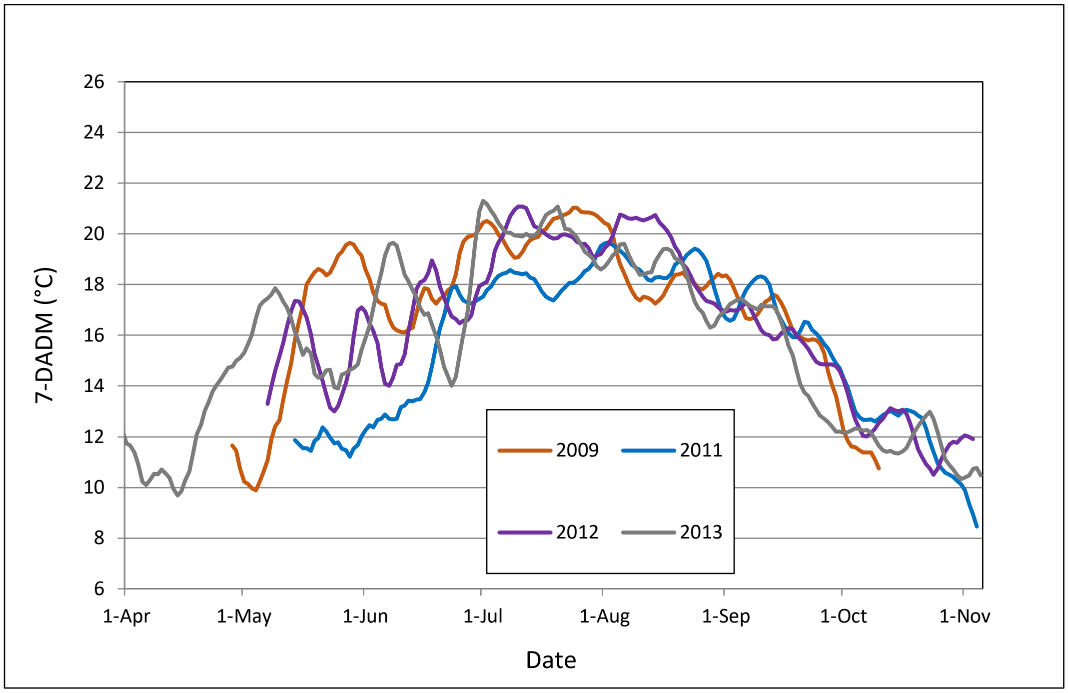


Figure 8-55. Seven-day averages of daily maximum water temperatures (7-DADM) in Ochoco Creek at RM 0.7 during the irrigation season. Source: CRWC 2014.

Steelhead Adult Migration

Water temperatures may be as high as 16°C in Ochoco Creek at the beginning of October, but the creek will cool during the month and remain below 12°C from November through March (Figures 8-54 and 8-55). These temperatures are not expected to inhibit steelhead migration.

Unlike historical conditions, Ochoco Creek will not be allowed to go dry during the winter under the DBHCP. During the adult migration period of October through March, DBHCP minimum flows in Ochoco Creek will be 3 cfs from Ochoco Dam to RM 6.3 and 5 cfs from RM 6.3 to the confluence with the Crooked River. Portions of the creek may be slightly higher due to tributary inflow, but overall flows will stay below 10 cfs in the winter except during flood events.

The results of HEC-RAS modeling of the relationship between flow and riffle channel depth in Ochoco Creek (Figure 8-56) indicate that flows of 3 to 5 cfs will not be sufficient to provide the minimum depth of 0.70 foot for migrating adult steelhead. This conclusion is supported by the recent tracking of adult steelhead that were released into Lake Billy Chinook during their upstream migration. In March of 2016, a single adult steelhead was detected migrating into Ochoco Creek for the first time since the reintroduction began (Burchell and Hill 2017). Daily average flows in Ochoco Creek were unusually high during March of 2016 due to a spring runoff event; they exceeded 20 cfs from March 7 through March 31 and exceeded 200 cfs for 10 days late in the month. In previous years of adult steelhead tracking (2012-2015) the daily average flow in Ochoco Creek did not exceed 10 cfs from January through March and no adult steelhead were detected in the creek (Hill and Quesada 2013; Hill et al. 2014; Wymore et al. 2015; Burchell et al. 2016). Taken together, flow and temperature conditions in Ochoco Creek suggest that while temperatures may be suitable during much of the migration period, steelhead are likely to encounter shallow riffles that preclude upstream migration through March in most years.

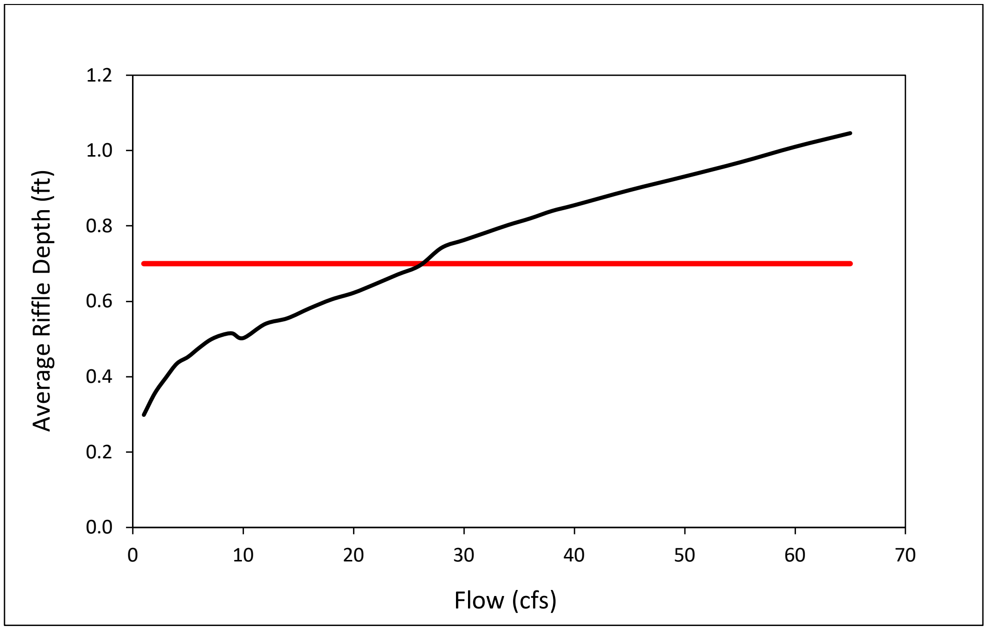


Figure 8-56. Relationship between flow and riffle depth in Ochoco Creek based on HEC-RAS hydraulic modeling. Horizontal red line indicates minimum depth for steelhead adult migration (0.70 foot). Source: See Appendix A-4.

Steelhead Spawning

Steelhead spawning may continue to be flow-limited in Ochoco Creek much the same as adult migration. Conservation Measure CR-2 specifies minimum flows during the storage season (mid-October through mid-April) of 3 cfs from Ochoco Dam to RM 6.3, and 5 cfs from RM 6.3 to the confluence with the Crooked River. During the irrigation season (mid-April through mid-October), the required minimum flow is 5 cfs for the entire distance from Ochoco Dam to the mouth. Actual flows may be higher than the required minimum once the irrigation season starts in mid-April, but not likely before mid-April when water is still being stored.

Steelhead spawn in the Crooked River subbasin from March through May. The HEC-RAS hydraulic modeling of Ochoco Creek indicates that flows of a magnitude adequate for spawning have not occurred under historical irrigation activities, and they are not expected to occur under the DBHCP except during occasional high flow events.

Water temperatures in the lower several miles of Ochoco Creek will also be limiting for steelhead spawning. Daily mean temperatures near the mouth of the creek have historically exceeded the upper limit of thermal preference for steelhead spawning (12°C) from March through May, and this trend is expected to continue under the DBHCP. The 7-DADM in the lower reaches of the creek could exceed 18°C by the end of May in some years (Figure 8-55). Upstream near Ochoco Dam, the cooling effect of Ochoco Reservoir will provide water temperatures below 12°C through June (Figure 8-54), but the benefits of this to spawning steelhead may be minimal. Overall, the combination of low flows and high water temperatures in the lower reaches of the creek makes steelhead spawning unlikely for the entire 11 miles between Ochoco Dam and the mouth of the creek.

Steelhead Egg Incubation

Water temperatures in Ochoco Creek are currently not conducive to steelhead egg incubation, and this is not expected to change as a result of the DBHCP. Temperatures directly below Ochoco Dam are consistently within the optimal range for incubation (5.6 to 11.1 °C) through June (Figure 8-54), but natural warming downstream of the dam eventually raises the water temperature to the point that it becomes too warm for incubation. Water temperatures in the lower reaches of Ochoco Creek can exceed 11.1°C by late April and exceed the threshold for stress to incubating eggs (15°C) in June of most years (Figure 8-55). As temperature increases, incubating eggs demand more dissolved oxygen. At the same time, however, the capacity for water to hold dissolved oxygen diminishes with increasing temperature, and temperatures over 15°C can delay hatching, cause smaller size-at-emergence, and elevate mortality in steelhead embryos.

Steelhead Summer Rearing

Summer rearing habitat is not likely to be the limiting factor for steelhead production in Ochoco Creek under the DBHCP. Rearing potential was evaluated by applying a fish capacity model developed for the Crooked River Basin (Appendix A-1) to the DBHCP minimum required flow of 5 cfs. Actual summer flows will be higher than the required minimum in much of the creek because water is conveyed from Ochoco Reservoir downstream to multiple diversions. However, portions of the creek could be at the minimum flow for extended periods during the summer, so the rearing habitat analysis was based on a flow of 5 cfs to determine the minimum potential capacity under the DBHCP. For purposes of comparison, the analysis also considered unregulated flows estimated by R2 and Biota Pacific (2014) and natural flows estimated by ODEQ (Watershed Sciences and MaxDepth Aquatics 2008). Water temperatures for all three flows scenarios are MWAT values derived from a HeatSource evaluation of the river performed by Courter et al. (2014).

The results of the summer capacity analysis are shown in Table 8-18. Estimated minimum juvenile steelhead rearing capacity under the DBHCP will be comparable to estimates for the ODEQ natural flow, and considerably higher than the estimate for unregulated flow. Ochoco Creek could support roughly 116,000 juvenile steelhead during the summer under the DBHCP minimum flow and the ODEQ natural flow.

Table 8-18. Estimated steelhead summer rearing capacity in Ochoco Creek.

Flow Scenario	Reach	Rearing Capacity (number of fish)		Mean Density (fish/ft^2)	Flow (cfs)		MWAT (°C)
		95th Quantile	Median		Mean	Minimum	
DBHCP Minimum	lower	84,830	79,117	0.0764	5.0	5.0	15.79
	upper	41,124	37,280	0.0420	5.0	5.0	16.60
ODEQ Natural	lower	85,024	79,277	0.0741	6.3	6.3	15.79
	upper	41,178	37,309	0.0408	6.3	6.3	16.60
Unregulated	lower	49,878	45,468	0.0600	2.5	2.5	15.78
	upper	18,765	16,147	0.0267	2.5	2.5	16.60

Steelhead Winter Rearing

Winter rearing potential for steelhead in Ochoco Creek was evaluated by applying the winter fish capacity model for the Crooked River Basin described in Section 8.2.3.1, *Crooked River*, to site-specific water temperatures and physical habitat attributes of Ochoco Creek (Appendix A-1). Winter minimum flows were set at 5 cfs in the lower reach (from the mouth to RM 6.3) and 3 cfs in the upper reach (RM 6.3 to Ochoco Dam). Unlike summer flows, these winter flows are not likely to be exceeded on a regular basis, and winter flows in lower Ochoco Creek will only rise above 5 cfs during flood events when the storage capacity of Ochoco Reservoir is about to be exceeded.

Winter juvenile steelhead rearing capacity in Ochoco Creek is similar for all three flow scenarios that were evaluated (Table 8-19). This is because the required minimum flows under the DBHCP are very similar to estimates of natural and unregulated flows. Most of the storage in Ochoco Reservoir occurs during spring snow melt and runoff; flows into the reservoir during the winter are generally quite low. Depending on the chosen method for estimating what winter flows would be without the irrigation activities, the DBHCP minimum flows are slightly higher (compared to unregulated flows) or slightly lower (compared to ODEQ natural flows). These differences are all small, and are not sufficient to produce significant changes in the juvenile fish rearing capacity of the creek. It is estimated that Ochoco Creek could support 59,000 juvenile steelhead during the winter under the DBHCP minimum flow and the ODEQ natural flow. This is roughly half the number of juvenile steelhead that could be supported in Ochoco Creek during the summer, suggesting that winter flows in Ochoco Creek are naturally limiting for juvenile steelhead rearing.

Table 8-19. Estimated steelhead winter rearing capacity in Ochoco Creek.

Scenario	Reach	Rearing Capacity (number of fish)		Mean Density (fish/ft^2)	Flow (cfs)		MWAT (°C)
		95th Quantile	Median		Mean	Minimum	
DBHCP Minimum	lower	41,479	36,928	0.0506	5.0	5.0	15.79
	upper	25,379	22,015	0.0360	3.0	3.0	16.60
ODEQ Natural	lower	43,781	39,118	0.0508	6.3	6.3	15.79
	upper	24,197	20,853	0.0322	6.3	6.3	16.60
Unregulated	lower	41,910	37,440	0.0549	2.5	2.5	15.78
	upper	24,470	21,173	0.0360	2.5	2.5	16.60

Steelhead Smolt Migration

As noted for the Middle Deschutes River, higher flows in the upper Deschutes Basin are expected to be positively associated with smolt survival during migration (Appendix A-3). Flows within Ochoco Creek during steelhead smolt migration in April through June are not expected to change appreciably from historical conditions. The conveyance and diversion of water will occur much as it has in the past, except that the extreme low flows smolts occasionally encountered will not occur under the DBHCP. The result may be slight improvement in flows during smolt migration within Ochoco Creek. In addition, the commitment in Conservation Measure CR-7 not to divert water associated with smolt migration pulse flows in the Crooked River will improve the survival of smolts that originate in Ochoco Creek and reach the mouth at the Crooked River

No data are available on optimal or preferred water temperatures for steelhead smolt migration, but migration travel times tend to decrease as temperatures warm in the spring. However, once temperatures reach about 16°C, piscivorous fish species also become more active and risk of predation becomes much higher for smolts. Limited water temperature data from Ochoco Creek suggests that predicted weekly average daily maximum water temperatures may exceed 16°C by May in the lower reach (Figures 8-55), but will remain well below 16°C in the upper reach (Figure 8-54).

Net Effect on All Life Stages of Steelhead in Ochoco Creek

Ochoco Creek provides limited potential for steelhead production under current conditions, and this is not expected to change under the DBHCP. Low flows and high water temperatures during adult migration and spawning provide the most significant obstacles to steelhead use of the creek, followed by low flows during the winter. Substantial increases from current flows in March through May would be required to support consistent spawning in the creek, and these are not anticipated under the DBHCP.

8.2.3.3 McKay Creek

Overview

Steelhead in the lower Crooked River will have access to McKay Creek upstream to a natural barrier at RM 19.6. Irrigation activities covered by the DBHCP influence flow in McKay Creek from Jones Dam (RM 5.8) to the mouth. During the irrigation season, water is alternately diverted from the creek into the Ochoco Canal at Jones Dam or spilled from the canal into the creek for conveyance downstream to one of OID's other canals. Similar processes of diversion and/or spill occur at the other canals as well. The result is flows in the lower 5.8 miles of McKay Creek during the irrigation season that are generally higher than flows immediately upstream, but variable from point to point due to the diversions and spills. There is no irrigation storage on McKay Creek and no diversion outside the irrigation season. Consequently, flow and temperature in McKay Creek are not affected by the covered activities during the winter. All diversions covered by the DBHCP on McKay Creek are screened to prevent the entrainment of juvenile salmonids and provided with ladders for volitional upstream and downstream passage.

The historical hydrology of McKay Creek is presented in Section 4.8, *Crooked River*, *Ochoco Creek and McKay Creek*. The effects of the DBHCP on McKay Creek hydrology appear in Section 6.5.5.3, *Effects of DBHCP Measures CR-3 on the Hydrology of McKay Creek*. Historical data on flows in lower McKay Creek are unavailable. Natural (unregulated) flows in the lower creek were synthesized from historical records for the upper watershed and OWRD estimates of monthly 50 and 80 percent exceedance flows (R2 and Biota Pacific 2014), and compared to projected minimum flows under the DBHCP without and with the McKay Creek Water Switch (Figure 8-57). This comparison shows that minimum flows under the DBHCP will meet or exceed unregulated minimum flows throughout the irrigation season. As the McKay Creek Water Switch described in Conservation Measure CR-3 is implemented, minimum flows during the irrigation season may be substantially higher. It is important to note, however, that increased minimum flows associated with the McKay Creek Water Switch will be the result of OID allowing natural flows reaching Jones Dam at RM 5.8 to pass through to the mouth of the creek. If natural flows at Jones Dam are low, as they often are by early summer, the minimum flow in lower McKay Creek may be supported only by water released into the creek by OID, which would result in 5 cfs at the mouth of the creek. Historical water temperature conditions in McKay Creek are summarized in Section 4.8, *Crooked River*, *Ochoco Creek and McKay Creek*.

Steelhead Adult Migration

There is no storage or diversion of water on McKay Creek during the winter. As a result, flow and temperature are not affected by the covered activities from mid-October through March when adult steelhead are potentially migrating (Table 8-7). The DBHCP is therefore not expected to impact adult steelhead migration in McKay Creek. HEC-RAS hydraulic modeling for McKay Creek indicates a flow of at least 28 cfs may be necessary to support migration through riffles at a depth of 0.70 foot (Figure 8-58). The unregulated median flow in McKay Creek in March, which will not be influenced by the DBHCP, is 42 cfs (Figure 8-57), suggesting adult steelhead migration may be possible during March in many years. Unregulated flows in November through February are considerably lower than 28 cfs.

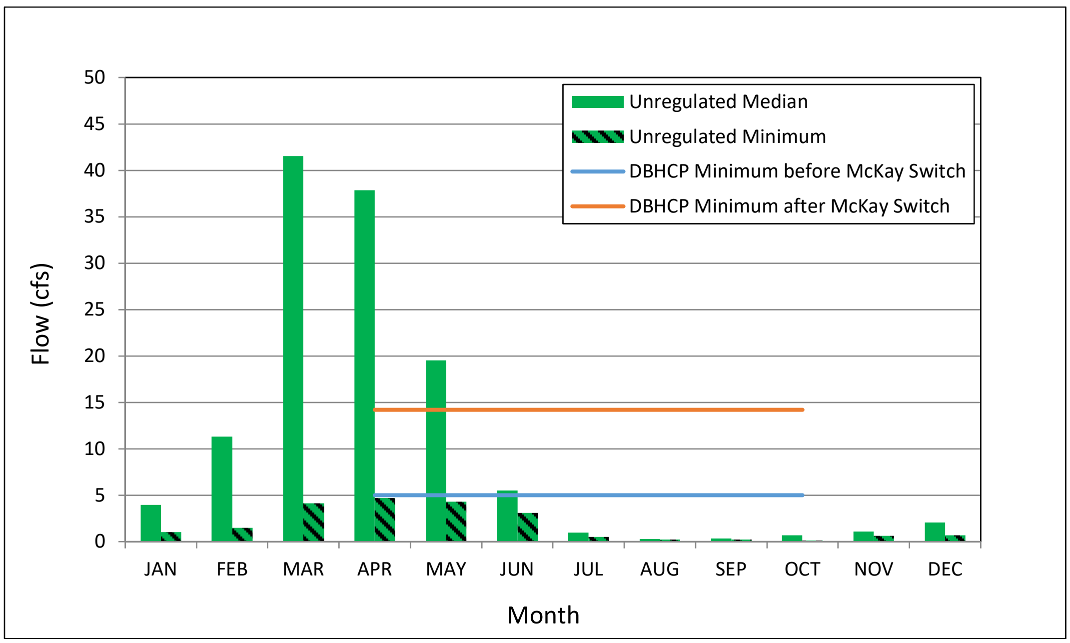


Figure 8-57. Daily average flows at the mouth of McKay Creek for unregulated and DBHCP conditions. Source: R2 and Biota Pacific 2014.

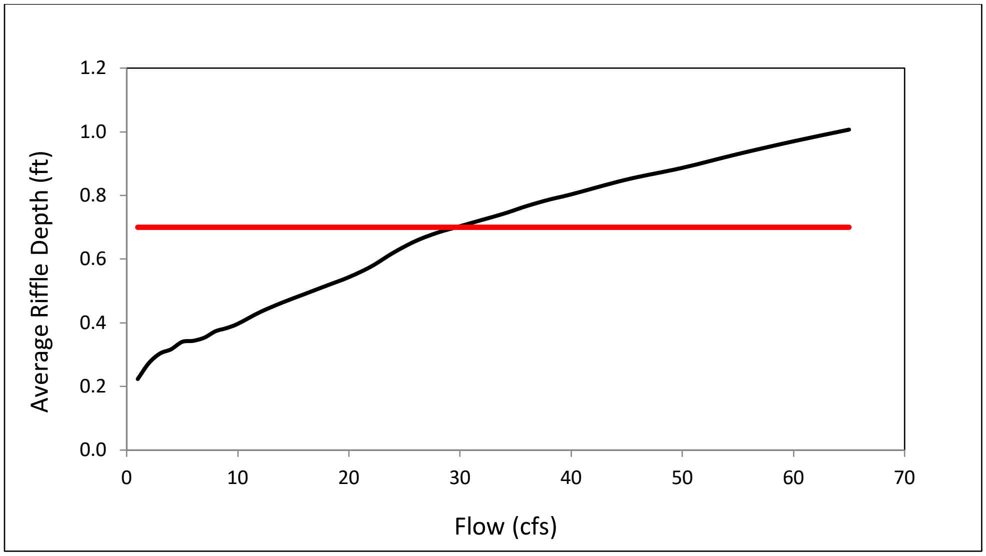


Figure 8-58. Relationship between flow and riffle depth in McKay Creek based on HEC-RAS hydraulic modeling. Horizontal red line indicates minimum depth for steelhead adult migration (0.70 foot). Source: See Appendix A-4.

Steelhead Spawning

Steelhead spawn in the Crooked River subbasin from March through May. McKay Creek is unregulated during March, and the median March flow is estimated at 42 cfs (Figure 8-57). This is more than enough flow to support steelhead spawning during March. In early April, when the creek is still unregulated in most years, the median flow is 38 cfs and still enough to support steelhead spawning. After mid-April, however, the minimum flow can be as low as 2 to 5 cfs without the McKay Creek Water Switch and as low as 11.2 to 14.2 after the Water Switch (see Conservation Measure CR-3). These regulated minimum flows do not provide water depth conditions sufficient to support steelhead spawning from mid-April through May.

Steelhead Egg Incubation

Historical water temperatures in McKay Creek during the irrigation season are shown in Figures 8-59 and 8-60. Temperature conditions are not expected to change under the DBHCP prior to the McKay Creek Water Switch. After the Water Switch, when irrigation season flows in the creek may be higher, water temperatures are expected to decrease. The magnitude of decrease has not been determined.

If steelhead spawn in McKay Creek, incubation can be expected to occur from March through June. Water temperatures in the creek are uninfluenced by the covered activities prior to mid-April, and this will not change under the DBHCP. After mid-April, diversions by OID and other irrigators reduce the flow and increase the temperature of the creek. Natural conditions and reduced flows from irrigation diversions upstream of OID raise the temperature of the water before it reaches Jones Dam, and the limited available data suggest the water undergoes additional warming between Jones Dam and the mouth. Water temperatures upstream and downstream of Jones Dam have historically exceeded the upper limit of the preferred range for steelhead incubation (5.6-11.1°C) by mid-April, and this will likely continue at least until the McKay Creek Water Switch is completed. After the Water Switch, temperatures could remain below 11.1°C longer into May.

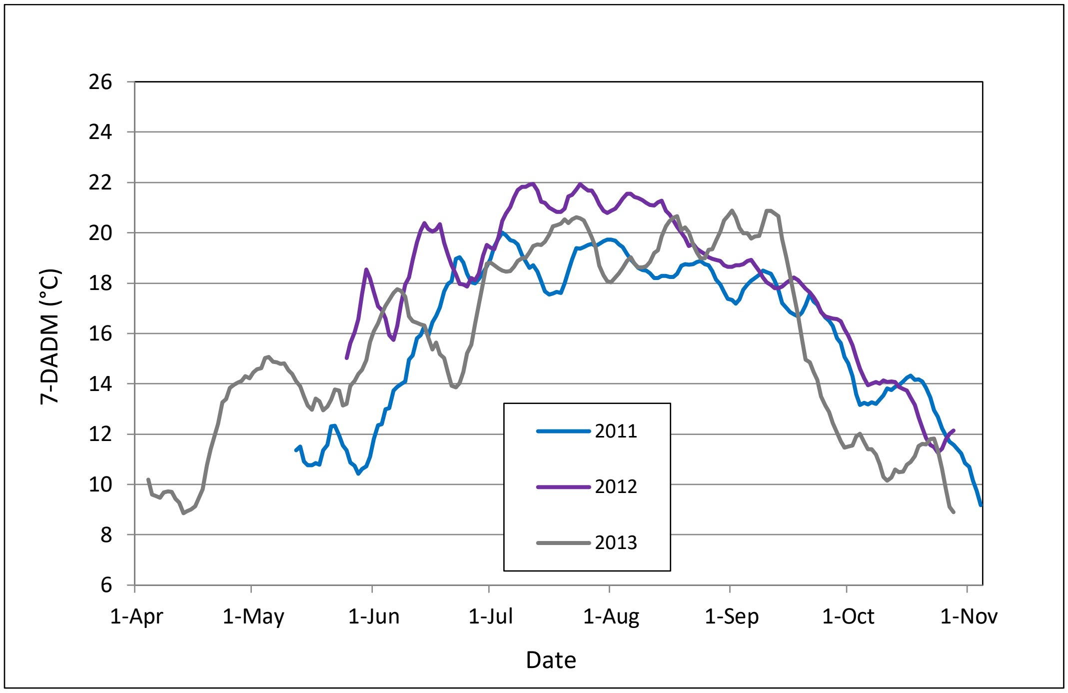


Figure 8-59. Seven-day averages of daily maximum water temperatures (7-DADM) in McKay Creek below Allen Creek (RM 8.3) during the irrigation season. Source: CRWC 2014.

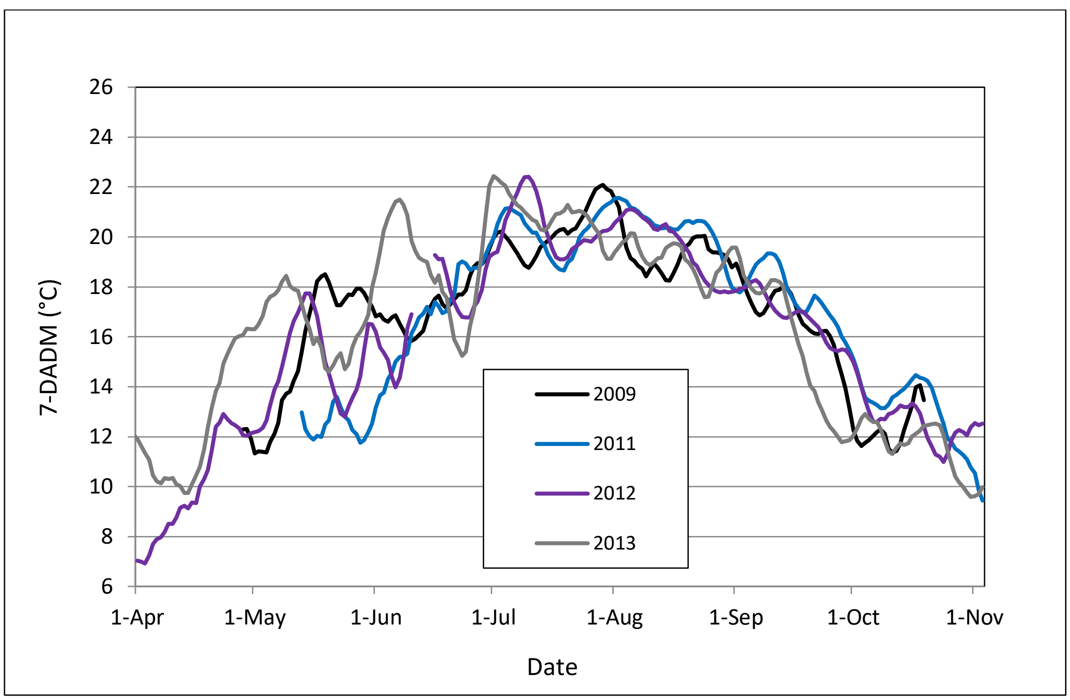


Figure 8-60. Seven-day averages of daily maximum water temperatures (7-DADM) in McKay Creek at US Route 26 (RM 0.4) during the irrigation season. Source: CRWC 2014.

Overall, water temperatures prior to the McKay Creek Water Switch will remain favorable for steelhead egg incubation in the lower 5.8 miles of creek through mid-April, but will likely be too warm for incubating eggs that remain past mid-April. After the Water Switch, when flows increase, favorable temperatures can be expected to occur longer into the incubation period.

Steelhead Summer Rearing

Summer rearing potential for steelhead in McKay Creek was evaluated by applying the fish capacity model developed in the Crooked River Basin (Appendix A-1) to site-specific water temperatures in the creek. The results indicate juvenile fish capacity is positively related to flow due to increases in habitat area associated with increases in flow (Table 8-20). Current rearing capacity is considerably higher than natural and unregulated conditions because of extremely low natural flows in McKay Creek by late summer (R2 and Biota Pacific 2014). Current conditions will continue under the DBHCP. Late summer flows in lower McKay Creek that support juvenile summer rearing will be largely the result of minimum flows to be provided by the DBHCP, and the naturally low flows upstream of Jones Dam in late summer will not be ameliorated by the McKay Creek Water Switch.

Table 8-20. Predicted summer capacity estimates for juvenile steelhead in McKay Creek.

Reach	Scenario	Rearing Capacity (number of fish)		Mean Density (fish/ft^2)	Habitat Area (ft^2)	Flow (cfs)	MWAT (°C)
		95th Quantile	Median				
MK-1	DBHCP	29,484	23,495	0.0406	607,478	5.0	17.3
	Natural	4,545	2,367	0.0049	485,893	0.4	17.3
	Unregulated	4,304	2,192	0.0049	454,688	0.2	17.3
MK-2	DBHCP	2,527	1,953	0.0506	38,538	3.0	17.4
	Natural	333	149	0.0045	33,462	0.4	17.4
	Unregulated	324	142	0.0045	31,875	0.2	17.4
MK-3	DBHCP	359	126	0.0024	57,272	2.0	18.2
	Natural	352	122	0.0024	51,161	0.4	18.2
	Unregulated	301	105	0.0024	48,735	0.2	18.2

Steelhead Winter Rearing

The DBHCP will have no effect on winter rearing for steelhead in McKay Creek because the covered irrigation activities do not affect flow, water temperature or water quality in the creek outside the irrigation season.

Steelhead Smolt Migration

As noted for the Middle Deschutes River, higher flows in the upper Deschutes Basin are expected to be positively associated with smolt survival during migration (Appendix A-3). DBHCP flows prior to the McKay Creek Water Switch will be comparable to historical flows, which are also comparable to unregulated minimums in May and June but less than the unregulated median in May (Figure 8-57). After the McKay Creek Water Switch, the flow in McKay Creek could be as high as 11.2 to 14.2 cfs in May and June. This would represent a substantial improvement in flow during smolt migration compared to historical conditions in McKay Creek. In addition, the commitment in Conservation Measure CR-7 not to divert water associated with smolt migration pulse flows in the Crooked River will improve the survival of smolts that originate in McKay Creek and reach the mouth at the Crooked River.

No data are available on optimal or preferred water temperatures for steelhead smolt migration, but migration travel times tend to decrease as temperatures warm in the spring. However, once temperatures reach about 16°C, piscivorous fish species also become more active and risk of predation becomes much higher for smolts. Water temperatures in McKay Creek during the period of smolt migration (April through June) can range naturally from 7.0 to more than 21.0°C (Figure 8-59 and 8-60). Water temperatures are much warmer in the lower section of McKay Creek than near the headwaters. In years with high downstream temperatures smolts could be vulnerable to predation by early-May. Temperatures are not expected to change under the DBHCP and therefore temperature-related effects on smolts will not change.

Net Effect on All Life Stages of Steelhead in McKay Creek

The DBHCP will benefit steelhead in lower McKay Creek by continuing to provide late-summer flows that are higher than unregulated flows, thereby improving conditions for juvenile rearing. Spawning conditions may improve if spring water temperatures decrease as a result of the McKay Creek Water Switch. Adult migration and winter rearing will be unaffected by the DBHCP because there is not storage or winter diversion of water. Smolt survival may be slightly improved within McKay Creek under the minimum DBHCP flows during May and June, and much improved by spring pulse flows once the juvenile fish reach the Crooked River.

8.2.4 Lake Billy Chinook

Overview

Steelhead from the Crooked River and Middle Deschutes subbasin populations use Lake Billy Chinook as a migration corridor. Smolts pass through the reservoir during outmigration from Whychus Creek, the Middle Deschutes River and the Crooked River, and adults pass through during their return to natal streams to spawn.

Lake Billy Chinook is a hydroelectric reservoir operated as run-of-river (i.e., outflow is approximately equal to inflow on a daily basis). The covered irrigation activities collectively alter inflow to the reservoir, but reservoir volume and water surface elevation are kept constant through operation of Round Butte Dam. The DBHCP will increase inflow to the reservoir compared to historical conditions in all months, as indicated by predicted outflows near Madras (Figure 8-61). During the storage season (October through March) the majority of this increase will originate from the Upper Deschutes River and will be the result of higher minimum flows below Wickiup Reservoir (see Conservation Measure WR-1). During the peak of the irrigation season (May through September) the increase from historical to DBHCP flows is the result of conserved water projects in the Upper Deschutes basin since 2001 that increased the minimum flow at RM 159 from 109 cfs to 143 cfs (see Section 8.1.1, *Middle Deschutes River*). As indicated in Figure 8-32, the increase in surface flow from historical levels between Bend and Lake Billy

Chinook during the summer has resulted in an increase in water temperature (7-DADM) of about 0.5°C where the river enters the reservoir. The current (and DBHCP) Max 7-DADM where the Deschutes River enters Lake Billy Chinook is still expected to be less than 16.0°C, and water temperatures within the reservoir are expected to remain within the preferred range juvenile outmigration and upstream passage of adults.

Three irrigation returns also contribute flow to Lake Billy Chinook directly at a combined rate of roughly 1.3 cfs during the irrigation season (see Section 3.5.5.6, *Return Flow*). In the driest month of the year (September) the three returns represent less than 0.03 percent of the daily flow through the reservoir, and are not anticipated to have measurable effects on water temperature or water quality.

Steelhead Adult Migration

Returning adult steelhead are captured at the downstream end of the Pelton Round Butte Project (RM 100) and released into Lake Billy Chinook to continue their upstream migration. Once released, the adults move fairly quickly to the upper arms of the reservoir (Deschutes River Arm, Metolius Arm and Crooked River Arm) where they hold until early March (Hill and Quesada 2013; Hill et al. 2014; Wymore et al. 2015; Burchell et al. 2016; Burchell and Hill 2017; Burchell 2018). The DBHCP will increase monthly median flows into Lake Billy Chinook from October through April, as indicated by reservoir outflow at Madras (Figure 8-61). These increased flows will come almost entirely from the Middle Deschutes River, and they could increase the attraction current for adult steelhead destined to spawn there. The effects of increased flows on steelhead headed to the Crooked River should be negligible.

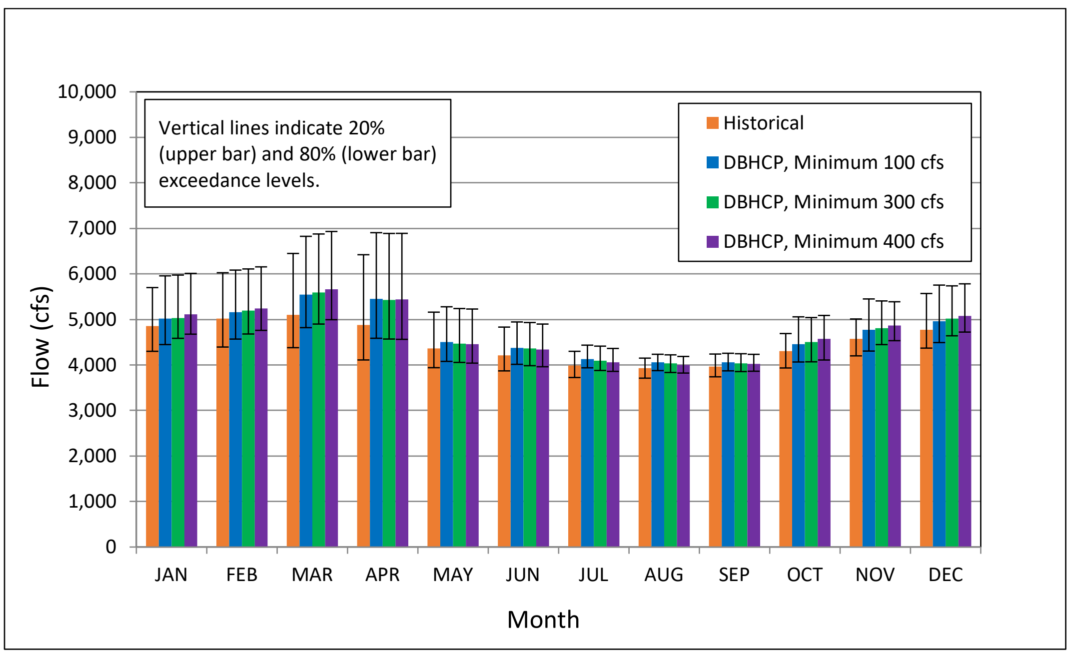


Figure 8-61. Monthly medians of daily average flows in the Deschutes River near Madras (RM 100) from 1981 through 2018. Sources: OWRD 2020d, Reclamation 2020a.

Steelhead Smolt Migration

The DBHCP is anticipated to have a positive effect on habitat for steelhead smolts migrating through Lake Billy Chinook. Increases in reservoir inflow from the Deschutes River under the DBHCP during March and April will coincide with the beginning of the smolt migration through the reservoir (Mendez and Hill 2017). In addition, Crooked River pulse flows specifically timed for smolt migration will reach Lake Billy Chinook without being diverted, and these will result in further increases in flow through the reservoir. Since higher flows are expected to be positively associated with smolt survival (Appendix A-3), increased flow through the reservoir may improve smolt survival.

Steelhead Trout Spawning, Incubation and Rearing

Steelhead trout do not spawn or rear in Lake Billy Chinook. The covered activities will have no effect on steelhead spawning, incubation or early juvenile rearing in the reservoir.

Net Effect on All Life Stages of Steelhead in Lake Billy Chinook

The DBHCP will have minor benefits to steelhead use of Lake Billy Chinook. Adult migration will be largely unaffected, and smolt migration may benefit from increased flows through the reservoir in the spring.

8.2.5 Lower Deschutes River

Overview

Steelhead have access to the Lower Deschutes River upstream to the Pelton Reregulating Dam at RM 100. The only covered activities within the Lower Deschutes River are three small irrigation returns with a combined flow of less than 20 cfs between RM 90 and RM 98 (see Table 3.7), but the entire lower river is influenced by the storage and diversion of water in the upper Deschutes and Crooked River subbasins.

Historical hydrology and water temperature conditions in the Lower Deschutes River are presented in Section 4.6, *Lower Deschutes River*. As required by the FERC license issued in 2005, the Pelton Round Butte Project is operated as run-of-river with respect to flow and water temperature. Releases of water from the hydroelectric project are controlled to maintain flows downstream of the Reregulating Dam within ± 10 percent of inflows to Lake Billy Chinook (RM 120) on a daily basis, and water temperatures downstream of the Project are managed to approximate temperatures entering Lake Billy Chinook. The upstream storage and diversion of water for irrigation purposes influence flows into Lake Billy Chinook year round, but the relative effects of the covered activities on the Lower Deschutes River are reduced by the substantial groundwater discharge and tributary inflow between Bend and Lake Billy Chinook. The historical flow downstream of RM 100 since 1981 has rarely dropped below 3,500 cfs, and the seasonal difference in flow has typically been less than 25 percent (Figure 8-61).

Summer water temperatures at RM 100 are consistently below 18°C (Figure 8-62). Further downstream, however, the general lack of shade and limited groundwater discharge cause the river to warm. Near Moody (RM 1.4) water temperatures consistently exceed 20°C in mid-summer (Figure 8-63). The Lower Deschutes River is identified as water temperature limited under Section 303(d) of the Clean Water Act for exceeding the summer maximum 7-DADM of 17.8°C for salmon and trout rearing and migration from RM 46.4 to the mouth (ODEQ 2017). It is also listed as water quality limited for exceeding the maximum 7-DADM of 12.8°C for salmon and trout spawning from RM 99.8 to 46.4.

NMFS (2005) reviewed current habitat conditions for steelhead in the Lower Deschutes River and evaluated the effects of irrigation activities associated with Reclamation facilities (primarily Crane Prairie Reservoir, Wickiup Reservoir, Prineville Reservoir, North Unit Main Canal and the Crooked River Diversion). Based on their review of available information, NMFS (2005) made the following observations and conclusions:

- Within the historical range of flows in the Lower Deschutes River there is not a clear direct relationship between flow and available spawning area. Ratliff and Stuart (2001) modeled the effects of flows between 3,500 and 6,500 cfs on steelhead spawning habitat and found that counteracting changes in water depth and water velocity caused some reaches to have an increase in spawning area with increasing flow while most areas showed a decrease.

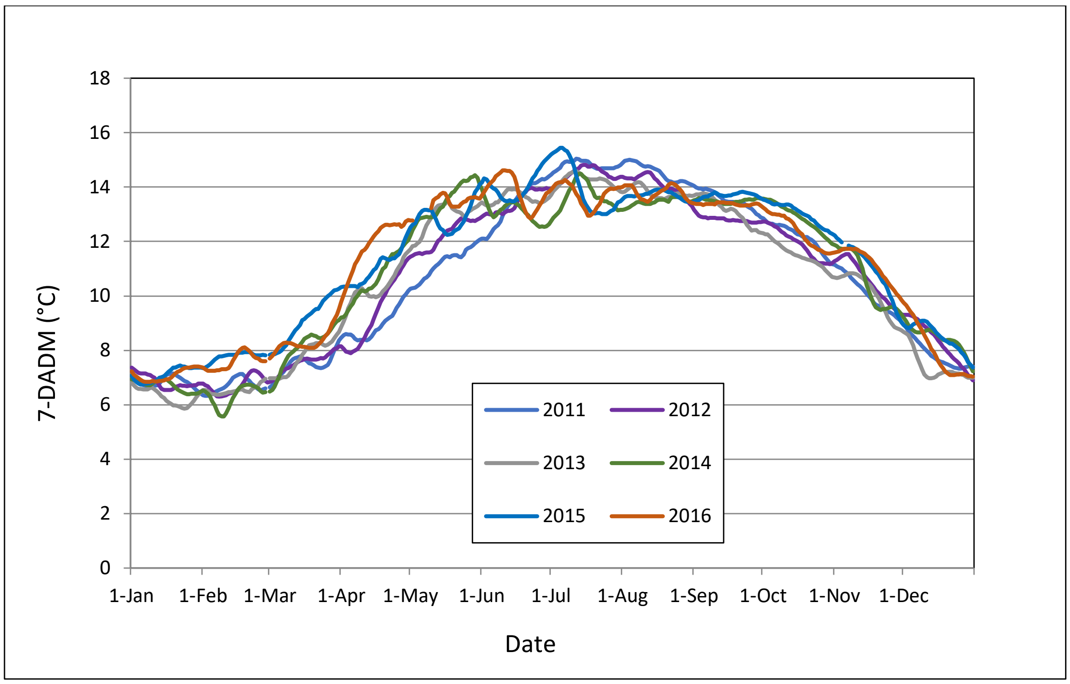


Figure 8-62. Seven-day averages of daily maximum water temperatures (7-DADM) in the Lower Deschutes River near Madras, Oregon (USGS Gage 14092500) from 2011 through 2016. Source: USGS 2017a.

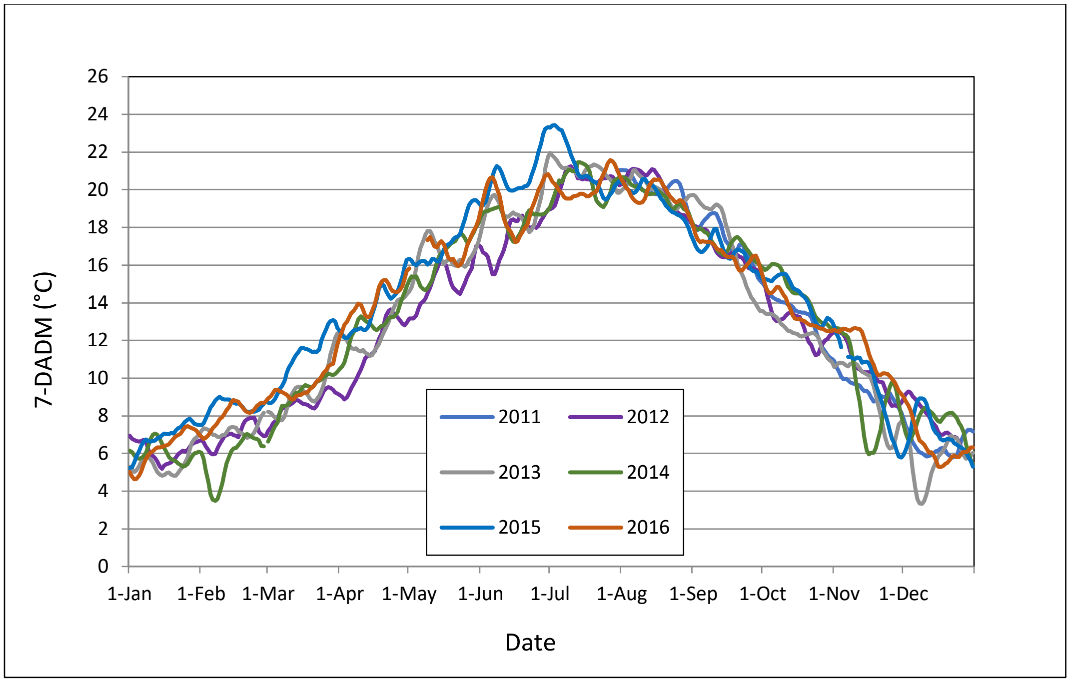


Figure 8-63. Seven-day averages of daily maximum water temperatures (7-DADM) in the Lower Deschutes River at Moody, near Biggs, Oregon (USGS Gage 14103000) from 2011 through 2016. Source: USGS 2017b.

- The natural stability of flows in the Lower Deschutes River has produced a stable river channel and allowed for the development of a well-vegetated riparian community that provides "excellent overhead cover and complex rearing habitat."
- Shallow juvenile rearing habitat is a significant limiting factor due to rapidly increasing depths along the river banks, making the habitat complexity provided by the overhanging vegetation very important to rearing salmonids.
- The primary effects of upstream irrigation activities on steelhead in the Lower Deschutes River are flow-related (i.e., changes in flow brought about by the storage and diversion of water in the upper basin that are perpetuated downstream of the Pelton Round Butte Project).
- Aquatic habitat conditions have been degraded from natural conditions by a number of past and ongoing human actions unrelated to the covered irrigation activities, including stream channelization, elimination of wetlands, construction of dams and levees, construction of roads, timber harvest, water withdrawals, unscreened water diversions, agriculture, livestock grazing, urbanization, outdoor recreation, fire exclusion/suppression, artificial fish propagation, fish harvest, and introduction of non-native species.

Steelhead Adult Migration

Conditions for migration of adult steelhead in the Lower Deschutes River will be unchanged by the DBHCP. Flows will be at or above historical levels for the entire migration period, with median flows of at least 4,000 cfs and 80 percent exceedance flows of at least 3,700 cfs in all months (Figure 8-61). Water temperatures are not expected to change under the DBHCP; the 7-DADM will be below 12.8°C from November through March, but above 12.8°C from May to October of most years (Figures 8-62 and 8-63). The 7-DADM will continue to reach as high as 22°C by mid-July near the mouth of the river.

Steelhead Spawning

The total area of spawning habitat for steelhead in the Lower Deschutes River may decrease slightly under the DBHCP as a result of increased flows. Median flows will increase from historical levels in March (7-11%), April (11-12%) and May (2-3%) due to increased releases from Wickiup Reservoir prior to irrigation demand for the water (Figure 8-61). Ratliff and Stuart (2001) noted a general decrease in the area of suitable spawning habitat with increasing flow between 3,500 and 6,500 cfs at Madras (USGS Gage 14092500). They attributed the decrease in habitat to the effects of flow on water velocity. The Deschutes River is confined to a steep-sided channel for much of the lower 100 miles. Increased flows through the confined channel tend to increase water depth and velocity more than they increase wetted area; and increased velocities can inhibit spawning. Some reaches with wider and/or less confined channels may see improvements in spawning habitat with increasing flows, but the majority of lower 100 miles of river will experience deterioration in spawning conditions. Water temperatures from March through May are not expected to change under the DBHCP; they should remain within the preferred range of 4.0 to 12.0 °C in March, but 2 to 6 °C above this range by late May (Figures 8-62 and 8-63).

Steelhead Egg Incubation

Conditions for steelhead egg incubation in the Lower Deschutes River may deteriorate a small amount under the DBHCP. Increased water velocities associated with increased flows could increase the potential for scouring of redds, particularly if the increases come after eggs have been deposited. The largest increases in median flows at Madras under the DBHCP will come in March (7-11%) and April (11-12%) when releases from Wickiup Reservoir are increased for Oregon spotted frogs prior to seasonal irrigation diversions at Bend. Conservation Measure WR-1 calls for those increased flows to begin by late March. Eggs deposited in early March could experience more than 10 percent increases in flow by the end of the month. Depending on site-specific conditions, the increased flows could result in scouring that prematurely dislodges eggs or alevins from gravels.

Water temperatures for incubation are not expected to change under the DBHCP. Temperatures for egg incubation will generally be within the preferred range of 5.6 to 11.1 °C in March, but 3 to 7 °C above the upper threshold by the end of May. Historically, temperatures have exceeded the threshold of 15.0°C for stress by early May near the mouth of the Deschutes River, and this is not expected to change under the DBHCP.

Steelhead Summer and Winter Rearing

Juvenile steelhead avoid rearing areas where water velocities exceed 0.4 meters per second (Bjornn and Reiser 1991). Flow conditions and channel geomorphology in the Lower Deschutes River confine juvenile steelhead trout rearing habitat to the river's edge (wetted perimeter), where velocity and predator refugia exist. In 2001, to meet Federal Energy Regulation Commission requirements for the relicensing of the Pelton Round Butte Project, Portland General Electric (PGE) examined how changes in flow (discharge) would affect the wetted perimeter of the Lower Deschutes River, based on data collected by Fassnacht et al. (2003). This study monitored the lower river between the Pelton Round Butte Project Reregulating Dam (RM 100) and the confluence with Trout Creek (RM 87) to assess the effects of the project operation on downstream bedload transport. Geomorphology, substrate compositions and transport frequency were monitored along transects across a range of flow conditions (3,500 – 8,000 cfs). These data were used to calculate the amount of edge habitat available at each transect location for the same range of flows (Duke 2001). In 2005, NMFS used the wetted perimeter data compiled by PGE to assess the impact of Deschutes River Basin Project water management scenarios proposed by Reclamation on juvenile summer steelhead rearing habitat availability in the Lower Deschutes River.

The effects of the DBHCP scenarios on juvenile rearing habitat availability in the Lower Deschutes River were assessed using a similar approach to NMFS (Appendix A-2). Specifically, predictions of wetted perimeter under historical conditions were compared to predictions calculated for each future alternative to demonstrate how the management action would change the availability of habitat for juvenile steelhead. A reduction in habitat relative to historical conditions is assumed to negatively impact rearing juvenile steelhead.

The results of the wetted perimeter analysis are presented in Table 8-21. For predicted median flows under the DBHCP, the total area of juvenile salmonid edge rearing habitat (wetted perimeter) will increase in the Lower Deschutes River during all months and during all phases of implementation (Figure 8-64). Increases associated with median flows will range from 14,563 square feet in July during later years of DBHCP implementation, to 121,003 square feet in April beginning in Year 1 of implementation. The relative magnitude of increase (percent of total available habitat) will be very small, however, ranging from 0.01 to 1.15 percent. Overall, the greatest increases (both in absolute value and percent change) will be in March and April. Reductions in edge rearing habitat are not predicted to occur under the DBHCP.

Table 8-21. Projected changes in juvenile salmonid edge rearing habitat (wetted perimeter) in the Deschutes River from RM 100 to RM 87 under the DBHCP, compared to historical levels.

	Change in Wetted Perimeter (feet²) (Numbers in parentheses indicate percent change from historical total wetted perimeter)		
	DBHCP Phase 1 Minimum 100 cfs at WICO in Winter	**DBHCP Phase 2** Minimum 300 cfs at WICO in Winter	**DBHCP Phase 3** Minimum 400 cfs at WICO in Winter
January			
10%	13,615 (*0.13*)	27,084 (*0.25*)	41,630 (*0.39*)
50%	32,354 (*0.31*)	35,089 (*0.33*)	49,745 (*0.47*)
90%	25,590 (*0.25*)	59,778 (*0.58*)	78,586 (*0.76*)
February			
10%	5,110 (*0.05*)	12,975 (*0.12*)	10,653 (*0.1*)
50%	32,125 (*0.3*)	38,332 (*0.36*)	46,323 (*0.44*)
90%	28,969 (*0.28*)	66,037 (*0.64*)	85,179 (*0.82*)
March			
10%	10,172 (*0.09*)	14,294 (*0.13*)	20,241 (*0.18*)
50%	91,223 (*0.86*)	10,3574 (*0.98*)	117,286 (*1.11*)
90%	62,321 (*0.6*)	10,0196 (*0.97*)	119,320 (*1.15*)
April			
10%	67,631 (*0.61*)	65,356 (*0.59*)	62,145 (*0.56*)
50%	121,003 (*1.15*)	118,705 (*1.13*)	117,272 (*1.12*)
90%	95,231 (*0.93*)	90,818 (*0.88*)	90,208 (*0.88*)
May			
10%	8,899 (*0.08*)	5,778 (0.05)	538 (*0.01*)
50%	30,003 (*0.29*)	21,788 (*0.21*)	19,241 (*0.19*)
90%	37,508 (0.37)	27,942 (*0.27*)	24,827 (*0.24*)
June			
10%	19,621 (*0.19*)	16,669 (*0.16*)	8,214 (*0.08*)
50%	31,486 (*0.3*)	29,578 (*0.29*)	25,101 (*0.24*)
90%	36,788 (*0.36*)	30,999 (*0.3*)	23,909 (*0.23*)
July			
10%	24,776 (*0.24*)	23,972 (*0.23*)	18,693 (*0.18*)
50%	31,109 (*0.3*)	22,669 (*0.22*)	14,563 (*0.14*)
90%	36,745 (*0.36*)	22,685 (*0.22*)	18217 (*0.18*)
August			
10%	15,472 (*0.15*)	12,520 (*0.12*)	8,090 (*0.08*)
50%	27,495 (*0.27*)	23,036 (*0.22*)	16,114 (*0.16*)
90%	37,004 (*0.36*)	29,478 (*0.29*)	26,185 (*0.26*)
September			
10%	22,405 (*0.22*)	19670 (*0.19*)	18168 (*0.17*)
50%	20,431 (*0.2*)	16011 (*0.16*)	14698 (*0.14*)
90%	26,698 (*0.26*)	24466 (*0.24*)	26335 (*0.26*)
October			
10%	71,708 (*0.68*)	72,616 (*0.69*)	79,798 (*0.76*)
50%	33,376 (*0.32*)	45,323 (*0.44*)	59,877 (*0.58*)
90%	32,795 (*0.32*)	32,701 (*0.32*)	34,687 (*0.34*)
November			
10%	84,158 (*0.79*)	84,377 (*0.79*)	78,979 (*0.74*)
50%	41,013 (*0.39*)	47,348 (*0.45*)	59,936 (*0.57*)
90%	3,386 (*0.03*)	38,508 (*0.37*)	56,871 (*0.55*)
December			
10%	26,090 (*0.24*)	33,146 (*0.31*)	41,948 (*0.39*)
50%	37,998 (*0.36*)	49,551 (*0.47*)	62,401 (*0.6*)
90%	26,544 (*0.26*)	61,118 (*0.59*)	77,936 (*0.75*)

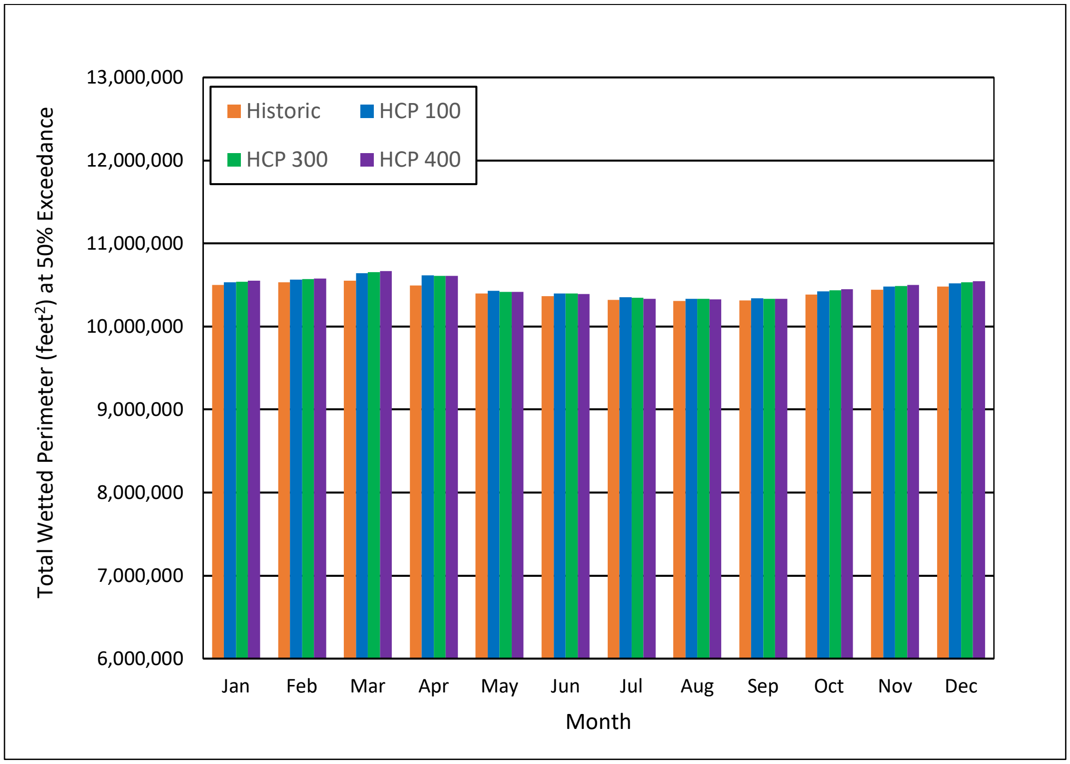


Figure 8-64. Projected juvenile salmonid edge rearing habitat (wetted perimeter) in the Deschutes River from RM 100 to RM 87 under historical and DBHCP median flows. Source: See Appendix A-2.

Overall, the increases in edge rearing habitat under the DBHCP are expected to have very small benefits to steelhead in the Lower Deschutes River. This is because the largest increases in wetted perimeter will come in March and April at a time when flows (Figure 8-61) and wetted perimeter (Figure 8-64) are already at the annual high. The lowest flows of the year, which likely determine the annual juvenile salmonid rearing capacity for the river, occur in August and September; and the increases in wetted perimeter associated with the DBHCP during these months will be quite modest. In addition, NMFS (2005) cited the work of Zimmerman and Reeves (2000) when concluding that most *O. mykiss* juveniles rearing in the mainstem Lower Deschutes River are the progeny of rainbow trout, and juvenile steelhead rear primarily in the lower reaches of intermittent tributaries where they experience less competition with resident trout. The mainstem Lower Deschutes River may only be important for steelhead rearing in drought years when the tributaries are dry (NMFS 2005).

Steelhead Smolt Migration

Outmigrating steelhead smolts may benefit from higher spring flows in the Lower Deschutes River under the DBHCP (Figure 8-61). Increases in reservoir outflow originating from the Deschutes River under the DBHCP will be greatest at the beginning of outmigration in April, when monthly median flows will be at least 552 cfs (11 percent) higher than they were historically. In addition, Crooked River pulse flows specifically timed for smolt migration will reach Lake Billy Chinook without being diverted, and these will result in further increases in flow downstream of the reservoir. Temperature conditions in the Lower Deschutes River are not expected to change as a result of the DBHCP and therefore will have no effect on smolt migration.

Net Effect on All Life Stages of Steelhead in the Lower Deschutes River

The DBHCP will have modest benefits to steelhead in the Lower Deschutes River. Conditions for adult migration will be unchanged, habitat for spawning and egg incubation may deteriorate slightly, and the total amount of rearing habitat may increase slightly. Smolt outmigration will benefit from increased flows during the spring.

8.2.6 Trout Creek and Mud Springs Creek

Overview

Trout Creek is a tributary to the Deschutes River at RM 87.2 (Figure 8-65). Mud Springs Creek is a tributary to Trout Creek at RM 2.5. All life stages of summer steelhead are known to use Trout Creek up to at least RM 14.5 and Mud Springs Creek up to an anadromous barrier at RM 1.6. Steelhead spawning in Trout Creek occurs from January through mid-April. Historical hydrology and water temperature conditions in the Lower Deschutes River are presented in Section 4.7, *Trout Creek*.

There is no storage or diversion of water associated with the DBHCP in the Trout Creek watershed, but two small returns from NUID contribute flow to Mud Springs Creek upstream of the anadromous barrier. The Lateral 58-11 Drain contributes flow to Sagebrush Creek, a tributary to Mud Springs Creek upstream of the anadromous barrier. It spills up to 50 cfs for part of one day at the start of the irrigation season (early April), and a variable amount of up to 5 cfs throughout the irrigation season (April through September). The Lateral 61-11 Drain operates in a similar manner with an operational spill of up to 25 cfs for part of one day in early April and a variable spill of up to 2 cfs from April through September. The Lateral 61-11 Drain spills into a manmade channel/wetland before flowing into Mud Springs Creek at RM 8.0, about 6.4 miles above the anadromous barrier. The returns have no effect on flows in Mud Springs Creek and Trout Creek from October through March when the NUID canal system is dry.

Flows in Trout Creek flows are gaged at Clemens Road near Gateway (OWRD No. 14095255), about 0.2 mile downstream from the confluence with Mud Springs Creek. Flows in Mud Springs Creek are gaged about 0.1 mile upstream from the confluence at OWRD No. 14095250 (Figure 8-65). The two creeks have very different annual flow regimes (see Figure 4-35). Trout Creek experiences high flows of several hundred cfs during late winter and early spring that rapidly diminish during the summer. Mud Springs Creek, on the other hand, exhibits an unusually constant hydrograph compared to most other streams in the area. From 2000 through 2018, the average daily flow in Mud Springs Creek averaged 10.3 cfs and ranged from 2.6 to 44.2 cfs (OWRD 2020c). Over the same period, the average daily flow in Trout Creek ranged from 1.3 cfs in June 2015 to 1,190 cfs in February 2017.

Live flow from Mud Springs Creek and seasonal irrigation returns carried by Mud Springs and Sagebrush creeks provide most of the summer/fall flow in the lower 2.5 miles of Trout Creek (Watershed Professionals Network 2002). This can be seen in a comparison of reported flows from 2000 to 2016 with OWRD calculations of natural flows (Figures 8-66 and 8-67). From June through November in both creeks, nearly all the reported flow is from sources other than the calculated natural flow. A significant portion of this reported flow originates from the irrigation returns, and much of the rest likely comes from springs that discharge into Mud Springs Creek below Agency Plains in the vicinity of the 61-11 Drain.

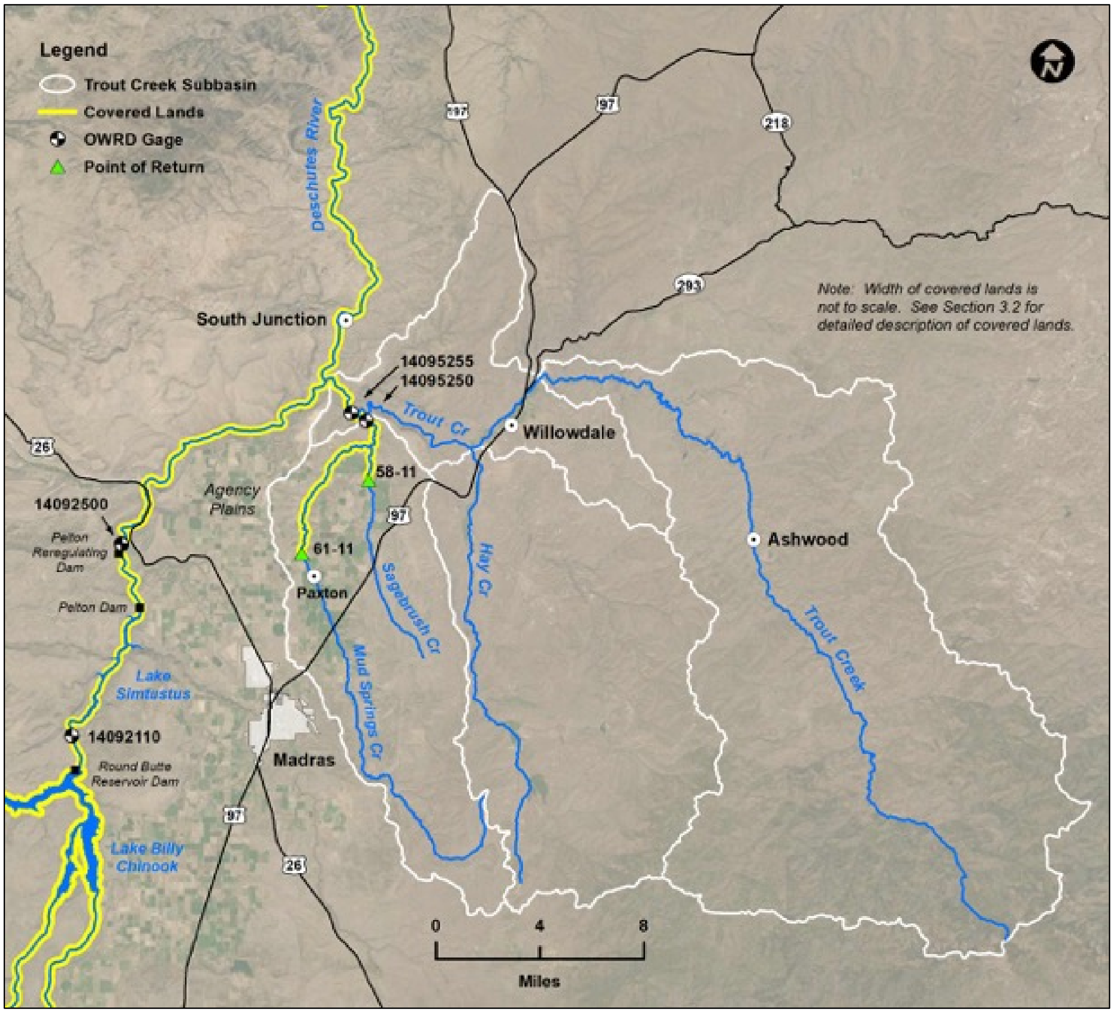


Figure 8-65. Map of the Trout Creek subbasin.

The effects of the return flows on the creeks were evaluated by comparing water temperatures in the returns to those in the receiving waters during the 2013 and 2014 irrigation season (Biota Pacific and CH2M 2017). The majority of the return flow originates in the 58-11 Drain, which was cooler than Mud Springs Creek upstream of the returns, but warmer than Mud Springs Creek several miles downstream (Figure 8-68). During the summer Mud Springs Creek appears to be warmed by surface flow from the 61-11 Drain, but cooled by the 58-11 Drain and groundwater discharge below Agency Plains, for an overall decrease in water temperature between the 61-11 Drain and the mouth of the creek.

Using mass-balance calculations, Biota Pacific and CH2M (2017) estimated that surface flow from the returns warmed Mud Springs Creek up to 4.3°C in August 2014 (Figure 8-69). In 2013 the warming effect was 1°C or less. Since most of the flow in lower Trout Creek during the irrigation season originates in Mud Springs Creek, the trends displayed in Figures 8-68 and 8-69 apply to Trout Creek as well. This is a rough estimate of just the effect of the surface returns alone on instream water temperature; it does not account for the counteracting cooling effect of the groundwater discharge associated with irrigation on Agency Plains that results in an overall decrease in water temperature in both creeks.

Steelhead Adult Migration and Spawning

Adult steelhead enter the lower Deschutes River from June through October and spawn in the Trout Creek watershed from January through mid-April (Zimmerman and Reeves 2000). Conditions for adult migration and spawning in Trout Creek and Mud Springs Creek will not change under the DBHCP. Flows in the two creeks are unaffected by irrigation activities from October through March and increase slightly in late April after the NUID canal is filled. The contributions of the irrigation returns to flows in April will not change as a result of the DBHCP. Water temperatures in both creeks will be below 12.8°C from mid-October through March in most years. The cooling effects of the surface returns and shallow groundwater discharge will continue to partially offset natural warming of the creeks in April, but temperatures will likely increase to as high as 14°C in Mud Springs Creek and 16°C in Trout Creek by the middle of the month in some years (see Figures 4-40 and 4-41).

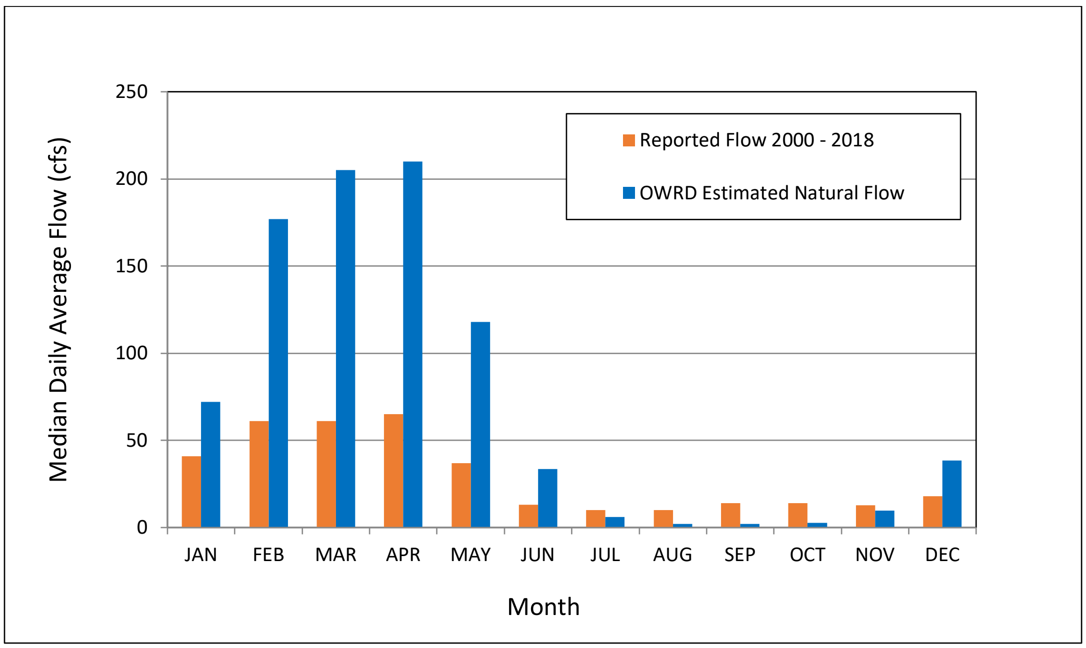


Figure 8-66. Comparison of reported flow (2000-2018) and estimated natural flow in Trout Creek. Sources: OWRD 2020e, 2020f.

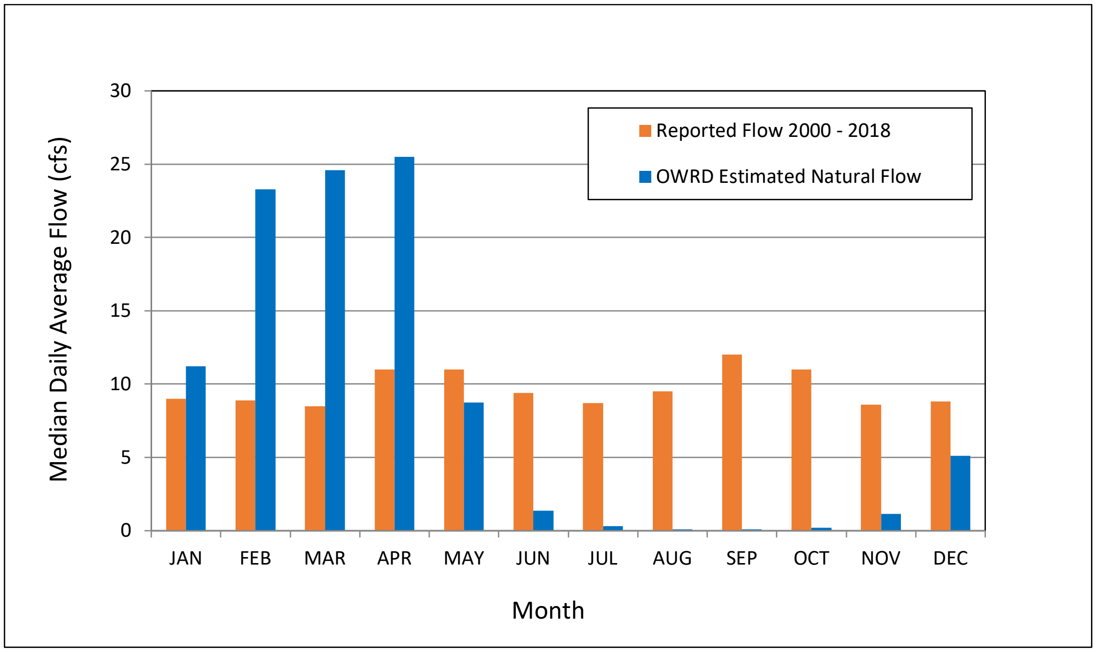


Figure 8-67. Comparison of reported flow (2000-2018) and estimated natural flow in Mud Springs Creek. Sources: OWRD 2020e, 2020f.

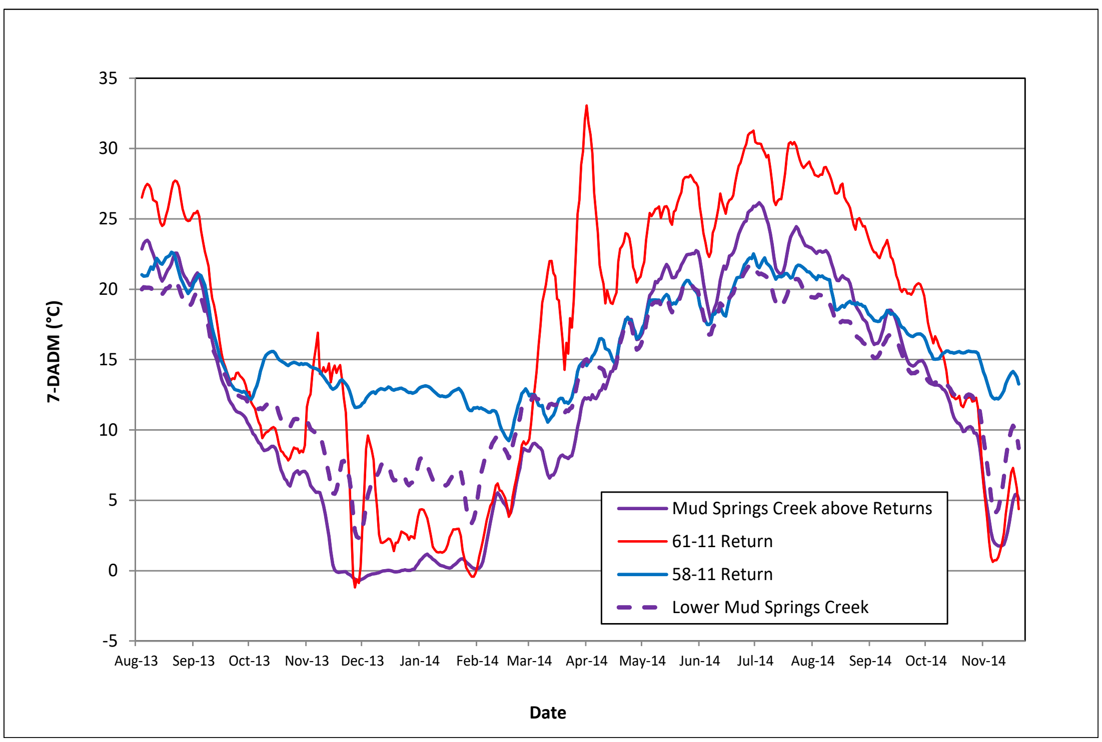


Figure 8-68. Water temperatures (7-DADM) in the 58-11 Drain, upper Mud Springs Creek and lower Mud Springs Creek in 2013 and 2014. Source: Biota Pacific and CH2M Hill 2017.

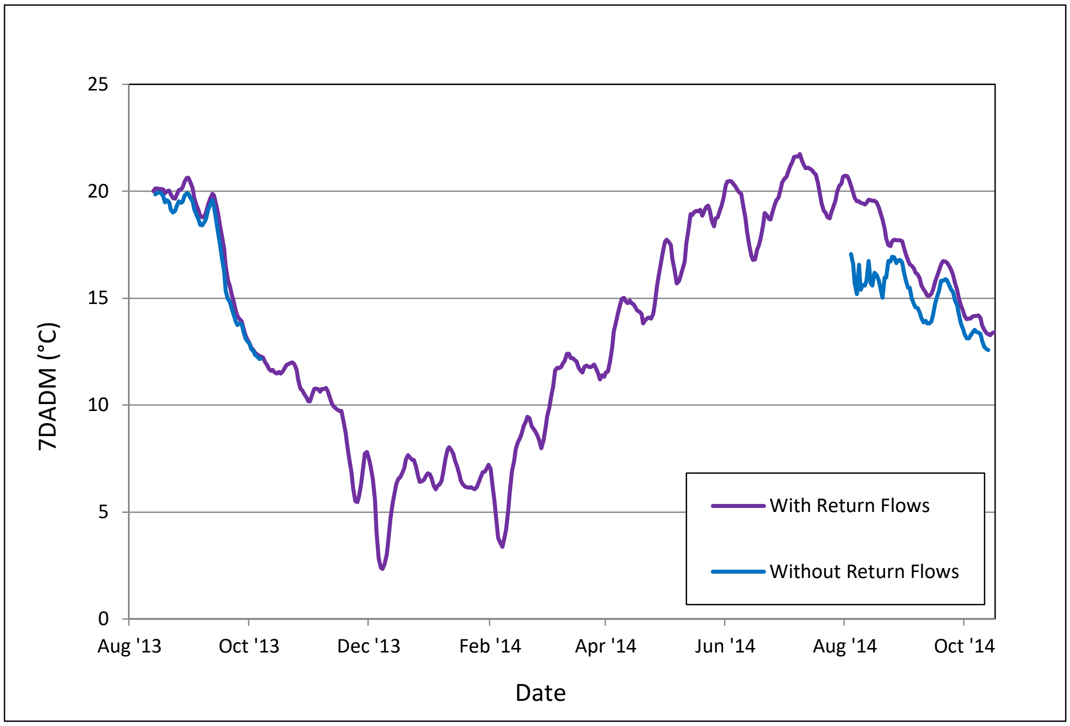


Figure 8-69. Comparison of 7-DADM for lower Mud Springs Creek with and without the influence of the 58-11 Drain and 61-11 Drain return flows in 2013 and 2014. Source: Biota Pacific and CH2M Hill 2017.

Steelhead Egg Incubation

Conditions for steelhead egg incubation in Trout Creek and Mud Springs Creek are unaffected by irrigation activities from January through March, and this will not change under the DBHCP. In April and May, both creeks experience increased flows and decreased water temperatures as a result of the covered irrigation activities, and these benefits will continue under the DBHCP. Water temperatures will remain within the preferred range of 5.6 to 1.1 °C for steelhead egg incubation through March in most years, but Trout Creek may reach as high as 20°C by mid-May. Temperatures in Mud Springs Creek will be 1 to 2 °C cooler than Trout Creek in May due to the cooling effect of the 58-11 Drain and groundwater discharge, but Mud Springs Creek will still reach at least 18°C by the end of the month.

Steelhead Summer and Winter Rearing

The DBHCP will not alter steelhead juvenile rearing conditions in Trout Creek and Mud Springs Creek. Winter rearing conditions are unaffected by DBHCP irrigation activities, and summer rearing conditions are improved slightly by the addition of flow and decrease in water temperature. The irrigation returns and shallow groundwater discharge into Mud Springs Creek will help sustain flows in lower Trout Creek throughout the summer and reduce water temperatures by as much as 2°C. With the benefit of the return flows, water temperatures in both creeks will still approach or exceed the threshold of 22°C for stress to juvenile steelhead in July.

Steelhead Smolt Migration

The influence of the DBHCP on smolt migration from Mud Springs Creek and Lower Trout Creek will not change from the current condition. Outmigration may benefit slightly from the continued one-day pulse of up to 75 cfs from the 58-11 and 61-11 drains in mid- to late April. For the remainder of the outmigration period, the net contribution of roughly 3 cfs to lower Mud Springs Creek and lower Trout Creek helps to sustain flows. This benefit will continue under the DBHCP.

Net Effect on All Life Stages of Steelhead in Mud Springs Creek and Lower Trout Creek

Overall, the DBHCP will have little effect on steelhead in Mud Springs Creek and lower Trout Creek. The covered irrigation activities have no effect on flow or fish passage during the fall and winter (October through March) when the NUID canal is dry. During the irrigation season (April through September), the 58-11 and 61-11 drains at the end of the canal, combined with shallow groundwater discharge from irrigated lands, increase flow and decrease water temperatures in Mud Springs Creek. This effect continues into the lower 2.5 miles of Trout Creek (below the confluence with Mud Springs Creek). In the absence of the irrigation water, the lower reaches of both creeks would have less flow and higher water temperatures throughout the summer, with negative consequences to steelhead. The benefits of the irrigation return flows will not change as a result of the DBHCP.

8.2.7 Summary of Effects on Steelhead

The DBHCP will have minor to moderate positive effects on steelhead in the Deschutes Basin, and the overall potential for successful reintroduction upstream of Pelton Round Butte Project will remain constant or improve slightly. Conditions for adult migration and spawning will show little overall change, and current conditions that allow adult access to most potential spawning habitat will continue. Incubation and summer rearing may improve slightly, while winter rearing could show measurable improvement, particularly during dry water years. Smolt migration will benefit from increased flows out of Wickiup Reservoir in April and pulse flows out of Prineville Reservoir at strategic times during the spring.

The lower Crooked River is of particular importance to the steelhead reintroduction, and the DBHCP will have two beneficial consequences to habitat in this reach. First, existing high-quality *O. mykiss* spawning and rearing habitat between Bowman Dam and the Crooked River diversion will be maintained under the DBHCP. The habitat conditions in this reach of the Crooked River are the result of irrigation storage in Prineville Reservoir and subsequent release of large amounts of cold water during the summer. The future availability of stored water for summer release is contingent on continued operation of the reservoir within historical seasonal limits, and these limits will continue under the DBHCP. Second, the DBHCP, in coordination with Reclamation's use of uncontracted water in Prineville Reservoir, will provide flows to support winter rearing and smolt migration in the Crooked River. Winter flow conditions, particularly within the high-value reach between Bowman Dam and Crooked River Diversion, are recognized as a potential limit to successful steelhead reintroduction (Porter and Hodgson 2016). The DBHCP will help sustain suitable winter rearing habitat, most importantly during dry water years. Smolt migration may be a limiting factor for steelhead reintroduction in the Crooked River, and recent experimental pulse flows indicate these may be important to successful migration (PGE and CTWSRO 2019). The DBHCP will contribute to the effectiveness of these pulse flows by ensuring they are not diverted for irrigation.

8.2.8 Effects of the DBHCP on Critical Habitat for Steelhead

NMFS (2005) designated the Lower Deschutes River and Trout Creek as critical habitat for steelhead (see Figures 5-7 through 5-9). Bambrick et al. (2005) had previously identified the primary constituent elements (PCE) of critical habitat for steelhead in freshwater and marine environments (see Table 5-9). Those PCEs pertinent to freshwater habitats on the covered lands are shown in Table 8-22. These are the physical or biological features essential to the conservation of the species and that may require special management consideration or protection. The effects of the DBHCP on steelhead critical habitat are evaluated by examining anticipated changes from current PCE conditions that may result from DBHCP implementation.

Table 8-22. Primary constituent elements of steelhead critical habitat in freshwater.

Primary Constituent Elements	Steelhead Life Stage
Water quality, water quantity, and substrate	Spawning, incubation, and larval development
Water quantity and floodplain connectivity	Juvenile growth and mobility
Water quality and forage [1/]	Juvenile development
Natural cover [2/]	Juvenile mobility and survival
Free of artificial obstructions, water quality and quantity, and natural cover[2/]	Juvenile and adult mobility and survival

Source: Bambrick et al. 2005.
Notes:
[1/] Forage includes aquatic invertebrate and fish species that support growth and maturation.
[2/] Natural cover includes shade, large wood, log jams, beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.

Water Quality

Covered activities in the Lower Deschutes River return 1 percent or less of the flow in the receiving water at the point of return, and thus all are incapable of altering the temperature of the receiving water more than 0.1°C (see Sections 4.6.3 and 4.6.4, *Current Conditions of the Covered Lands and Waters*). Given the infrequent and modest return flows under the DBHCP, there is little potential for contributing further to temperature limitations. The covered activities are not likely to affect other water quality parameters like DO and pH in the Lower Deschutes River because the system is primarily driven by operations of the Pelton-Round Butte Project and seasonal dynamics in Lake Billy Chinook (NMFS 2005) and this will not be affected by the DBHCP.

In Trout Creek, the covered activities currently make a significant contribution to summer and fall flows, which may increase water temperatures. This may negatively affect early migrating adult fish that arrive before ambient conditions have cooled the water to temperatures suitable for migration.

Water Quantity

Flows in the Lower Deschutes River are reduced year round by the covered irrigation activities, but these reductions have not been associated with significant reductions in the quantity or quality of habitat for migrating or rearing steelhead. Under the DBHCP, flows will increase in the Lower Deschutes River, with the potential for minor improvements in habitat quality.

The covered activities currently make a significant contribution to summer flows in lower Trout Creek. These increased flows, and the benefits they provide to steelhead summer rearing, will continue under the DBHCP.

Floodplain Connectivity

The covered activities have no effect on riparian, floodplain or upland habitat management in the Lower Deschutes River and Trout Creek, and thus the DBHCP will have no impact on floodplain connectivity in designated critical habitat for steelhead.

Substrate

The covered activities have no effect on bedload recruitment/movement or sediment transport/delivery in the Lower Deschutes River and Trout Creek. Consequently, the DBHCP will have no impact on substrate in designated critical habitat for steelhead.

Free of Artificial Obstructions

The covered activities cause no obstructions to steelhead migration in the Lower Deschutes River and Trout Creek. The DBHCP will create no new obstructions to steelhead movements or modify any existing obstructions in designated critical habitat. Smolt survival conditions are expected to improve within designated critical habitat due to increased river flow.

Natural Cover

The covered activities have no effect on natural cover (instream or riparian) in the Lower Deschutes River and Trout Creek. The DBHCP will have a positive effect on edge habitat conditions for juvenile steelhead in designated critical habitat.

Forage

Because nutrients in the Lower Deschutes River are driven by surface withdrawal in Lake Billy Chinook (Eilers and Vache 2019), the contribution of the small irrigation returns relative to the total flow are unlikely to affect trophic dynamics and the overall availability of forage.

8.3 Sockeye Salmon

The Deschutes River once supported a run of anadromous sockeye salmon that spawned in Link Creek and reared in Suttle Lake in the Metolius River subbasin (Thiede et al. 2002). Dams constructed on Suttle Lake and downstream waters in the early part of the 20th century prevented anadromous sockeye from reaching the lake, and a land-locked population of kokanee developed (Nehlsen 1995). Populations of kokanee also exist in Wickiup and Crane Prairie reservoirs, due in part to releases of hatchery fish (see Table 5-11). When Round Butte Dam was constructed in the early 1960s a kokanee population developed within Lake Billy Chinook. At least some of the kokanee in Lake Billy Chinook share genetics with the Suttle Lake population, but hatchery sockeye fry from other Northwest stocks have also been released at a number of locations upstream of Lake Billy Chinook and these may have contributed to the establishment of kokanee in the reservoir (Ratliff and Schulz 1999). It is possible that kokanee from Wickiup Reservoir, some of which have been detected downstream in the Deschutes River at Bend, contribute to the Lake Billy Chinook population as well.

Although there has been no sustained anadromous sockeye run in the Deschutes Basin for about 70 years, small numbers of sockeye have continued to reach the Pelton fish trap below the Reregulating Dam at RM 100 (see Figure 5-13). Some of these are known to be kokanee from Lake Billy Chinook that successfully migrated downstream through the Pelton Round Butte Project, while others are thought to be strays from other populations in the Columbia Basin (Ratliff and Schulz 1999).

Upstream and downstream fish passage has recently been provided at Pelton Round Butte Project, and efforts are currently underway to reestablish an anadromous run of sockeye in the Deschutes Basin. These fish will presumably spawn in accessible waters upstream of Lake Billy Chinook, rear within the reservoir and travel downstream through the hydroelectric project as smolts. Accessible waters currently used for spawning by kokanee include the Metolius River subbasin, the Deschutes River upstream as far as Steelhead Falls (RM 127.7), the lower 2 miles of Whychus Creek and the Crooked River upstream to Opal Springs Dam (RM 7.2). With the recent completion of fish passage facilities at Opal Springs Dam, it is anticipated sockeye salmon could travel farther upstream in the Crooked River during the term of the DBHCP.

The Metolius River subbasin receives the vast majority of kokanee spawning above Lake Billy Chinook, and the other tributaries make up only a small percentage of the total (Kern et al. 1999; Thiede et al. 2002). Given that anadromous sockeye historically spawned in the Metolius subbasin and the majority of kokanee continue to spawn there, it is assumed that if a sustainable run of sockeye is reestablished it too will spawn primarily in the Metolius subbasin. The emphasis for reintroduced sockeye habitat upstream of Round Butte Dam has therefore been on Lake Billy Chinook (for rearing) and the Metolius River subbasin (for spawning and fry development). The other tributaries to Lake Billy Chinook are expected to play minor roles in the reintroduction of sockeye.

The irrigation activities covered by the DBHCP influence current and potential sockeye salmon habitat in the Middle Deschutes River, Whychus Creek, Crooked River, Lake Billy Chinook and the Lower Deschutes River (Figure 8-70). Although kokanee are present in Wickiup and Crane Prairie reservoirs, these habitats are above natural barriers on the Deschutes River and will not be part of the reintroduction of anadromy. Kokanee within Wickiup and Crane Prairie reservoirs are therefore not covered by the DBHCP. The covered activities do not affect habitat conditions for sockeye in the Metolius River subbasin.

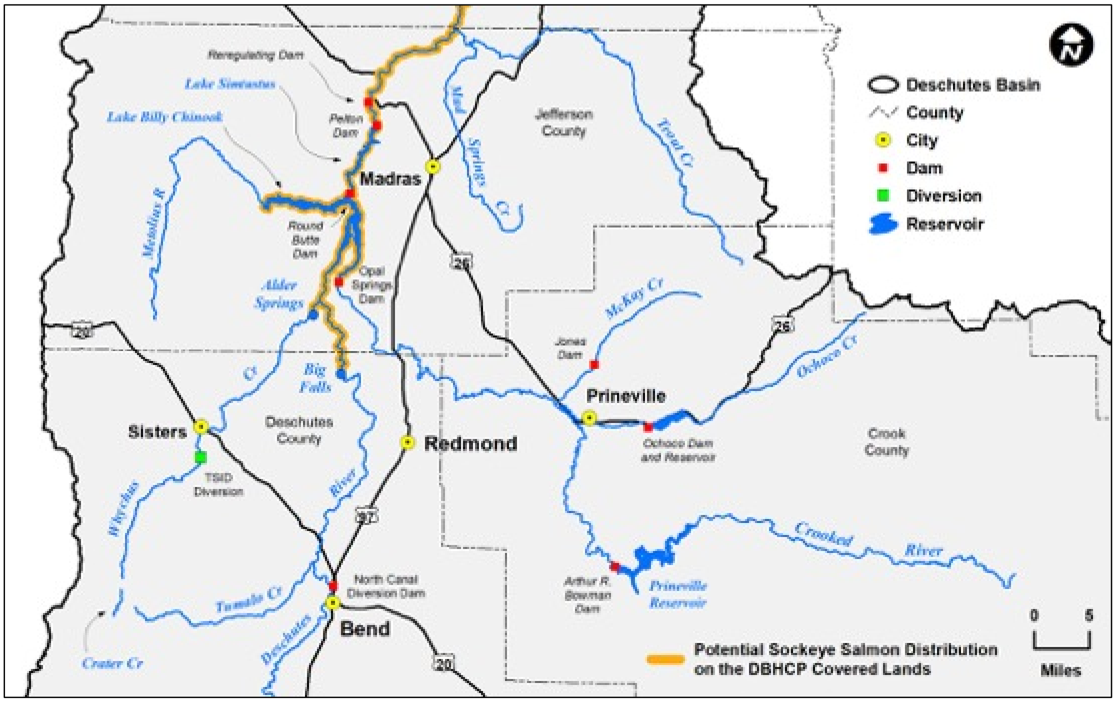


Figure 8-70. Waters covered by the DBHCP that are currently accessible to sockeye salmon/kokanee.

The seasonal timing of sockeye salmon presence in the Deschutes Basin is estimated from the known timing of kokanee in the basin and the results of recent sockeye spawning and migration studies (Kern et al. 1999; Ratliff and Schulz 1999; Hill and Quesada 2013; Hill et al. 2014; Wymore et al. 2015; Burchell et al. 2016; Burchell and Hill 2017; Burchell 2018). Adult sockeye are expected to migrate upstream to the Pelton fish trap in July and August (Table 8-23). After holding temporarily in Lake Billy Chinook, they will move up into tributary streams to spawn in September. Incubation will last until November or early December, and fry will move down into the reservoir from March through May. Sockeye will rear in the reservoir for 1-2 years before outmigrating in February through April.

The effects of the DBHCP on sockeye occur indirectly through the changes in hydrology and water quality described in detail in Chapter 6, *Habitat Conservation*. Direct effects can also occur through entrainment and blockage to migration at covered irrigation diversions, although sockeye are not expected to migrate upstream as far as any of those covered storage reservoirs or diversion dams. The conservation measures described in Chapter 6 have been designed to address both indirect and direct effects of the covered activities on sockeye and other covered species.

Changes to hydrology resulting from the covered activities are variable by season and location. Flows in the Deschutes River and Crooked River are reduced by the storage of irrigation water in the fall and winter and by the diversion of irrigation water during the late spring and summer. No storage occurs on Whychus Creek, but flows are reduced by irrigation water diversions in the spring and summer and stock water diversions in the fall and spring. Stock water diversions also reduce flows in the Deschutes River periodically during the winter.

Table 8-23. Seasonal presence and water temperature suitability for sockeye salmon in the Upper Deschutes Basin.

Life History Stage	Season[1/]	Water Temperature Suitability (°C)				
		Preference	Avoidance	Stress/ Disease	Delay	Lethal
Adult Migration[1/]	Jul – Oct	7.2 – 15.5	ND	ND	18.0 – 22.8	23.5 – 24.8
Spawning[2/]	Sep – Oct	8.0 – 13.0	ND	ND	ND	ND
Incubation[3/]	Sep – Dec	4.4 – 12.7	ND	> 15.6	ND	16.7 – 18.3
Juvenile Rearing[4/]	Year round	11.6 – 14.4	> 18.0	< 7.2; > 23.0	ND	24.4
Outmigration[5/]	Feb – Apr	> 7.0	ND	ND	< 5.0; > 12.0	ND

Notes:

1) Brett 1952; Brett 1971; Bell 1990; Fies et al. 1996b *in NPCC 2004*; McCullough et al. 2001; Hill et al. 2014; Burchell and Hill 2017
2) Pauley et al. 1989; Bell 1990; Bjornn and Reiser 1991; Fies et al. 1996b *in NPCC 2004*
3) Reiser and Bjornn 1979; Pauley et al. 1989; Fies et al. 1996b *in NPCC 2004;* USEPA 2001b
4) Donaldson and Foster 1941; Brett 1952; Brett 1964; Brett et al. 1969; Pauley et al. 1989; Bell 1990
5) Hart 1973; Ratliff and Schulz 1999; McCullough et al. 2001

The effects of the covered activities on covered fish species are determined by comparing historical conditions on the covered lands to future conditions under the DBHCP. For consistency with hydrologic analyses presented in Chapter 6, *Habitat Conservation*, historical conditions are defined as conditions that existed from 1981 through 2018, and future DBHCP conditions are those that will occur during DBHCP implementation beginning in 2021. In most cases, historical conditions are the same as current conditions (i.e., conditions immediately prior to DBHCP implementation), but in a number of cases current conditions are improved from average or median historical conditions due to water conservation projects that occurred progressively over the 11 years of DBHCP development. These early conservation actions cannot be attributed directly to the DBHCP because they occurred prior to federal approval of the DBHCP, but they nevertheless have resulted in improved conditions for covered species. Habitat improvements associated with early conservation actions will be identified in the following analysis and distinguished from the effects of the DBHCP.

Natural (also called unregulated) conditions are discussed briefly for some geographic areas to describe the natural habitat potential of those affected reaches, but not as a basis for comparison of the effects of the DBHCP. Natural conditions are not used as the basis for comparison because they are no longer achievable after 100 years or more of land use change in the basin, and because in certain locations irrigation activities have been beneficial to covered species and a return to natural conditions would be undesirable. Natural conditions are important to note, however, because they provide insights into the natural potential of the covered lands to support the covered species. In many cases, the conservation benefits of the DBHCP are limited by the natural potential of the covered lands.

8.3.1 Middle Deschutes River

Overview

The analysis of effects of the DBHCP on sockeye in the Middle Deschutes River is limited to the 7.7 miles of river currently or potentially occupied by the species between the upstream limit of Lake Billy Chinook (RM 120.0) and Steelhead Falls (RM 127.7) (Figure 8-70). Kokanee spawning in this reach has been reported previously (Kern et al. 1999), but sockeye's use of the river to date has been very limited. Adult sockeye collected below the Pelton Round Butte Project from 2012 through 2017 were radio-tagged and released into Lake Billy Chinook to complete their upstream migration. Movements of these fish were tracked using both fixed and mobile radio receivers, providing information about locations that were used by adult spawners. Results to date indicate extremely low sockeye use of the Middle Deschutes River, with most adults migrating to the Metolius River subbasin (Table 8-24).

Table 8-24. Results of monitoring of returning adult sockeye salmon captured at the Pelton Round Butte Project from 2012 through 2017.

Year	Number of Fish Captured at PRB	Number of Fish Tagged and Released Upstream	Proportion Detected Following Release			
			Middle Deschutes River	Whychus Creek	Crooked River	Metolius River
2012[1/]	86	86	0.00	0.00	0.00	0.19
2013[2/]	25	25	0.00	0.00	0.00	0.20
2014[3/]	21	21	0.00	0.00	0.00	0.48
2015[4/]	36	0	0.00	0.00	0.00	0.00
2016[5/]	535	91	0.00	0.00	0.00	0.60
2017[6/]	57	6	0.00	0.00	0.00	0.67

Notes:

[1/] Hill and Quesada 2013
[2/] Hill et al. 2014
[3/] Wymore et al. 2015
[4/] Burchell et al. 2016
[5/] Burchell and Hill 2017
[6/] Burchell 2018

There are no irrigation storage reservoirs, diversions or return flows within the Middle Deschutes River; the effects of the covered activities are limited to changes in flow resulting from the storage, release and diversion of water in the Deschutes River and its tributaries more than 30 miles upstream. Historical hydrology and water quality of this reach are described in Section 4.2, *Upper and Middle Deschutes River*. Flows are strongly influenced by groundwater discharge and surface tributary inflow within the reach that diminish the relative effects of upstream irrigation activities. Current instream water rights provide a minimum flow of 143 cfs upstream of Steelhead Falls during the peak of the irrigation season (mid-May to mid-September), but subsurface inflow from groundwater and surface inflow from Whychus Creek increase the average flow to over 500 cfs by the time the river reaches Lake Billy Chinook (see Figure 4-5).

The DBHCP will not alter flows in this reach during the irrigation season, as indicated by projected daily average flows upstream at RM 160 (Figure 8-27). The *DBHCP, Minimum 100 cfs* flows for April through September shown in Figure 8-27 reflect current conditions, and these are greater than historical flows because they include the benefits of early conservation actions since 2010. Irrigation season flows in this reach could continue to increase from current conditions over the next 30 years if there are additional conserved water projects, but these projects are not reflected in Figure 8-27 or included in this analysis because they would be unrelated to the DBHCP.

During the storage season of October through March, flows in the Middle Deschutes River will increase as a result of the DBHCP because fall and winter flows below Wickiup Dam (Hydromet Station WICO) will increase. As with irrigation season flows, the *DBHCP, Minimum 100 cfs* flows for October through March shown in Figure 8-27 reflect current conditions because the requirement to maintain a minimum flow of 100 cfs at WICO is already being implemented. In the future, as the required minimum flow at WICO increases, the winter flow in the Middle Deschutes River will also increase. Additional benefit will be derived from Measure DR-1, which will prevent stock water diversions from reducing flows through Bend to less than 250 cfs from November through March.

Water temperatures at the upstream and downstream ends of the Middle Deschutes River from 2011 through 2016 are presented in Figures 8-28 and 8-29, respectively. These are not expected to change as a result of the DBHCP. Within this portion of the reach utilized by sockeye salmon, temperatures will be closer to those depicted by Figure 8-29 (RM 120) due to the substantial influx of cold groundwater that occurs in the reach. From 2011 through 2016 the 7-DADM at Culver (RM 120) never reached 18°C and it exceeded 16°C only briefly. The Middle Deschutes River is listed as water temperature limited under Section 303(d) of the Clean Water Act for exceeding the maximum 7-DADM of 18°C for salmon and trout rearing and migration, although the data presented in Figure 8-29 suggest this designation may not be appropriate for the portion of the river downstream of Steelhead Falls. The reach is also listed as water quality limited for dissolved oxygen during salmonid spawning (January 1 to May 1) and flow modification.

Sockeye Adult Migration

Adult sockeye salmon are expected to reach the Deschutes River Arm of Lake Billy Chinook in July and August and migrate into spawning tributaries from late August through October. Recent data for the Deschutes River near Culver (Figure 8-29) suggest water temperature conditions are consistently within the preferred range for adult sockeye migration in September, and are below the threshold for delayed migration (18°C) throughout the entire migration period. Upstream at Steelhead Falls, however, warmer temperatures could delay migration from July through much of August. By mid-September the entire reach from Lake Billy Chinook to Steelhead Falls should be within the preferred temperature range. These conditions will persist under the DBHCP.

Predicted changes in riffle depth in the Middle Deschutes River were examined to assess the location of potential physical barriers that might occur as a result of the DBHCP (Appendix A-4). Adult sockeye require a minimum channel depth of 0.59 foot for passage during upstream migration (Thompson 1972). Under the DBHCP, predicted average riffle depths in the Middle Deschutes River will range between 0.88 and 2.06 feet during adult sockeye migration, meeting the minimum depth requirement in each month (Figure 8-71). Adult sockeye are not expected to encounter physical barriers during their upstream migration in the Middle Deschutes River.

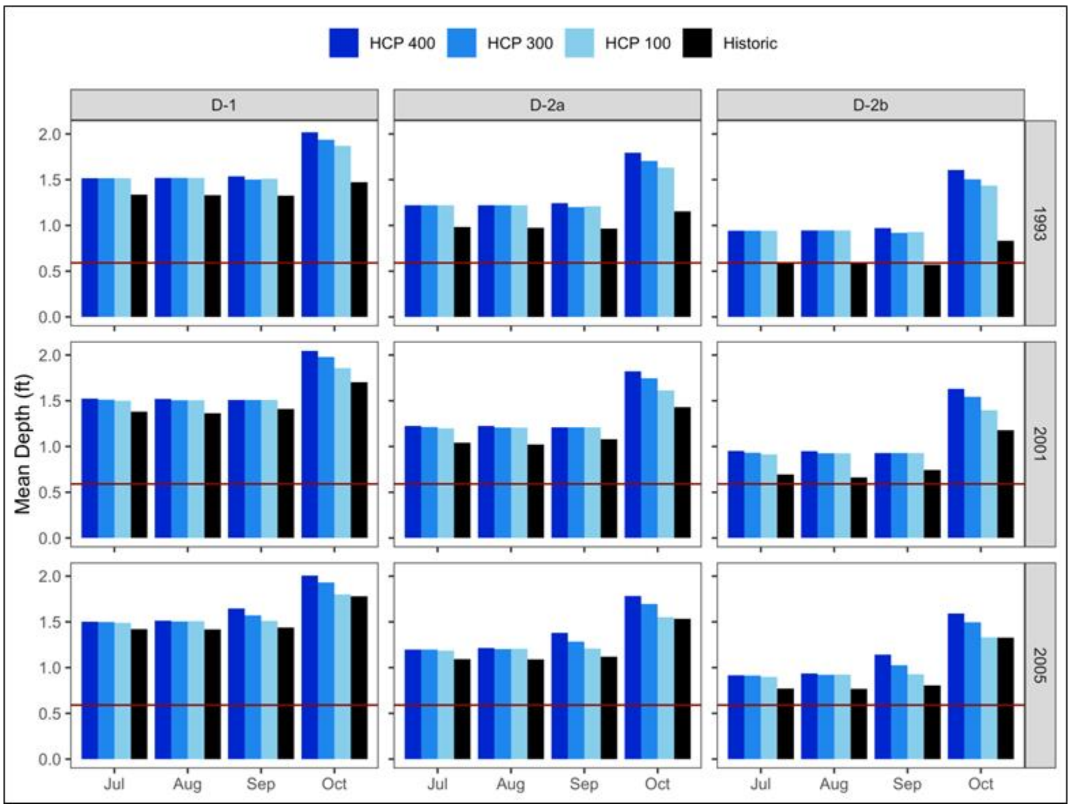


Figure 8-71. Estimated average riffle depth in the Middle Deschutes River during the sockeye migration period (red horizontal line indicates minimum depth required for passage). Source: See Appendix A-4.

Sockeye Spawning

Female sockeye salmon choose redd locations in cool, clear streams in shallow pool tailouts and in the transition areas between riffles and other slower velocity habitat types with suitable gravel size, depth, and water velocity. Typical sockeye spawning habitat requirements are described in Table 8-25. Females also generally prefer locations with uniform water velocity and course sediment that will allow a steady supply of water. Preferred temperatures for spawning are between 8.0 and 13.0 °C (Table 8-23). Direct observations of sockeye selecting spawning sites in the Middle Deschutes River are limited because there are very few returning adult fish. Even in years when adult returns have been high at the Pelton fish trap, mobile tracking efforts indicate that fish almost exclusively move into the Metolius River for spawning (Burchell and Hill 2017).

Table 8-25. Spawning habitat criteria used to assess impacts of the DBHCP on sockeye salmon.

Habitat Characteristic	Criteria	Source
Water Depth	Minimum to cover the fish	Burgner 1991
	≥ 0.49 ft. [estimated]	Bjornn & Reiser 1991; Reiser & Bjorn 1979
	0.3 to 2.5 ft.	Pebble Limited Partnership 2012 in Woll et al. 2014
Fines Composition	< 5% in redd	McNeil & Ahnell 1964 in Bjornn & Reiser 1991
	< 15%	Lorenze & Eiler 1989
	20% is harmful	Stowell et al. 1983; Bjornn & Reiser 1991
Substrate Size	0.5 to 4.0 inches in diameter	Bell 1990
Velocity	Areas of upwelling or subsurface flow preferred	Lister & Genoe 1970; Vining et al. 1985 in Bjornn & Reiser 1991
	< 3.3 ft/s	Lorenze & Eiler 1989
	< 4.25 ft/s	Pebble Limited Partnership 2012 in Woll et al. 2014

Water temperatures in the Middle Deschutes River downstream of Steelhead Falls exceed the preferred range for sockeye spawning through mid-September (Figures 8-28 and 8-29) and this is not expected to change as a result of the DBHCP. The ODEQ Heat Source model (Watershed Sciences and MaxDepth Aquatics 2008) was used to estimate the effects of different flows on summer water temperatures in the Deschutes River from Lake Billy Chinook to Big Falls (Figure 8-72). Historical flows in the analysis are based on the 2001 instream water rights of 109 cfs at the upstream end of the reach. Current (DBHCP) flows are based on the existing instream water rights of 143 cfs. Natural flows were defined by ODEQ to be 1,347 cfs. The HeatSource model results show that increasing flow in this reach during the summer increases peak water temperature. This positive relationship between flow and temperature exists because the water entering the reach from upstream is warm, and an increase in flow provides a greater thermal mass to be cooled by groundwater discharge and surface inflow within the reach. This is a natural condition, as indicated by the higher water temperatures at RM 120.0 under natural flows. Increases in summer flow that have occurred since 2001 have increased summer temperatures within the reach, and any future increases unrelated to the DBHCP could increase summer temperatures further. Adult sockeye seeking spawning habitat in the Middle Deschutes River will likely find water temperatures too warm until late September. These conditions may account for the limited amount of kokanee and anadromous sockeye spawning that has been reported in the Middle Deschutes River to date (Table 8-24). This natural limitation on water temperature will not change under the DBHCP.

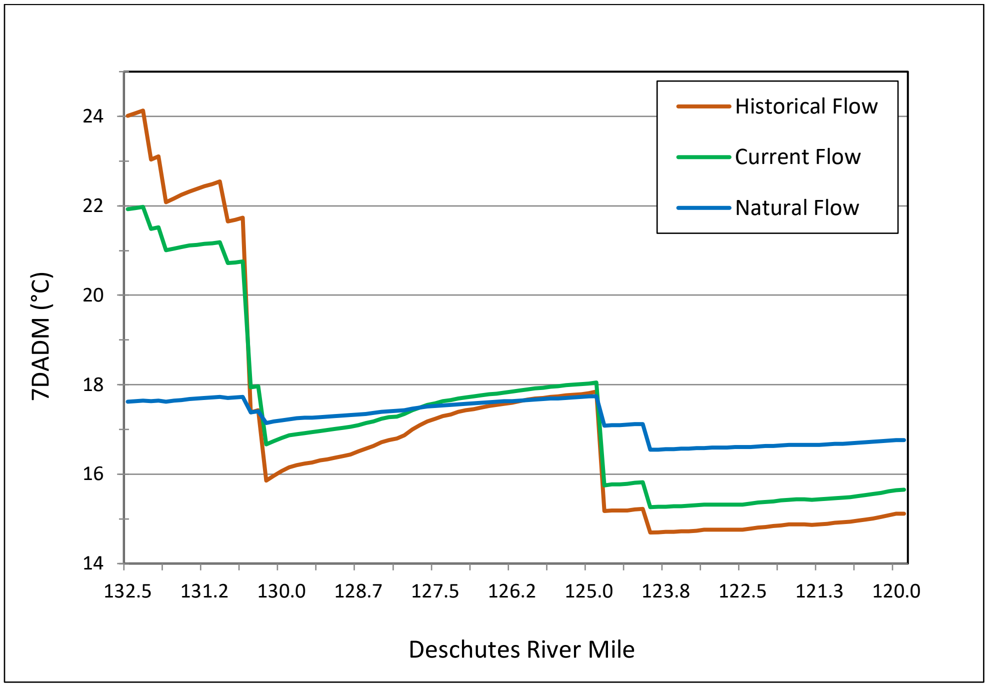


Figure 8-72. Heat Source predictions of the annual maximum of the 7-day average of daily maximum water temperatures (Max 7-DADM) for the Deschutes River between Big Falls (RM 132.2) and Lake Billy Chinook (RM 120.0).

DBHCP flows in the Middle Deschutes River will not change from current conditions in September, but flows in October will increase incrementally over time due to increased releases from Wickiup Reservoir (Figure 8-27). Minimum depths required for spawning (Table 8-25) are generally less than minimums required for adult migration (0.59 foot). Because flows are expected to remain above migration minimums through October (Figure 8-71), flows are likewise expected to meet minimum spawning depth requirements.

Sockeye Egg Incubation

Despite temperature limitations on sockeye spawning in the Middle Deschutes River, small numbers of adults may continue to spawn in this reach. Figures 8-28 and 8-29 suggest the reach is also too warm for sockeye egg incubation for much of September, when the 7-DADM is consistently above 12.7°C, but suitable for incubation from October through December. In early September, the 7-DADM near Steelhead Falls can exceed the stress threshold of 15.6°C. It is possible that sockeye may avoid these higher temperatures by delaying spawning until October when conditions for incubation are favorable, but there are limited data to verify this. Alternately, warm water temperatures in the Middle Deschutes River in September may contribute in part to the preference by adult kokanee and sockeye to spawn in the Metolius River subbasin. As noted for sockeye spawning, warm water temperatures in this portion of the Middle Deschutes River are a natural phenomenon that will not be altered by the DBHCP.

Flows in the Middle Deschutes River will remain unchanged under the DBHCP during September, but increase during the remainder of sockeye egg incubation in October through December (Figure 8-27). Dramatic increases in flow can scour redds or physically remove eggs. However, high temperatures that likely preclude adults from migrating to spawning grounds during the low-flow periods in August and September would result in most spawning occurring when flows are already high and females can choose optimal redd locations for the current flow.

Sockeye Rearing

Young sockeye salmon that incubate in the Middle Deschutes River will move downstream to Lake Billy Chinook within several months after emergence from gravel. The exact timing of downstream movement from the Middle Deschutes River is not known, but studies in the Metolius River subbasin (Kern et al. 1999) suggest it occurs from early March to early June and peaks during April and May. Sockeye rearing in the Middle Deschutes River is therefore limited to the months of November through May. The 7-DADM in the Middle Deschutes River has historically been below 11°C from November through March and below 7°C from December through February (Figures 8-28 and 8-29), suggesting the river may be too cold for sockeye rearing. These conditions are expected to continue under the DBHCP.

Flows in the Middle Deschutes River are at their annual high during November through March (Figure 8-27) and these are expected to be even higher under the DBHCP due to increased releases of water from Wickiup Reservoir. By April, however, flows typically decrease due to the start of the irrigation season, and this pattern will continue under the DBHCP. Flows in April and May will be higher than they were historically, but they will still average less than 200 cfs by May. Based on hydraulic modeling from the Middle Deschutes River at low flows (Courter et al. 2014), average depths of pools (2.0 feet at 100 cfs, 2.48 feet at 200 cfs) and riffles (0.72 foot at 100 cfs, 0.96 foot at 200 cfs) will be sufficient to support rearing or movement of juveniles to rearing habitat in Lake Billy Chinook.

Sockeye Smolt Migration

Sockeye salmon leave the Middle Deschutes River as fry and rear in Lake Billy Chinook. The DBHCP therefore has no effect on sockeye smolt migration within the Middle Deschutes River.

Net Effect on All Life Stages of Sockeye in the Middle Deschutes River

The Middle Deschutes River provides potential habitat for kokanee spawning, incubation and early juvenile rearing, and it is assumed at least a small number of the anadromous form of sockeye salmon will make similar use of the reach in the future. Habitat conditions will not change as a result of the DBHCP. Historical limitations on sockeye use related to high water temperatures in September and low water temperatures during mid-winter will continue. The majority of sockeye salmon spawning upstream of Lake Billy Chinook is expected to occur in the Metolius River subbasin, and the DBHCP will not change this. For the small number of sockeye that utilize the Middle Deschutes River, the DBHCP will have no negative effects on adult migration, spawning, incubation, early juvenile rearing or juvenile migration to the reservoir.

8.3.2 Whychus Creek

Overview

To date, no adult sockeye released into Lake Billy Chinook have been documented moving upstream from the reservoir into Whychus Creek, even during 2016 when a record number returned to the Pelton fish trap (Table 8-24). However, kokanee spawning in lower Whychus Creek has been reported in the past (Ratliff and Schulz 1999) and the possibility exists that a small number of anadromous adult sockeye could spawn there in the future.

Kokanee in Lake Billy Chinook currently have physical access upstream in Whychus Creek to a natural barrier at RM 37.1, but they have never been observed beyond the lower 2 miles of the creek (Fies et al. 1996a). This is likely due to late summer and early fall water temperatures that increase markedly above Alder Springs (RM 1.4). If adult sockeye enter Whychus Creek in the future they are likely to show a similar pattern and limit their use to the lower 1.4 miles.

There are no storage reservoirs on Whychus Creek, and no covered activities other than the TSID main diversion at RM 24.2 and one small patron diversion at about RM 26. Water is diverted from March through November, but diversion rates are highest during the peak irrigation season of April to October. The historical hydrology of Whychus Creek is described in Section 4.5, *Whychus Creek*. The effects of the DBHCP on hydrology are presented in Section 6.4.3.4, *Effects of DBHCP Measure WC-1 on Whychus Creek Hydrology.* Natural flow in Whychus Creek varies considerably on a seasonal basis, with peak flows during spring snowmelt and winter storms, and low flows in late summer. Historically, irrigation diversions substantially reduced summer flows in the lower 24 miles of the creek. In recent years, however, conserved water projects by TSID and others have resulted in instream water rights of over 31 cfs. The new instream flows are reflected in DBHCP flows at Sisters (Figure 8-33), although flows at Sisters are consistently lower than flows immediately below the TSID diversion, where the water right is measured, due to channel losses and irrigation diversions between the two points. The net effect of the new instream rights is that median and 80 percent exceedance flows in the lower 24 miles of Whychus Creek will be higher throughout the irrigation season than they were historically. The apparent decreases in median flows in Whychus Creek during March, October and November under the DBHCP are the result of TSID diversions in these months being artificially low for recent historical conditions (2000 through 2017) due to canal piping projects that prevented TSID from diverting water. These reduced diversions increased the historical stream flows shown in Figure 8-33. Now that piping is completed, TSID will return to its normal practice of diverting water from March through November and Whychus Creek flows will return to levels similar to those that occurred prior to 2000.

Historical water temperature conditions in Whychus Creek are summarized in Section 4.5, *Whychus Creek*, and water temperature conditions under the DBHCP are described in 6.4.3.5, *Effects of DBHCP Measure WC-1 on Whychus Creek Water Temperature*. Summer temperatures generally increase with downstream distance from the TSID diversion until a cooling effect is provided by groundwater discharge at Alder Springs (RM 1.4). Peak summer temperature (Max 7-DADM) can regularly exceed 18°C upstream of Alder Springs (Figure 8-36), but downstream of the springs peak summer temperatures characteristically remain below 16°C (Figure 8-37). Whychus Creek is listed as water temperature limited under Section 303(d) of the Clean Water Act for exceeding the year-round maximum 7-DADM of 18°C for salmon and trout rearing and migration from the mouth to RM 40.3 (ODEQ 2017), but Figure 8-37 suggests this condition does not apply to the lower 1.4 miles of the creek.

Sockeye Adult Migration

Water temperatures in the lower 1.4 miles of Whychus Creek have consistently been within the preferred range for adult sockeye migration in September and October (Figure 8-37) and this is not expected to change under the DBHCP. Upstream of Alder Springs, water temperatures are frequently above the preferred range until mid- or late September (Figure 8-36), and this too will continue unchanged under the DBHCP. Adult sockeye seeking spawning habitat in Whychus Creek in September will likely remain below Alder Springs as kokanee have in the past.

Adult sockeye require a minimum channel depth of 0.59 foot for passage during upstream migration (Thompson 1972). The relationship between flow and riffle channel depth in four analysis reaches of Whychus Creek is illustrated in Figure 8-73. Under the DBHCP, the monthly median flow in Whychus Creek at Sisters (the boundary between Reaches W-4 and W-3) in September and October will be 17 to 28 cfs, and the allowable minimum flow will be 12 cfs (Figure 8-33). Whychus Creek will accumulate flow downstream of Sisters from surface tributaries and groundwater discharge, and by the time it reaches the mouth (Reach W-1) the monthly minimum in September and October will be at least 50 cfs. The relationship between flow and riffle depth provided in Figure 8-73 indicates the lower reaches of Whychus Creek (W-1 and W-2) are likely to have sufficient depth for adult sockeye migration in September and October with median and minimum DBHCP flows, but the upper reaches (W-3 and W-4) may have marginal or insufficient water depth even at median DBHCP flows. Sockeye are therefore expected to encounter physical barriers at Reach W-3 during their upstream migration in Whychus Creek.

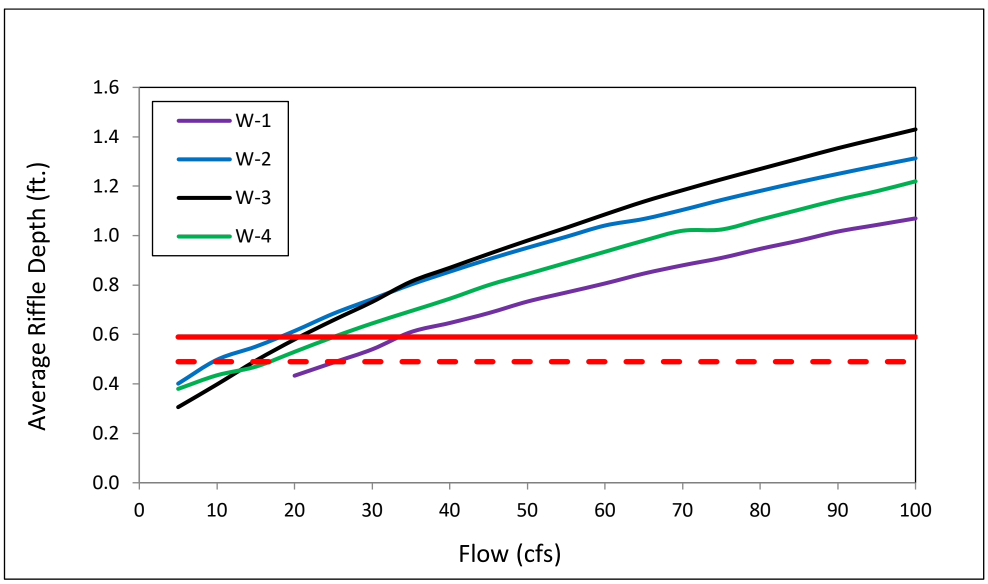


Figure 8-73. Relationship between flow and riffle depth in Whychus Creek Analysis Reaches W-1 through W-4 based on HEC-RAS hydraulic modeling. Solid red line indicates minimum depth for sockeye adult migration (0.59 foot). Dashed red line indicates minimum depth for sockeye spawning (0.49 foot). Source: See Appendix A-4.

Sockeye Spawning

The DBHCP is not expected to result in a significant change in water temperatures from historical conditions in lower Whychus Creek during September and October when sockeye could be spawning. Data presented in Figure 8-37 indicate historical 7-DADM values as high as 13.5°C at RM 0.25 in early September of some years, but in most years the 7-DADM has been between 8.0 and 13.0°C throughout September and October. The DBHCP will not alter these conditions, and water temperatures downstream of Alder Springs will generally remain suitable for sockeye spawning. Similarly, water temperatures upstream of Alder Springs will not change under the DBHCP and they will continue to be too warm for sockeye spawning in September of most years (Figure 8-36).

Minimum water depth for sockeye spawning is 0.49 foot. The relationship between flow and riffle depth in Figure 8-73 indicates that depths in all reaches of Whychus Creek downstream of the TSID diversion will be sufficient to support sockeye salmon spawning in September and October with DBHCP median and minimum flows.

Sockeye Egg Incubation

Water temperatures in lower Whychus Creek are expected to continue following the historical trend during the time of year when sockeye eggs could be present and developing. The 7-DADM will generally remain below 13.0°C from September through December (Figure 8-37), and temperature conditions will remain favorable for sockeye egg incubation under the DBHCP.

Sockeye Rearing

Young sockeye salmon that incubate in Whychus Creek would move downstream to Lake Billy Chinook within several months after emergence from gravel. The exact timing of downstream movement to be expected in Whychus Creek is not known, but studies in the Metolius River subbasin (Kern et al. 1999) suggest it could occur from early March to early June and peak during April and May. Sockeye rearing in Whychus Creek would therefore occur in the months of November through May, when the 7-DADM is consistently below 14°C (Figures 8-37). Consequently, favorable water temperatures for juvenile sockeye rearing are expected to continue under the DBHCP.

Under the DBHCP, median and 80 percent exceedance flows in lower Whychus Creek will decrease from recent historical levels in November and March and increase in December, January, February and May (Figure 8-33). However, minimum flows will increase in all months due to increased instream water rights. The net effect of this on sockeye salmon rearing habitat will be more consistent availability of habitat through the winter with less potential for extremely low flows compared to historical conditions.

Sockeye Smolt Migration

If sockeye salmon spawn in Whychus Creek, the resulting young fish will leave as fry and rear in Lake Billy Chinook. The DBHCP therefore has no effect on sockeye smolt migration within Whychus Creek.

Net Effect on All Life Stages of Sockeye in Whychus Creek

Whychus Creek is expected to play a very small role in the successful reintroduction of sockeye salmon to the Deschutes River because the majority of spawning and rearing upstream of Lake Billy Chinook is expected to occur in the Metolius River subbasin. Small numbers of adult sockeye may spawn in the lower 1.4 miles of Whychus Creek in September and October, and young sockeye would move downstream to Lake Billy Chinook by June of the following year. Temperature and flow conditions in the lower 1.4 miles of creek currently meet known criteria for sockeye spawning, incubation, early juvenile rearing, and outmigration, and this is not expected to change under the DBHCP.

8.3.3 Crooked River

Overview

Kokanee are thought to spawn in the Crooked River upstream at least as far as Opal Springs Dam at RM 7.2 in very small numbers (Stuart et al. 1996), creating the possibility that anadromous sockeye could do so as well. If sockeye eventually spawn in the Crooked River, total numbers are expected to be very low (Kern et al. 1999). Tracking of returning adult sockeye in Lake Billy Chinook since 2012 has failed to document spawning in the Crooked River (Table 8-24). The recent construction of fish passage at Opal Springs Dam is not likely to appreciably increase upstream use of the Crooked River by sockeye because water temperatures above Opal Springs (RM 8.0) are consistently higher in September when sockeye would be seeking spawning sites.

Flows in the lower Crooked River are influenced by the storage, diversion and return of water at multiple upstream facilities covered by the DBHCP, but the relative effects of the covered activities are almost negligible due to the substantial discharge of cold groundwater at Opal Springs. The historical hydrology of the Crooked River is presented in Section 4.8, *Crooked River*, *Ochoco Creek and McKay Creek*. The effects of the DBHCP on Crooked River hydrology appear in Section 6.5.3.3, *Effects of DBHCP Measures CR-1 on the Hydrology of the Crooked River*. Monthly median flow below Opal Springs Dam (OWRD Gage 14087400) has historically ranged from 1,240 cfs in July to 1,700 cfs in April (Figure 8-74). Flows under the DBHCP will not vary appreciably from these historical levels.

Historical water temperature conditions in the Crooked River are summarized in Section 4.8, *Crooked River*, *Ochoco Creek and McKay Creek*. Due to the influence of the cold groundwater discharge at Opal Springs, water temperatures downstream of there are consistently cool year round (Figure 8-75).

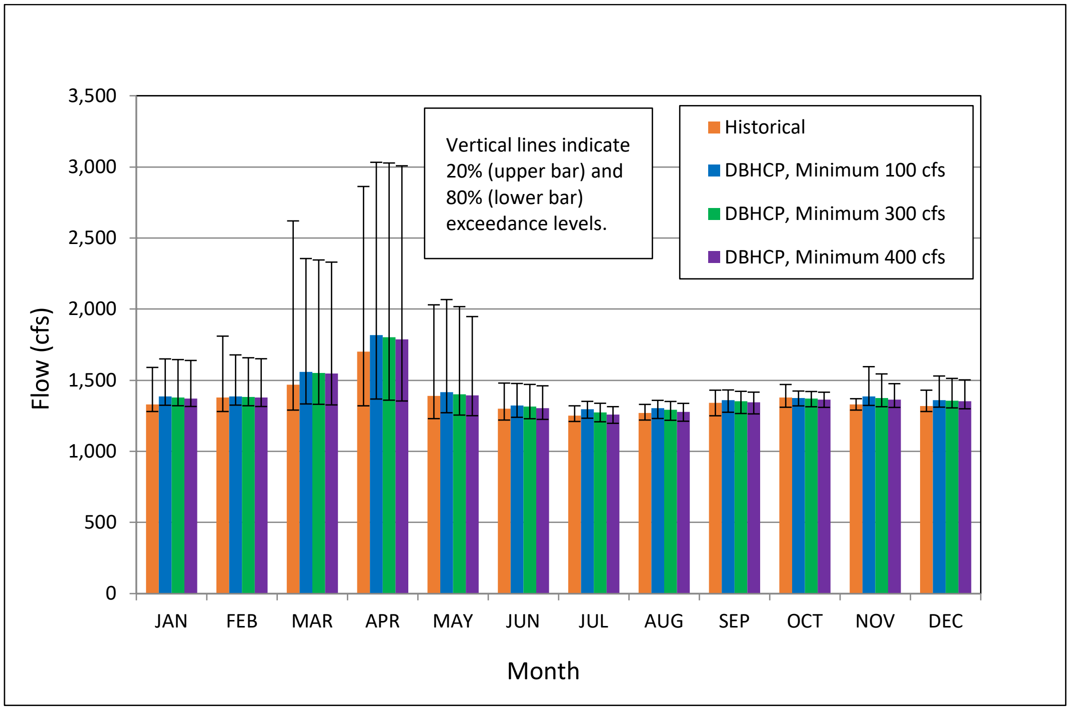


Figure 8-74. Monthly medians of daily average flow in the Crooked River below Opal Springs (USGS Gage 14087400) for historical and projected DBHCP conditions (minimum flows refer to winter flows in the Deschutes River below Wickiup Dam). Sources: OWRD 2020g, Reclamation 2020a.

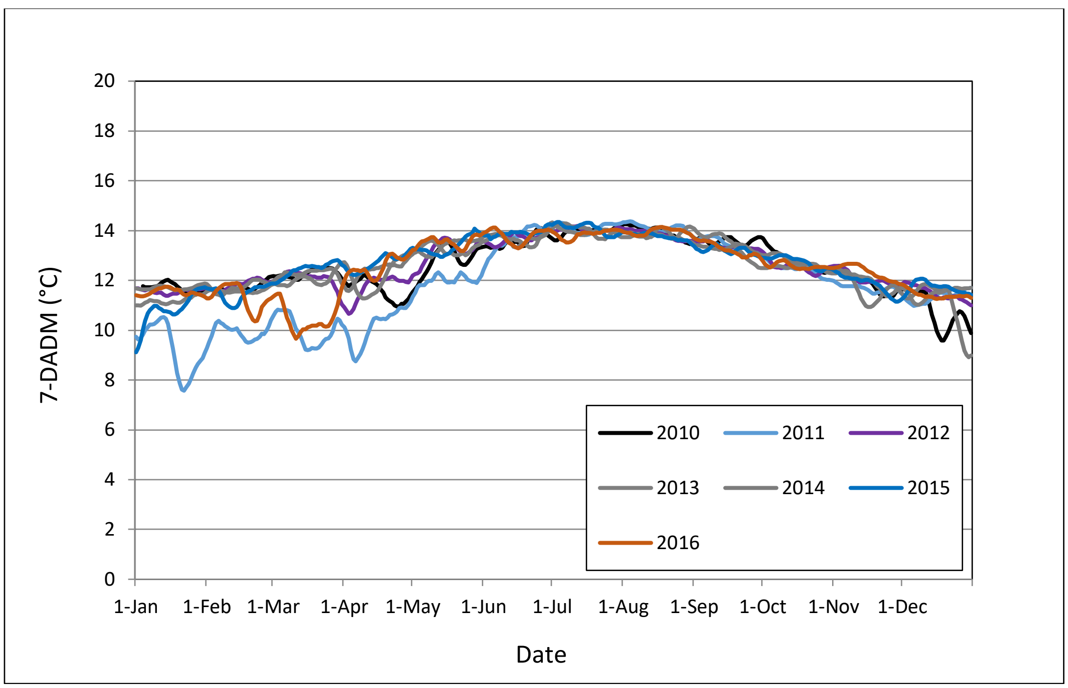


Figure 8-75. Seven-day averages of daily maximum water temperatures (7-DADM) in the Crooked River below Opal Springs (RM 6.7) from 2010 through 2016. Source: USGS 2019.

Sockeye Adult Migration

Water temperatures in the lower 8 miles of the Crooked River are consistently within the preferred range for adult sockeye migration in September and October (Figure 8-75). This will not change under the DBHCP, and migrating sockeye will continue to find suitable temperatures in this reach of the river. In contrast, the 7-DADM upstream of Opal Springs consistently remains above 16°C through mid-September, at times exceeding the lethal limit for sockeye adults (see Figure 4-56). Such excessive temperatures are likely to discourage upstream migration by adult sockeye. These naturally warm waters upstream of Opal Springs will also be present under the DBHCP, and temperature conditions for adult sockeye migration upstream of Opal Springs are not expected to improve.

Median flows in the lower Crooked River under the DBHCP increase slightly from historical levels in September and decrease slightly in October (Figure 8-74). Both changes will be subtle and will represent very small relative changes in total flow. Overall, flows in the lower Crooked River will remain high due to spring discharge, and conditions will remain suitable for migrating adult sockeye.

Although adult sockeye are unlikely to migrate upstream of Opal Springs, predicted riffle depths upstream of the springs were examined to determine whether physical barriers to migration might occur under the DBHCP (Appendix A-4). Adult sockeye require a minimum channel depth of 0.59 foot for passage during upstream migration (Thompson 1972). Under the DBHCP, predicted average riffle depths in the Crooked River upstream of Opal Springs during the adult sockeye migration period will range between 0.63 and 1.85 feet and meet the minimum depth requirement in each month (Figure 8-76). Flows near Opal Springs exceed the flows for the upstream reaches shown in Figure 8-76 and will therefore also exceed the minimum depth requirement. As a result, sockeye would not be expected to encounter physical barriers to upstream migration in the Crooked River.

Sockeye Spawning

Conditions for sockeye spawning in the lower Crooked River will not change under the DBHCP. Water temperatures will continue to be slightly above the preferred range through mid-September, but within the preferred range in late September and October (Figure 8-75). However, flows in the lower river will remain naturally high throughout the sockeye spawning period (Figure 8-74), and this could discourage adult spawners seeking riffle habitat of moderate depth (Table 8-25).

The 49 miles of river between Opal Springs and the Crooked River Diversion (RM 57) will have considerably lower flows than below Opal Springs, but water temperatures will exceed the preferred range for spawning (Figures 8-41 through 8-43). Upstream of the Crooked River Diversion (Figure 8-40), temperature and flow conditions may both be suitable for sockeye spawning in September, but the 49 miles of unfavorable conditions between Opal Springs and the Crooked River Diversion may prevent sockeye from migrating that far upstream. Overall, the naturally warm waters will continue to make spawning unlikely upstream of Opal Springs under the DBHCP, particularly in September. Nevertheless, any adults that move above Opal Springs would find flows that meet minimum spawning depth requirements since minimum depths required for spawning (Table 8-25) are generally less than minimums required for adult migration (0.59 foot), and flows are expected to remain above migration minimums through October (Figure 8-74).

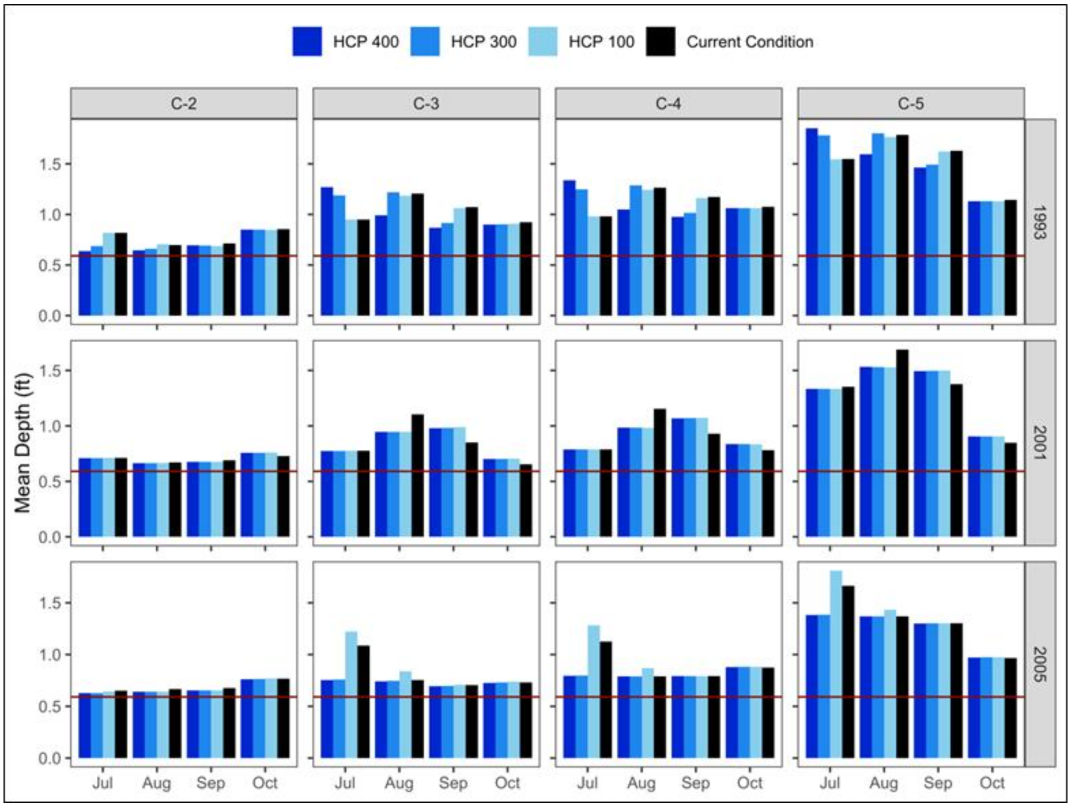


Figure 8-76. Estimated average riffle depth in the Crooked River during the sockeye migration period. Horizontal line indicates minimum depth required for passage. Source: See Appendix A-4.

Sockeye Egg Incubation

Water temperatures in the lower Crooked River have historically been slightly above the preferred range for sockeye egg incubation in September, but within the preferred range from October through December (Figure 8-75). This will not change under the DBHCP. Flows in the lower Crooked River will also change very little during the incubation period, and they will remain consistently high (Figure 8-74). Any limitations on sockeye egg incubation associated with the deep and fast-moving waters of the lower Crooked River will continue under the DBHCP. Upstream of Opal Springs, water temperatures drop precipitously in the fall, and although waters will be too warm for sockeye egg incubation in September they may be favorable from October through December when the eggs of late-spawning adults could be present. This will not change under the DBHCP.

Sockeye Rearing

Young sockeye salmon that incubate in the Crooked River would move downstream to Lake Billy Chinook within several months after emerging from the gravel. The exact timing of downstream movement to be expected in the Crooked River is not known, but studies in the Metolius River subbasin (Kern et al. 1999) suggest it could occur from early March to early June and peak during April and May. Sockeye rearing in the Crooked River would therefore occur in the months of November through May, when the 7-DADM downstream of Opal Springs is between 10 and

14 °C in most years (Figure 8-75). Consequently, favorable water temperatures for juvenile sockeye rearing are expected to continue downstream of Opal Springs under the DBHCP. Upstream of Opal Springs, where winter water temperatures are more heavily influenced by ambient air temperatures, the Crooked River is likely to drop below the preferred range for sockeye rearing by November as it has in the past (see Figure 4-56).

Flows in the Crooked River downstream of Opal Springs will continue to remain high during the winter, and this could limit the availability of shallow rearing habitat for juvenile sockeye. Upstream of Opal Springs, flows will be lower and shallow rearing habitat could be more abundant.

Sockeye Smolt Migration

If sockeye salmon spawn in the Crooked River, the resulting young fish will leave as fry and rear in Lake Billy Chinook. The DBHCP therefore has no effect on sockeye smolt migration within the Crooked River.

Net Effect on All Life Stages of Sockeye in the Crooked River

The Crooked River is expected to play a small role in the reintroduction of anadromous sockeye salmon to the Deschutes River basin. Use of the river by kokanee has historically been quite low (Kern et al. 1999) and studies to date indicate very little use of the river by sockeye (Table 8-24). The DBHCP will not alter habitat conditions for sockeye in the Crooked River or increase the likelihood for sockeye presence. Natural limitations on sockeye spawning and rearing (high flows downstream of Opal Springs and unfavorable water temperatures upstream of the springs) will not change under the DBHCP, and the potential for sockeye use of the river is expected to remain low.

The City of Prineville sewage effluent treatment discharge is not anticipated to have adverse effects on sockeye salmon. All effluent discharges will provide slight increases in instream flow, which will have positive effects on fish habitat. Discharges directly to the Crooked River will occur only during the fall, winter and early spring (November 1 through April 30) when water temperatures in the river are well below the upper thresholds for sockeye. Furthermore, direct discharges will occur at dilution rates of at least 15:1 and thus will have negligible potential to increase or decrease river water temperature.

8.3.4 Lake Billy Chinook

Overview

Lake Billy Chinook supports a large population of kokanee (Gauvin et al. 2010) and it is anticipated anadromous sockeye will make use of the reservoir as well during adult migration and juvenile rearing. The covered irrigation activities influence the rate and temperature of water flowing into the reservoir, but reservoir storage volume and water level are held constant as a condition of the FERC license for the Pelton Round Butte Project. Changes to the volume and temperature of water entering the reservoir as a result of the DBHCP will vary by season, but most will be relatively minor.

Sockeye Adult Migration

Adult sockeye salmon returning from marine waters are collected at the Pelton fish trap and released into Lake Billy Chinook. In recent years, adults have returned primarily in July and

August (Hill and Quesada 2013; Hill et al. 2014; Wymore et al. 2015; Burchell et al. 2016; Burchell and Hill 2017; Burchell 2018) and a similar trend is anticipated in the future. Once they are in the reservoir, the adults move fairly quickly to the tributary arms (Metolius Arm, Deschutes Arm and Crooked River Arm) and hold until they move upstream to spawn in late August or September.

The DBHCP will cause little or no measurable change in habitat conditions within Lake Billy Chinook from July through September. Reservoir inflow from the two tributaries affected by irrigation activities (Middle Deschutes River and Crooked River) will increase slightly in late summer, but the magnitude of increase will be very small compared to total inflow and will go largely unnoticed in the reservoir. As required by the FERC license for the Pelton Round Butte Project, outflows from Lake Billy Chinook will be adjusted to account for any change in inflow, and reservoir volume will remain constant.

Water temperatures within the reservoir in July through September are similarly not expected to change as a result of the DBHCP. As noted previously, water temperatures in the lower reaches of the affected tributaries are determined largely by cold groundwater discharges that occur downstream of the covered activities. The minor changes in flow resulting from the DBHCP will have very little effect on the temperature of water entering the reservoir, and even less effect on the temperature of the water within the reservoir due to its large volume.

Sockeye Spawning and Incubation

Sockeye salmon associated with Lake Billy Chinook migrate to tributary streams (primarily in the Metolius River subbasin) to spawn. Neither anadromous sockeye nor kokanee are known to spawn in the reservoir, and neither is expected to spawn there during the term of the DBHCP.

Juvenile Rearing

Young sockeye salmon that begin life in the Metolius River subbasin and other tributaries to Lake Billy Chinook move downstream to the reservoir within several months after emerging from the gravel. They remain in the reservoir to rear for up to 2 years before migrating downstream. Thiesfeld et al. (1999) evaluated conditions for juvenile sockeye rearing in Lake Billy Chinook and concluded the reservoir is likely to be recruitment limited. That is, the reservoir is large enough and productive enough to accommodate more juveniles than are likely to be present, given other limitations on smolt to adult survival and early survival of fry in tributary streams. While Thiesfeld et al. (1999) were uncertain about the potential for a self-sustaining run of sockeye in the Deschutes Basin, they did not expect conditions in Lake Billy Chinook to limit the success of the reintroduction effort.

Juvenile rearing in Lake Billy Chinook is not expected to be affected by the DBHCP. Inflow to the reservoir will increase during the irrigation storage season (October through March) in response to higher releases upstream at Wickiup Reservoir, and remain the same as historical levels during the irrigation season. Water temperatures in the reservoir are not expected to change substantially as a result of the DBHCP.

Sockeye Smolt Migration

After rearing for up to 2 years in Lake Billy Chinook, sockeye smolts move downstream through the Pelton Round Butte Project from February through April (PGE and CTWSRO 2016). The DBHCP may improve conditions for downstream migration by increasing base flows through the reservoir at this time of year (Figure 8-61) as well as helping to ensure that pulse flows in the

Crooked River reach the reservoir (see Conservation Measure CR-7). Ratliff and Schulz (1999) found a correlation between high flows during February and March and kokanee movement through Round Butte Dam. If a similar relationship exists for anadromous sockeye, increased flows in March and April under the DBHCP could increase downstream migration of sockeye through the improved passage facilities at the dam and support overall efforts to reestablish an anadromous run in the river.

Net Effect on All Life Stages of Sockeye in Lake Billy Chinook

The DBHCP is expected to have a small but positive effect on sockeye salmon in Lake Billy Chinook. The reservoir is used by sockeye during upstream migration of adults and rearing of juveniles. Flows and water temperatures in the reservoir during adult migration will be largely unaffected by the DBHCP, while flows during the winter (when juveniles will also be present) will be increased. Due to the operational requirements of the reservoir, increased flows will not alter reservoir volume or water surface elevation, but they will increase the rate of water moving through the reservoir (i.e., attraction current) which may improve conditions for downstream movement of smolts in February and March. Lake Billy Chinook is believed to be recruitment limited, and thus is not likely to be the limiting factor for successful reintroduction of a self-sustaining run of anadromous sockeye in the Deschutes River. The DBHCP will only improve conditions for sockeye in the reservoir, and thus will have no negative effect on the reintroduction.

8.3.5 Lower Deschutes River

Overview

Anadromous sockeye are first observed at the Dalles Dam on the Columbia River in late May and early June (FPC 2019) and likely enter the lower Deschutes River shortly after passing the dam. The majority of Deschutes Basin sockeye arrive at the Pelton fish trap (RM 100) in July and August (Burchell and Hill 2017). Smolts pass downstream through the Lower Deschutes from February to June (Mendez 2018). The only covered activities within the Lower Deschutes River are three small irrigation returns with a combined flow of less than 20 cfs between RM 90 and RM 98 (see Table 3.7), but the entire lower river is influenced by the storage and diversion of water in the upper Deschutes and Crooked River subbasins.

Historical hydrology and water temperature conditions in the Lower Deschutes River are presented in Section 4.6, *Lower Deschutes River*. As required by the FERC license issued in 2005, the Pelton Round Butte Project is operated as run-of-river with respect to flow and water temperature. Releases of water from the Project are controlled to maintain flows downstream of the Reregulating Dam within 10 percent (±) of inflows to Lake Billy Chinook (RM 120) on a daily basis, and water temperatures downstream of the Project are managed to approximate temperatures entering Lake Billy Chinook. The upstream storage and diversion of water for irrigation purposes influence flows into Lake Billy Chinook year round, but the relative effects of the covered activities on the Lower Deschutes River are reduced by the substantial groundwater discharge and tributary inflow between Bend and Lake Billy Chinook. The historical flow downstream of RM 100 since 1981 has rarely dropped below 3,500 cfs, and the seasonal difference in flow has typically been less than 25 percent (Figure 8-61).

Summer water temperatures at RM 100 are consistently below 18°C (Figure 8-62). Farther downstream, however, the general lack of shade and limited groundwater discharge cause the river to warm. Near Moody (RM 1.4) water temperatures consistently exceed 20°C in mid-summer (Figure 8-63). The Lower Deschutes River is identified as water temperature limited under Section 303(d) of the Clean Water Act for exceeding the summer maximum 7-DADM of 17.8°C for salmon and trout rearing and migration from RM 46.4 to the mouth (ODEQ 2017). It is also listed as water quality limited for exceeding the maximum 7-DADM of 12.8°C for salmon and trout spawning from RM 99.8 to RM 46.4.

Sockeye Adult Migration

Conditions for migration of adult sockeye in the Lower Deschutes River will be unchanged by the DBHCP. Water temperatures at Madras (Figure 8-62) will remain within the preferred range of 7.2 to 15.5 °C almost year round, while temperatures near the mouth of the river (Figure 8-63) will exceed 15.5°C by the end of April. Flows will be at or above historical levels for the entire adult migration period, with median flows of at least 4,000 cfs and 80 percent exceedance flows of at least 3,700 cfs in all months (Figure 8-61).

Sockeye Spawning, Incubation and Rearing

Anadromous sockeye salmon are not expected to spawn or rear in the Lower Deschutes River. The DBHCP will have no effect on these life stages of sockeye in the lower river.

Sockeye Smolt Migration

Outmigrating sockeye smolts may benefit from higher spring flows in the Lower Deschutes River (Figure 8-61). As a result of the DBHCP, median flows in the lower river will be at their annual high, and the net increase from historical flows will be at its greatest, in March and April when sockeye smolts will be moving downstream. These higher flows should enhance conditions for migration. In addition, Crooked River pulse flows specifically timed for smolt migration will reach Lake Billy Chinook without being diverted, and these will result in further increases in flow downstream of the reservoir. Water temperatures in March and April will be unchanged from historical levels. The 7-DADM will be below 12.0°C the entire distance from Madras to the mouth in March, but above 12.0°C near the mouth in April and above 12.0°C the entire distance in May (Figures 8-62 and 8-62). Little is known about smolt to adult survival for Deschutes River sockeye, but record high adult returns in 2016 (Burchell and Hill 2017) suggest that current conditions in the Lower Deschutes River are not impeding the reintroduction effort.

Net Effect on All Life Stages of Sockeye in the Lower Deschutes River

The DBHCP will have no negative effect, and potentially a positive effect, on sockeye migration in the Lower Deschutes River. Conditions for adult and smolt migration may improve as a result of small relative increases in flow, and both activities are expected to continue at levels comparable to those reported since the initiation of reintroduction in 2011.

8.1.6 Summary of Effects on Sockeye Salmon

The DBHCP will have minor positive effects on sockeye salmon in the Deschutes Basin. As a result, the potential for successful reintroduction upstream of Pelton Round Butte Project will remain unchanged or improve slightly. Anadromous sockeye and their land-locked counterpart kokanee have historically made very little use of lands covered by the DBHCP upstream of Lake Billy Chinook, and this is not anticipated to change as a result of reintroduction. The vast majority of sockeye spawning upstream of Lake Billy Chinook is expected to occur in the Metolius River subbasin, where it will not be influenced by the covered activities and the

DBHCP. The lower reaches of Whychus Creek, Middle Deschutes River and Crooked River, where sockeye could spawn in small numbers, will continue to have high flows and cool waters provided by natural groundwater discharge, and this will not change under the DBHCP.

Conditions for adult sockeye migration through the Lower Deschutes River and Lake Billy Chinook will be unaffected or improved by the DBHCP because flows entering the reservoir, which are influenced by the covered activities, will increase by small relative amounts during the period when sockeye would be migrating upstream. During sockeye outmigration, increased releases from Wickiup Reservoir under the DBHCP from mid-October through mid-April and pulse flows from Prineville Reservoir in the spring could improve conditions for the movement of sockeye smolts through Lake Billy Chinook, which could facilitate the reestablishment of an ocean-going population.

8.4 Oregon Spotted Frog

The following analysis of effects of the DBHCP on the Oregon spotted frog is organized into the four subsets (geographic areas) of the covered lands that are currently occupied by the species (Figure 8-77). The four geographic areas are:

- Crane Prairie Reservoir and Upper Deschutes River (downstream to Wickiup Reservoir),
- Wickiup Reservoir,
- Upper Deschutes River (Wickiup Dam to Bend), and
- Crescent Creek/Little Deschutes River.

Habitat conditions differ widely between these four areas, as do the effects of the covered activities and the benefits of the conservation measures. Individual analysis of each geographic area provides the most meaningful and precise assessment of effects. Where there are interactions between geographic areas, those are noted.

The effects of the DBHCP on Oregon spotted frogs in all four geographic areas occur indirectly through the changes in hydrology described in detail in Chapter 6, *Habitat Conservation*. The covered activities result in changes to water depths in wetlands occupied or potentially occupied by Oregon spotted frogs. In some cases these changes are detrimental to the frogs because they reduce or eliminate the availability of habitat for all or part of the year. In other cases the changes brought about by the covered activities are beneficial because they increase the availability of habitat. The covered activities also cause seasonal fluctuations in flow and water surface elevations. Seasonal fluctuations per se are not necessarily impacts to Oregon spotted frogs because fluctuations are natural events to which the species has adapted over millennia. Natural fluctuations in water depth may help create the ecological niche to which the Oregon spotted frog is uniquely adapted, thereby reducing competition with closely related amphibian species (Licht 1974). Seasonal fluctuations can be considered impacts, however, when their timing or magnitude deviates substantially from the natural condition and exceeds the ecological tolerance of the frog. Conversely, positive impacts can occur when anthropogenic hydrologic changes reduce natural fluctuations that were adverse to Oregon spotted frog survival.

The natural hydrology of the upper Deschutes subbasin has largely been replaced by a modified regime determined by the historical operation of the Crane Prairie, Wickiup, and Crescent reservoirs for over 70 years (through 2015). These historical operations are described in Chapter 6, Section 6.2, *Upper and Middle Deschutes River* and Section 6.3, *Crescent Creek and Little Deschutes River*. In some cases this modified hydrologic regime has been detrimental to Oregon spotted frogs, and the DBHCP contains measures to reverse or correct that situation. In other instances, however, historical operations have provided improvements to Oregon spotted frog habitats compared to unregulated conditions, and the DBHCP seeks to retain those benefits.

Because of this complex relationship between unregulated, historical and DBHCP flows in the upper Deschutes subbasin, all three hydrologic regimes are considered in the analysis of effects. The exceptions to this are for the habitat within the reservoirs (Crane Prairie and Wickiup) for which there are no unregulated conditions (i.e., the natural condition would be no reservoirs). For the reservoirs, the analysis of effects is based solely on a comparison of historical and DBHCP conditions.

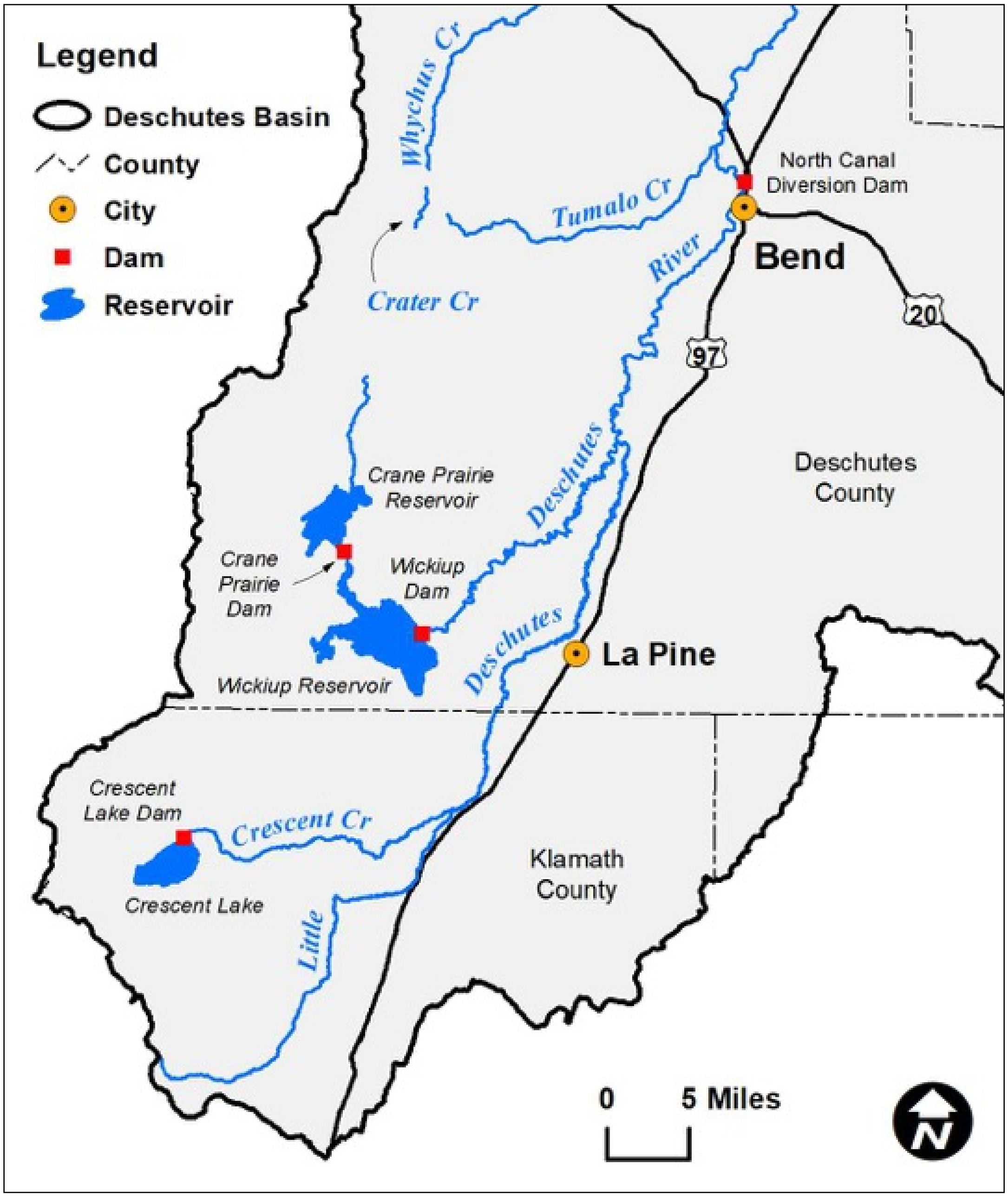


Figure 8-77. Overview map of the upper Deschutes Basin showing Oregon spotted frog habitats affected by irrigation activities covered by the DBHCP.

The conservation measures of the DBHCP do not return the hydrology of the covered lands to a fully natural condition, for two reasons. First, fully natural hydrology, if it were achievable, would require elimination of the covered activities that affect Oregon spotted frogs (primarily the storage and release of irrigation water). Complete elimination of the covered activities would be impracticable, and would be inconsistent with the intent of ESA Section 10(a). The completion of the DBHCP and issuance of incidental take permits is based on the premise that the covered activities will continue, albeit in modified fashion to reduce their negative impacts on covered species.

The second reason for not providing fully natural flows under the DBHCP is that doing so would likely have more negative impact to Oregon spotted frogs than continuation of the covered activities with the conservation measures in place. This is because many existing Oregon spotted frog habitats on the covered lands owe their existence to the historical operation of the reservoirs. Elimination of the reservoirs and the summer flows they provide would threaten or directly eliminate some of those habitats. Habitat conditions prior to construction of the reservoirs in the early 20th Century are unknown, but it is possible that habitats were eliminated during and after construction. It is also possible that those habitats would reappear over time after removal of the reservoirs, but such a process would take decades or longer, during which time Oregon spotted frog populations on the covered lands would likely be lower than they currently are. The DBHCP is designed to avoid this situation.

The description of incidental take in the DBHCP relies on impacts to wetland habitat for the Oregon spotted frog as a surrogate for direct impacts to the frog. There are two reasons to use habitat as a surrogate. First, direct harm to a secretive species like the Oregon spotted frog is extremely difficult to document and quantify. Injured or dead frogs are rarely observed, and accurately extrapolating from isolated individuals to the affected population as a whole would be impossible to do given the limited information about the actual size of the existing population. Any attempt to estimate the number of individual Oregon spotted frogs harmed by the covered activities would be highly speculative.

The second reason to use habitat as a surrogate is there are limited instances in which anthropogenic mortality can be accurately distinguished from natural mortality. The Oregon spotted frog is an *r*-selected species (MacArthur and Wilson 1967): it has a very high reproductive rate to compensate for high natural mortality (Licht 1975; Duellman and Trueb 1986). Female adult spotted frogs begin breeding at 2 to 3 years of age; they breed annually for up to several years thereafter, and they produce up to 600 eggs each year. These are all indications of a species that experiences high natural mortality at all life stages (Licht 1971). Due to their preference to breed in shallow, seasonal wetlands, local populations of Oregon spotted frogs can experience complete loss of reproductive effort (i.e., 100% mortality of eggs) in a single year if natural stream flows are too low and/or they fluctuate rapidly during incubation. Natural predation of eggs and larval stages is also high, and in the upper Deschutes Basin predation pressure is even greater due to non-native fish and amphibians whose presence is unrelated to the operation of the irrigation reservoirs. The covered activities have the potential to exacerbate natural mortality by increasing the magnitude and/or frequency of unfavorable flows. However, it is difficult to discern the extent to which reservoir operation is actually increasing natural mortality rates, particularly given the difficulty in determining trends in population and subpopulation size through egg mass counts (USFWS 2017). For purposes of the DBHCP, therefore, incidental take of Oregon spotted frogs is defined as changes in the hydrology of the covered waters from the unregulated condition (or in the case of the reservoirs the historical condition) that make the associated wetlands less favorable to the successful completion of the frog's annual life cycle.

As discussed in Chapter 5 (see Section 5.5.2, *Habitat Requirements*), Oregon spotted frog breeding sites are typically in perennial, open-water wetlands bordered by seasonally-flooded, low-growing emergent vegetation dominated by native sedges (McAllister and Leonard 1997; Bull 2005; Watson et al. 2003). Egg masses are typically not attached to vegetation, but often are deposited on mats of the previous year's emergent vegetation (Pearl and Hayes 2004). Tadpoles prefer somewhat deeper water of perennial pools or creeks moderately vegetated with sedges, rushes, and other emergent, floating, or submerged vegetation (Watson et al. 2003; Pearl and Hayes 2004), often with a small component of palustrine shrub or forested habitat (Germaine and Cosentino 2004). Pearl and Hayes (2004) concluded that Oregon spotted frog summer habitat is most likely influenced by demands associated with foraging and predator avoidance. Microhabitats with standing water close to vegetative cover and flocculent organic substrates appeared to be particularly important.

Winter habitat for Oregon spotted frog includes ponds, pools and channels in either still or moving waters that are over 6 inches (15 cm) deep (Hallock and Pearson 2001; Hayes et al. 2001); reasonably close to breeding and summer season areas and connected by surface water or wetland habitat; and comprised of emergent wetland, scrub-shrub wetland, aquatic bed and unconsolidated bottom habitats (Watson et al. 2003, as cited in Germaine and Cosentino 2004). Pearl et al. (2018) note that much of the early literature is based on sites located at low to mid-elevations in British Columbia and western Washington, while few data are available for overwintering sites in the high elevations of the Oregon Cascades, where waterbodies can freeze for several months. Recent studies of Oregon populations, including sites on the Deschutes River, show use of springs, undercut streambanks, semi-terrestrial beaver channels, beaver lodges, and lava flows (Pearl et al. 2018).

The following analysis of effects to Oregon spotted frog habitats is based on the USFWS determination of acres of habitat (USFWS 2017; see Chapter 5, Table 5-13). National Wetland Inventory (NWI) maps were used to delineate the estimated wetland acreages and open water habitats that may be affected by the covered activities at each waterbody or river reach. The NWI wetland habitat types that are utilized by spotted frogs include freshwater emergent wetland, freshwater forested/shrub wetland, freshwater pond, lake, and riverine (USFWS 2017). Freshwater emergent, freshwater forested/shrub wetland and freshwater pond acreages are combined in this analysis and referred to as "vegetated wetlands". The lake and riverine habitats represent open water with an unvegetated substrate. Additional resolution on wetland habitats at specific sites is included in the discussion, where available from analysis of the NWI maps or other existing data.

8.4.1 Crane Prairie Reservoir and Upper Deschutes River between Crane Prairie Dam and Wickiup Reservoir

This analysis area includes Crane Prairie Reservoir and that portion of the Upper Deschutes River between Crane Prairie Dam and the maximum pool elevation of Wickiup Reservoir, a distance of slightly less than 1 mile (Figure 8-78). Oregon spotted frogs are present in Crane Prairie Reservoir during the spring and summer, and recent data from a USGS radio-telemetry study show presence in and near the reservoir during the winter as well (USGS unpublished, as cited in USFWS 2019b). Oregon spotted frogs are not currently known to occur within the 0.9 mile of

Upper Deschutes River between the reservoirs. However, breeding has been observed in the extreme upstream end of Wickiup Reservoir. This site, referred to as the Deschutes River arm wetland, was confirmed to be under the influence of Wickiup Reservoir in 2018 and is discussed as part of Wickiup Reservoir below).

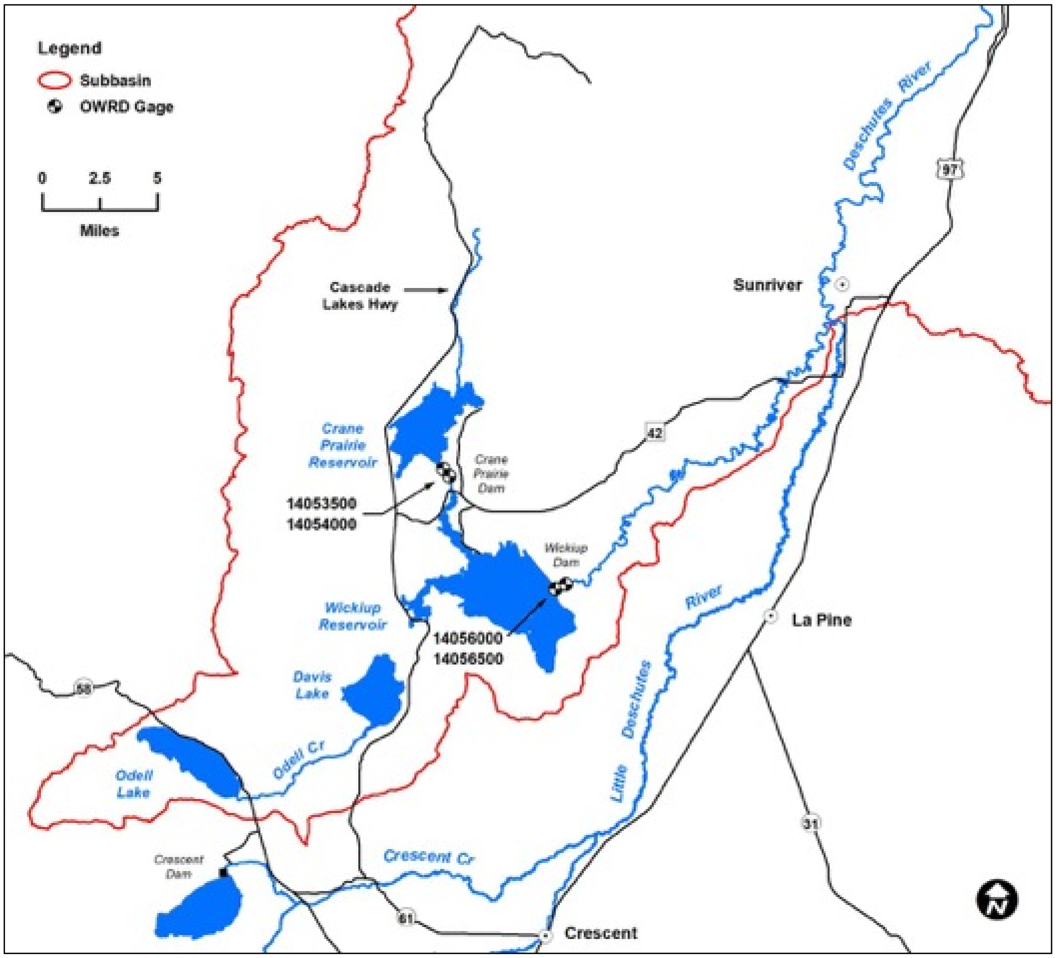


Figure 8-78. **Map of upper Deschutes Basin showing Crane Prairie Reservoir and Wickiup Reservoir.**

8.4.1.1 Crane Prairie Reservoir

Overview

Partial surveys in recent years have documented as many as 915 Oregon spotted frog egg masses in Crane Prairie Reservoir and associated wetlands (see Chapter 5, Table 5-12). Habitat conditions prior to construction of the original Crane Prairie Dam in 1922 are unknown, making it impossible to determine an unregulated condition for the reservoir. The analysis of effects is therefore based on comparison of DBHCP conditions to historical operations of the reservoir.

For the past several decades the reservoir has been operated to store water from mid-October through mid-April and release water for irrigation from mid-April through mid-October. The active storage capacity of the reservoir is over 50,000 acre-feet, but actual use of storage on an annual basis has been less than this. From 2002 through 2015, annual release of storage for irrigation ranged from about 2,500 to 13,516 acre-feet and averaged 7,714 acre-feet (see Chapter 6, Figure 6-2). Loss of water to seepage and evaporation has contributed another 2,700 to 13,000 acre-feet to the annual fluctuation in storage volume. These fluctuations in volume have resulted in corresponding fluctuations in reservoir water surface elevation (from the high at the beginning of the irrigation season to the low at the end of the irrigation season) of more than 6 feet in some years (see Chapter 6, Figures 6-5 and 6-6). Due to variation in reservoir inflow and annual irrigation demand, the seasonal high and low points for water surface elevation have also varied considerably from year to year.

Fluctuations in water surface elevation can be detrimental to Oregon spotted frogs in a number of ways. The USFWS (2014b) listing document summarized the habitat conditions required for spotted frogs to complete their life cycle as “shallow water areas for egg and tadpole survival; perennially deep, moderately vegetated pools for adult and juvenile survival in the dry season; and perennial water for protecting all age classes during cold, wet weather.” The species prefers relatively shallow waters with vegetated substrates for forage and escape from predators during the breeding and rearing period (USFWS 2014b).

In Crane Prairie Reservoir these preferred habitats exist in a band that extends up to several hundred feet from the shore in the deltas formed by the tributary streams (Deschutes River, Cultus River, Cultus Creek, Deer Creek, Quinn River and Charlton Creek), and along the gently sloping north shore. Deeper areas of the reservoir are mostly unvegetated. Extremely low water levels at the onset of breeding in the spring can force frogs to deposit eggs over unvegetated substrate where waters will become deeper than preferred for developing tadpoles once the reservoir is filled. Extremely high water levels during breeding can force females to deposit eggs amongst the shade of woody shoreline vegetation where larval development can be delayed. Increasing water levels during egg incubation can set egg masses adrift and expose eggs and larvae to predation. Decreasing water levels in spring can leave eggs and young tadpoles stranded out of water where they cannot survive. Rapidly decreasing water levels in mid- and late summer can cause similar stranding of tadpoles and small juveniles. Extremely low water levels in the fall and winter can reduce options for overwintering to unvegetated substrates where predation can be high.

Seasonal fluctuations in water surface elevation have decreased in Crane Prairie Reservoir in recent years, and overall water surface elevations have been higher, due to a number of water conservation projects by the Districts that have reduced their demand for irrigation storage. Nevertheless, water levels have continued to be less than optimal for Oregon spotted frogs at times. High water surface elevations in the spring have extended the area of inundation into dense woody vegetation along the shoreline of the reservoir in some years. Similarly, low water surface elevations in the fall and winter of some years have left all emergent wetlands exposed.

Conservation Measure CP-1 establishes target minimum and maximum water surface elevations for Crane Prairie Reservoir that will serve the dual purpose of reducing overall reservoir fluctuations and maintaining desirable water depths in existing wetlands. Water surface elevations could be outside the range specified in Measure CP-1 during extreme high or low flow conditions in the Upper Deschutes River, but such occurrences will be very rare because the reservoir is sized to fill under all anticipated runoff conditions, including extended drought, and the dam is designed to bypass the highest flows on record.

The target maximum water surface elevation of Crane Prairie Reservoir under the DBHCP will be 4,443.48 feet during the spring and summer. The target minimum water surface elevation will be 4,441.23 feet in the fall. The water surface elevation will then increase over the winter to achieve the spring target of 4,443.48. These limits will provide consistent wetland inundation conditions from year to year, and allow for a typical maximum seasonal fluctuation in water surface elevation of only 2.25 feet, compared to an average of over 4 feet in recent years.

The habitat requirements of the Oregon spotted frog vary by life stage and season, but a common theme among all preferred wetland habitats during breeding and rearing is the presence of shallowly inundated herbaceous emergent vegetation (USFWS 2016). Deeper waters and areas with lower vegetative cover are used in addition to emergent wetlands in the non-breeding and overwintering periods (USFWS 2016) In Crane Prairie Reservoir, well-developed emergent wetlands of sedges (*Carex* spp.) and rushes (*Juncus* spp.) are present from the shoreline at elevation 4,443.90 feet (approximate volume 50,000 acre-feet) to about elevation 4,439.32 feet (approximate volume 29,900 acre-feet) (Table 8-26). In places, sparse emergent vegetation extends to as low as 4,438.15 feet, but most of the reservoir bottom below elevation 4,439.00 feet is unvegetated mud, sand and gravel. Above elevation 4,443.90 feet sedges give way to woody shrubs such as willows (*Salix* spp.) and water birch (*Betula occidentalis*), and eventually to trees.

Table 8-26. Lower limits of emergent vegetation measured in Crane Prairie Reservoir in 2016.

Location	Lower Limit of Vegetation (feet)	
	Dense Sedge	Sparse Sedge and Rush
Southeast shoreline	4,439.79	4,438.62
East shoreline	4,439.95	not present
East of Deschutes River mouth at Cow Camp	4,439.25	unknown
West of Deschutes River mouth at Cow Camp	4,439.48	not present
Shoreline at Deer Creek mouth	4,438.82	4,438.15
Shoreline at Carlton Creek mouth	4,439.15	not present
East bank of Cultus River	4,439.32	not present
East of Cultus River mouth	4,439.32	4,438.82
At Cultus Creek mouth	4,438.98	4,438.65
Northeast shoreline near resort	not present	4,438.65
Northeast shoreline across from resort	4,439.40	4,438.90
Median Elevation	**4,439.32**	**4,438.65**

Source: Vaughn and Diller 2016.

During the storage season, Crane Prairie Reservoir will be given priority for filling so that it begins filling as early as November and reaches at least elevation 4,443.23 feet (3 inches below the allowable maximum) by March 15. A reservoir elevation of at least 4,443.23 feet from March 15 through July 15 will then allow nearly all emergent wetland to remain inundated throughout Oregon spotted frog breeding and summer rearing (Figure 8-79). A minimum water surface elevation of 4,441.23 feet in the fall will allow emergent wetlands to be inundated to depths of at least 2 feet for migrating and overwintering Oregon spotted frogs as the reservoir refills from November to mid-March. Extremely high water surface elevations that have been suggested as contributing to poor Oregon spotted frog reproductive success in previous springs will no longer occur. In a like manner, the DBHCP will eliminate the extremely low water surface elevations that have been suspected of limiting opportunities for overwintering in the reservoir and impairing seasonal migration.

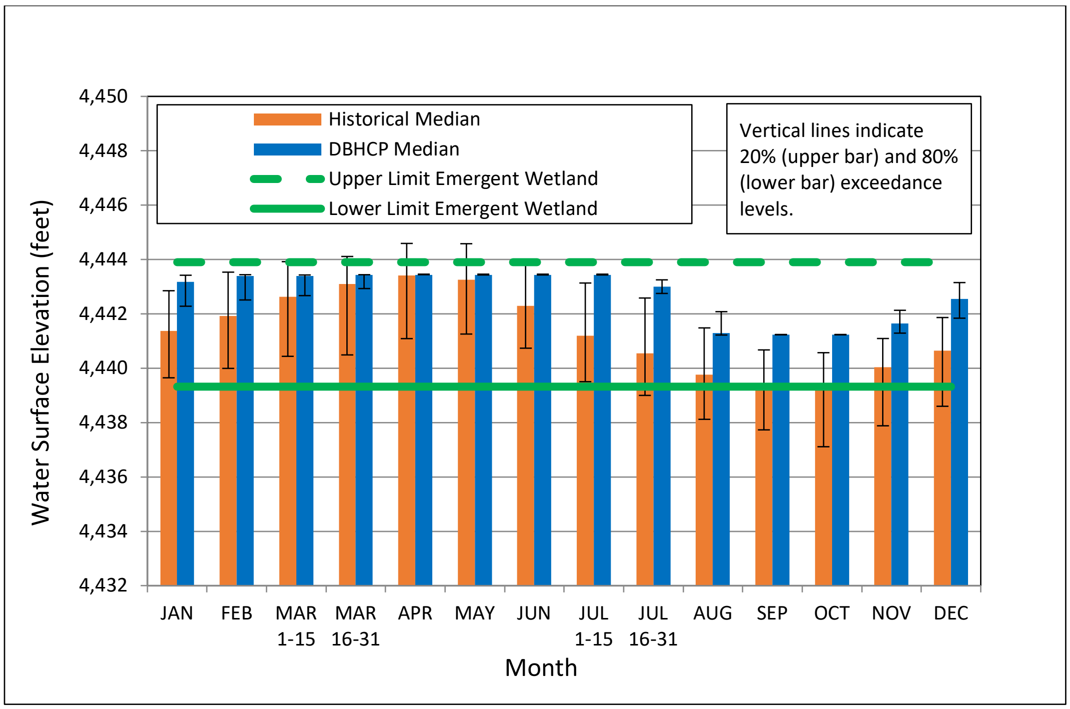


Figure 8-79. Comparison of monthly median water surface elevations and emergent wetland vegetation limits in Crane Prairie Reservoir. Sources: Reclamation 2020a, 2020b.

Fluctuations in water surface elevation during Oregon spotted frog breeding and summer rearing will be kept to a practical minimum by maintaining the reservoir between elevation 4,443.23 feet and 4,443.48 feet from March 15 through July 15. This 3-inch range is necessary due to the operational constraints of the reservoir. Surface inflow to the reservoir can change daily at any time of year, and the outlet structure of Crane Prairie Dam is not designed to maintain a constant water surface elevation as inflow changes. Based on operational experience, however, it is believed the dam can be operated to maintain surface elevations within a 3-inch range.

When annual drawdown of the reservoir begins in mid-July, the initial rate of drawdown will be 0.05 foot (0.6 inch) per day to maintain desirable water depths for late-developing tadpoles, which cannot leave the water. After July 31, when it is believed that all but a very small percentage of tadpoles will have completed metamorphosis, the rate of drawdown will increase to 0.10 foot (1.2 inches) per day.

The rate and timing of reservoir drawdown specified in Conservation Measure CP-1 are based on recent observations of Oregon spotted frogs in the reservoir. It is possible that Oregon spotted frog metamorphosis continues past July 31 in the reservoir, and/or that a drop in water depth of 1.2 inch per day is too much to avoid the stranding of some tadpoles and juvenile frogs. To address this minor uncertainty, Adaptive Management Measure CP-1.2 requires periodic monitoring for stranding during drawdown and adjustment to the timing and/or rate of drawdown if stranding is observed. Under this adaptive management measure, the onset of drawdown could be delayed to as late as August 15 and the rate of drawdown could be reduced to as low as 0.6 inch per day if necessary to avoid stranding. Conversely, if no stranding is observed after August 15 the rate of drawdown may be increased to 3.0 inches per day, and monitoring will continue.

To assist USFWS, USFS, ODFW and Reclamation with management of invasive species in Crane Prairie Reservoir, Conservation Measure CP-1 also includes a provision for lowering the reservoir an additional 5,000 acre-feet (to approximate volume 33,000 acre-feet; approximate elevation 4,440.05) on a periodic basis. The reservoir is inhabited by non-native predators of Oregon spotted frogs (e.g., brown bullhead) and invasive plants (e.g., reed canarygrass) that can render otherwise suitable wetland habitat unsuitable for Oregon spotted frogs. With concurrence from USFWS, the additional 5,000 acre-feet may be released from the reservoir in the fall to help combat the invasive species and simultaneously provide additional water for downstream habitat enhancement. This will be done on a case-by-case basis with prior review and oversight by USFWS. If it is done, the water surface elevation in the reservoir will temporarily leave about 0.73 feet (8.75 inches) of inundation above the lower limit of vegetation. Refilling will then begin immediately so that suitable conditions for overwintering (minimum inundation of 12 inches over vegetation) will be provided.

Habitat Conditions

Under the DBHCP, Crane Prairie Reservoir will be operated to maintain inundated emergent wetland habitat year round. The water surface elevation of the reservoir will not exceed the upper limit of emergent vegetation at elevation 4,443.90 feet, except during extreme flood events, and it will not drop to the lower limit of emergent wetland vegetation at elevation 4,439.32 feet unless reservoir inflow is insufficient to keep pace with seepage and maintain a flow of 30 cubic feet per second (cfs) downstream of Crane Prairie Dam. This will provide shallow water over sedge-dominated wetlands near the shoreline of the reservoir for Oregon spotted frog breeding and egg deposition in the spring. Water surface elevations will remain within a 3-inch range from the beginning of breeding in mid-March until mid-July to facilitate egg and larval development and provide summer foraging habitat for adults. After mid-July, the reservoir will be drawn down slowly to a winter elevation that leaves up to 1.9 feet of inundation over emergent vegetation for overwintering within the reservoir and/or migration to overwintering sites outside the reservoir.

The DBHCP will not eliminate reservoir fluctuation altogether because a certain amount of fluctuation is needed to maintain desired vegetative conditions. Oregon spotted frogs in Central Oregon breed and deposit eggs in shallow (average 7 inches deep), emergent wetlands of moderate to dense sedges, rushes and grasses that are close to the shore, and the frogs generally avoid waters with bare substrates and wetlands dominated by tall growing vegetation such as cattails and shrubs (Pearl et al. 2009). Shallow waters with limited shade provide warm conditions to accelerate egg development, while vegetated substrates provide food for larvae and cover from predators. In Crane Prairie Reservoir, these conditions are found in seasonally-flooded wetlands dominated by sedges and rushes that tolerate or require inundation for at least part of the growing season. These wetlands have developed under a regime of seasonally-fluctuating water levels over the past 75+ years. Without inundation for at least a portion of the growing season, these areas could become dominated by shrubs and small trees such as willow and water birch that currently exist along the shoreline of the reservoir. At the opposite extreme, inundation for the entire growing season could favor the development of tall, dense wetland vegetation such as cattails. In either case, conditions for Oregon spotted frog breeding in the reservoir could deteriorate over time. The intent of Measure CP-1 is to maintain a reservoir regime that balances the impacts of fluctuating water levels on Oregon spotted frogs with the need for seasonal fluctuation to support the wetland habitat conditions upon which the frogs depend. This will be accomplished by reducing the magnitude of annual fluctuation to a target maximum of 2.25 feet and keeping at least a portion of the emergent wetlands inundated during all seasons.

The area of Oregon spotted frog habitat that is expected to be present in Crane Prairie Reservoir under the DBHCP was estimated by calculating the acres of herbaceous emergent wetlands present at preferred water depths for each life stage, at the reservoir water surface elevations specified in Conservation Measure CP-1 (Table 8-27). Note that this analysis evaluates habitat based on the median of the lower elevation limit of emergent vegetation (Table 8-26) rather than mapped Critical Habitat (USFWS 2016), and the acreage totals differ. Existing bathymetry (area capacity tables) for Crane Prairie Reservoir (Reclamation 1971) and observed lower limits of emergent vegetation (Table 8-26) were used to calculate the acres of vegetated wetland inundated between 6-12 inches (breeding season), at all depths (summer rearing and foraging season), and over 12 inches deep (overwintering). NWI mapping indicates the majority (85%) of vegetated wetlands at Crane Prairie are sedge-dominated emergent wetlands (R2 and Biota Pacific 2018). Values for summer rearing and foraging habitat are presented as a range due to variation in the area of inundated wetlands present at the minimum and maximum water surface elevations.

Similar quantities of habitat could have been present in Crane Prairie Reservoir under historical operations in years when water surface elevations coincided with those prescribed in Measure CP-1. In other years, however, historical operations resulted in less habitat at the preferred water depths, particularly when water surface elevation was above 4,443.90 feet (volume more than 50,000 acre-feet) or below 4,439.32 feet (volume less than 29,900 acre-feet).

Measure CP-1 will provide greater year-to-year consistency in the amount and location of habitat than the historical condition. The cycle of good and bad years for breeding brought about by high and low spring water levels (see Chapter 6, Figure 6-5) will be much reduced, if not eliminated altogether under the DBHCP. Consistency in water surface elevation during the spring will allow Oregon spotted frogs, which have been reported to show strong site fidelity (Hallock 2013), to reliably find suitable breeding conditions in the same locations each year. The habitat acreage values in Table 8-27 do not fully address the quality of the habitat, as determined by location (high or low in the fluctuation zone) or seasonal stability. These aspects are discussed by the individual life-history stages of the species in the following subsections.

Table 8-27. Estimated acres of Oregon spotted frog habitat in Crane Prairie Reservoir under the DBHCP.

Habitat Type	Area (acres)
Breeding	80
Summer Rearing and Foraging	629-663
Overwintering	139

Source: Vaughn 2019.

Oregon Spotted Frog Overwintering

Winter habitat selection is one of the least understood aspects of Oregon spotted frog ecology, but it has been suggested that overwintering habitat may be a limiting factor for the long-term persistence of some populations (Pearl et al. 2009). In a summary of habitat associations of the Oregon spotted frog, Pearl and Hayes (2004) noted clear differences in winter habitat selection across the range of the species, particularly during the coldest periods. In western Washington, where wetlands remain inundated all winter and persistent ice is uncommon, frogs tend to spend the entire winter in calm, relatively shallow (average 7 inches deep) open water above submerged vegetation (Watson et al. 2003). In the Washington Cascades, however, where subfreezing temperatures and cap ice are common, Oregon spotted frogs have been observed moving from shallow vegetated wetlands to deeper flowing waters associated with streams and springs just before or during ice formation (Hayes et al. 2001). It has been speculated the frogs make these movements to seek warmer or more oxygenated waters when wetlands are covered with ice, but available data are inconclusive (Pearl and Hayes 2004). In wetlands associated with the Upper Deschutes River, Pearl et al. (2018) found Oregon spotted frogs overwintering in a range of site conditions, including vegetated perennial ponds, river banks, semi-terrestrial beaver channels and lava flows. In a recent study of Crane Prairie Reservoir (USGS unpublished, as cited in USFWS 2019b), Oregon spotted frogs were found to remain within the reservoir through the winter, mostly where water depths were less than 50 cm (< 20 inches).

The proximity of overwintering sites to breeding habitats may also be important. Pearl and Hayes (2004) reported short distances (averages as low as 45 meters [148 feet]) between overwintering habitats and oviposition sites in Washington and Oregon. Bowerman (pers. comm. cited in Pearl and Hayes 2004) observed seasonal movements between an overwintering pond and a breeding marsh in the upper Deschutes Basin of more than 100 meters (328 feet). The longest seasonal movement reported by Shovlain (2005) in the Klamath Basin was 120 meters (394 feet). Hallock and Pearson (2001) speculated that Oregon spotted frogs in the Washington Cascades could be moving up to 1 km (0.6 mile) between overwintering and breeding sites, but their data were inconclusive. Adult Oregon spotted frogs in wetlands associated with the Upper Deschutes River moved up to nearly 400 meters (1,312 feet) from late summer to winter habitats, but the majority of movements were between 100 and 200 meters (328 to 656 feet) (Pearl et al. 2018). In Crane Prairie Reservoir, however, USGS (unpublished, as cited in USFWS 2019b) found Oregon spotted frogs moved an average of 270 meters (886 feet) from late summer to early winter (95% confidence interval was 298 – 2,151 feet), although the majority of these (94%) still remained within the reservoir concentrated in areas of known breeding sites near the mouths of the Deschutes River, Cultus River, Cultus Creek and Charlton Creek. The mouths of these streams are also associated with alluvial fans that support the bulk of the emergent wetland vegetation in the reservoir.

Conservation Measure CP-1 is based on the assumption that inundated emergent wetlands within Crane Prairie Reservoir are important to Oregon spotted frogs prior to and during overwintering. Most Oregon spotted frogs in the Deschutes Basin enter the overwintering phase from mid-September to early November (Chelgren et al. 2008; Pearl et al. 2018; Bowerman pers. comm. 2016). In many years under historical operation, the emergent wetlands in Crane Prairie Reservoir were completely dewatered by late August when the water surface elevation dropped below 4,440 feet (see Chapter 6, Figure 6-6). In this situation, frogs may have left the cover of vegetation, remaining in the unvegetated shallows of the lowered reservoir, or migrating through the unvegetated shallows to reach overwintering habitats in the tributary streams. Use of the unvegetated shallows would increase the frogs' risk of predation due to the lack of vegetative cover. Under the DBHCP, an estimated 139 acres of shallowly inundated (12 inches or deeper) vegetated wetlands will be maintained between overwintering habitats and breeding/summer foraging habitats throughout the winter (Table 8-27). This will allow Oregon spotted frogs to move within the reservoir as well as between the reservoir and the tributary streams throughout the winter, without increasing their susceptibility to predation.

In years when the reservoir is lowered an additional 5,000 acre-feet in late summer to combat invasive species and provide additional water to support downstream habitats, the minimum water surface elevation will leave vegetated wetlands within the reservoir inundated to a depth of at about 8.75 inches. Refilling of the reservoir will then quickly resume, however, until the desired water depths for overwintering are achieved.

Oregon Spotted Frog Breeding

Oregon spotted frogs generally breed and deposit their eggs in calm waters less than 12 inches deep over emergent wetland vegetation (USFWS 2016). Egg masses have been observed over a greater range of depths (e.g., Pearl et al. 2009); in some cases, variation in water depths after egg deposition is responsible. Surveys of Crane Prairie Reservoir for the DBHCP in 2017 and 2018 found egg masses in water between 3 and 14 inches deep, with 80 percent of the egg masses in water 6 to 10 inches deep. In the upper Deschutes Basin, eggs are deposited in late March or April and incubation can last up to 30 days (Bowerman and Pearl 2010). For several weeks after emergence, tadpoles have limited mobility and spend most of their time in the cover of submerged vegetation at or very near the site of incubation. Throughout this time (from egg deposition through early tadpole development) the young are highly susceptible to fluctuations in water surface elevation. Because egg deposition and early development occur in shallow waters, decreases in water surface elevation of more than a few inches can expose eggs and young tadpoles to desiccation, freezing and/or predation. Similarly, increases of several inches in water surface elevation can expose the free-floating egg masses to wind and wave action that can transport them away from protected shorelines.

Conservation Measure CP-1 is designed to provide optimal hydrological conditions for Oregon spotted frog breeding in Crane Prairie Reservoir. The water surface elevation at the beginning of the breeding season in mid-March (4,443.23 to 4,443.48 feet) will place the shallow margins of the reservoir over dense, matted sedge-dominated emergent wetland of the type preferred for egg deposition. From mid-March through mid-July, the water surface elevation will be maintained within a 3-inch range to reduce the potential for stranding and dislodging of egg masses and to maintain favorable conditions for larvae. Based on Crane Prairie Reservoir bathymetry, an estimated 80 acres of vegetated wetlands inundated with 6 to 12 inches of water will be present (Table 8-27).

The potential for extremely high water surface elevations (above 4,443.90 feet) that can cause eggs to be deposited within the shade of woody shoreline vegetation will be reduced under the DBHCP. Similarly, low water surface elevations at the beginning of the breeding season followed by significant increases in water depth during incubation will no longer occur, thereby reducing the potential for egg masses to be transported into deep water where egg and tadpole survival are diminished. Breeding conditions comparable to those provided under the DBHCP may have occurred in Crane Prairie Reservoir in some past years, but they did not occur consistently from year to year. Consistency in the availability of preferred breeding habitat under the DBHCP is expected to bring greater stability to the Oregon spotted frog population in the reservoir, and reduce the risk for local extirpation.

Oregon Spotted Frog Summer Rearing and Foraging

Oregon spotted frog juveniles and adults spend much of the summer months in deep, perennial, moderately-vegetated wetland pools (Watson et al. 2003); in areas outside of the Deschutes Basin, they are also known to use meadow habitat during wet conditions (Licht 1986). Summer home range sizes are small and movements are relatively short compared to seasonal migrations to and from overwintering habitats (Hayes 1998 and Pearl and Bury 2000; both cited in Pearl and Hayes 2004). Vegetative cover from predators is thought to be particularly important for juveniles and adults during the summer (Pearl and Hayes 2004). Less is known about the summer habitat requirements of tadpoles, but it is assumed they remain in shallow waters connected to breeding wetlands where they feed and find cover in submerged vegetation until they complete metamorphosis about 4 months after emerging (Licht 1974).

Conservation Measure CP-1 will maintain stable wetland habitat conditions in Crane Prairie Reservoir through mid-summer, and provide a gradual transition to winter wetland habitat conditions. Water surface elevations will be regulated within a 3-inch range (4,443.23 to 4,443.48 feet) from the onset of breeding in mid-March until the majority of larvae have metamorphosed in mid-July. This will enable tadpoles, juveniles and adults to forage and find cover in emergent wetlands without the need to relocate in response to changing water levels. From July 16 through July 31, the reservoir may be drawn down at a rate of no more than 0.05 foot (0.6 inch) per day to enable tadpoles to keep pace and remain within shallow water. After July 31 the maximum rate of drop will be 0.1 foot (1.2 inches) per day. If the timing or rate of reservoir drawdown specified in Conservation Measure CP-1 results in the stranding of late-developing tadpoles, the drawdown will be modified in accordance with Adaptive Management Measure CP-1.2 to prevent the stranding. Between 629 and 663 acres of vegetated wetlands, at all inundation depths, will be present in the reservoir during the summer rearing and foraging season (Table 8-27).

The total maximum drop in water surface elevation after July 15 in most years will be 2.25 feet (27 inches), to the annual low of 4,441.23 feet. At the end of reservoir draw-down, emergent wetland within the reservoir will still be inundated with up to 1.9 feet (22.8 inches) of water and the total area of emergent wetland with at least 1 foot of inundation will be an estimated 139 acres (Table 8-27). In years when the reservoir is lowered an additional 5,000 acre-feet in late summer, the rates of drawdown will be the same as normal years, although the minimum water surface elevation will leave vegetated wetlands within the reservoir inundated to a depth of less than 9 inches. Refilling of the reservoir will therefore quickly resume until the desired water depths for overwintering and spring breeding are achieved.

8.4.1.2 Upper Deschutes River (Crane Prairie Dam to Wickiup Reservoir)

An estimated 39 acres of vegetated wetlands exist in the 0.9-mile reach of the Deschutes River between Crane Prairie Dam and Wickiup Reservoir; mostly in small patches of 0.5 acre or less (see Chapter 5, Table 5-13). None of these wetlands is known to be inhabited by Oregon spotted frogs (there are limited areas of calm water), but the reach is evaluated here because of the possibility that it could support small numbers of undetected frogs. The reach lies between Crane Prairie Reservoir, where all life stages of Oregon spotted frogs are present, and the Deschutes River arm wetland complex at the upper limit of Wickiup Reservoir where egg masses and adults have been observed in some years (see Section 8.5.2, *Wickiup Reservoir*). This proximity to occupied habitats creates the possibility for frogs to be present in this reach during seasonal migration and/or dispersal, if not at other times of year as well. The effects of the DBHCP on Oregon spotted frog habitats in this reach are evaluated by comparing flows below Crane Prairie Dam (Hydromet Station CRAO) under unregulated, historical and DBHCP conditions.

Compared to unregulated flows, DBHCP flows in the Deschutes River between the reservoirs will be lower in all months (Figure 8-80). This is due to the seepage losses within Crane Prairie that can be as high as 100 cfs when the reservoir is full (see Chapter 6, Figure 6.4). The net effect of increased seepage will be reduced reservoir outflow under the DBHCP throughout the year.

Compared to historical conditions, the DBHCP will result in lower flows (and associated water depths) throughout the year and greater day-to-day fluctuations in flow (more frequent and larger changes in flow) in some months. Median DBHCP flows will be lower than historical flows for most of the storage season (November to March) because Crane Prairie Reservoir will be given priority over Wickiup Reservoir for filling. Historically, the 1938 Inter-district Agreement between the irrigation districts required proportional filling of the reservoirs, which meant that neither reservoir filled completely in many years. Under the DBHCP, Crane Prairie Reservoir will always be filled during the winter before Wickiup Reservoir, resulting in lower median outflows from Crane Prairie during the storage season. By mid-March, Crane Prairie will typically be filled and the outflow will be increased to prevent spring runoff from overfilling the reservoir. This will produce higher median flows downstream of the dam in late March and April than occurred historically. From May through July DBHCP flows will again be lower than historical flows because the reservoir will be held nearly full for Oregon spotted frogs and irrigation water will not be released. Outflows will also be lower than historical levels in September because drawdown of the reservoir will end sooner (less water will be released) than in the past. The seasonal increase in outflow that historically occurred in June will not occur until mid-July under the DBHCP, and the annual peak flow will be lower.

Overall, the magnitude of fluctuations in flow (the differences between 20% exceedance flows and 80% exceedance flows for each month) will be greater for the DBHCP because reservoir outflow will be adjusted up and down more frequently than in the past. In particular, greater fluctuation in flows in mid-March through mid-July will make conditions less conducive to Oregon spotted frog breeding within this reach of the river. Median flows below Crane Prairie Dam will remain within the target range of 100 to 400 cfs (see Conservation Measure CP-1) in all months.

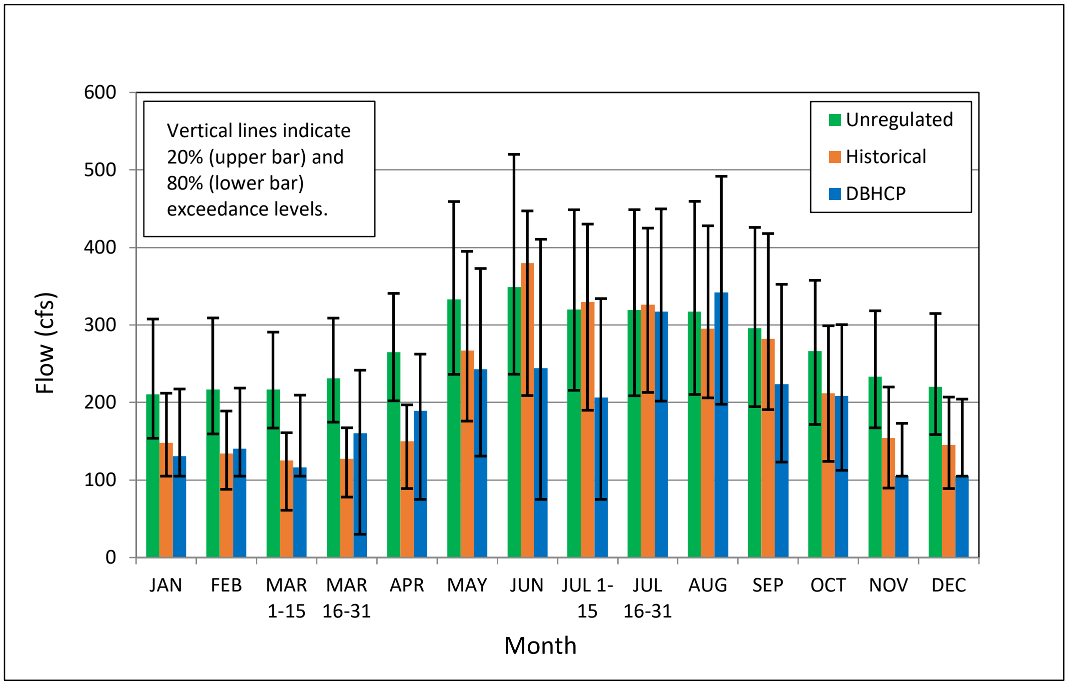


Figure 8-80. Monthly medians of daily average flows in the Deschutes River below Crane Prairie Dam (Station CRAO) for unregulated, historical and DBHCP projected conditions. Sources: OWRD 2020h, Reclamation 2020a.

The net effect of the DBHCP on Oregon spotted frog habitat in this reach of the Deschutes River will be a decrease in water depth during most of the year, a decrease in the month-to month variation in water depth, and an increase in day-to-day variation in water depth. The reach will remain wetted throughout the year, however, and the anticipated changes in hydrology are not likely to appreciably alter conditions for Oregon spotted frog dispersal and migration. The potential for overwintering may be slightly less if water depths are lower, and the potential for successful reproduction may be lower due to increased fluctuation in water levels during the spring and early summer. Overall, however, there will be little or no effect on Oregon spotted frogs in this reach because there is currently no know use of the reach by the species.

8.4.1.3 Wickiup Reservoir

Overview

Wickiup Reservoir lies downstream of Crane Prairie Reservoir on the Deschutes River (Figure 8-78). The two reservoirs are separated by less than 1 mile of free-flowing river. Wickiup has twice the surface area and four times the storage capacity of Crane Prairie. Unlike Crane Prairie, however, the storage capacity of Wickiup Reservoir is heavily utilized each year, resulting in fluctuations of more than 20 feet in surface elevation (water depth) between spring and fall (see Chapter 6, Figure 6-13).

Oregon spotted frogs are present upstream and downstream of Wickiup Reservoir, but the numbers of frogs within the reservoir are very low (USFWS 2017, 2019a, 2019b). Widely fluctuating water depths and steeply sloping substrate preclude the development of stable wetland habitats in most of the reservoir and prevent Oregon spotted frogs from persisting. Attempted breeding (egg masses) has been identified at three sites in Wickiup Reservoir. Pearl (2010, as cited in USFWS 2017) reported observations of fewer than 10 egg masses total in the northeastern part of the reservoir over several years. Six egg masses were observed in 2013 in the Southeast Bay (USFWS 2017). Both sites are typically dry by early summer as the reservoir is drawn down. The third site is in the extreme upstream end of the reservoir, downstream of where the Deschutes River enters (Deschutes River arm wetland). This third site was monitored during the breeding seasons of 2014 through 2019. Egg masses were detected in all years except 2017 (USFWS 2019a; O'Reilly pers. comm. 2019). Total egg masses ranged from 5 to 11 (Chapter 5, Table 5-12).

Conservation Measure WR-1 will address the effects of Wickiup Reservoir on Oregon spotted frog habitats downstream along the Deschutes River by increasing winter flows below Wickiup Dam (reservoir outflows) in increments over 20 years. By Year 13 of the DBHCP, the minimum instream flow during the storage season (mid-September through March) will be 400 cfs, compared to the historical minimum of slightly over 20 cfs. This increase in flow will be accomplished by passing water through the reservoir during the winter rather than storing it. Since reservoir inflow will decrease slightly from historical conditions due to modified management of Crane Prairie Reservoir, increased winter outflow will result in incrementally less overall storage of water in Wickiup Reservoir. This will mean the reservoir will not reach full pool in the spring as often as it did in the past and it will be completely drained by late summer more often than in the past. As a consequence, wetlands near the shoreline will be inundated with less frequency and resulting conditions for Oregon spotted frog breeding and summer foraging within the reservoir will be even less suitable than they were historically.

Monthly medians of daily water surface elevations in the reservoir for historical and DBHCP conditions are shown in Figure 8-81. Full pool elevation for the reservoir is 4,337.7 feet. The reservoir historically reached full pool by the end of the storage season in at least 5 out of 10 years and it reached 95 percent of full pool (190,000 acre-feet) in over 7 out of 10 years. The amount of time at full pool has been limited, however, because irrigation releases (and reservoir drawdown) typically begin in April shortly after full pool is reached. The historical daily median water surface elevation during Oregon spotted frog breeding in April was 4,337.15 feet, about 0.6 feet (8.3 inches) below full pool. During the first 7 years of DBHCP implementation, when the winter minimum flow below the dam will be 100 cfs, the median water surface elevation in the reservoir in April will be 4,336.4 feet; slightly more than 1 foot below full pool and 0.75 below the historical median. By Year 13, when the minimum flow below the dam during the winter will be 400 cfs, the median water surface elevation of the reservoir in April will be 4,327.68 feet, which is 10 feet below full pool and almost 10 feet below historical levels. When the winter minimum flow is 400 cfs the reservoir will be at full pool in April less than 1 percent of the time. Due to the requirement to provide a flow of 600 cfs below Wickiup Dam by April 1 each year, the reservoir will actually be losing storage volume (dropping) in late March and early April of most years.

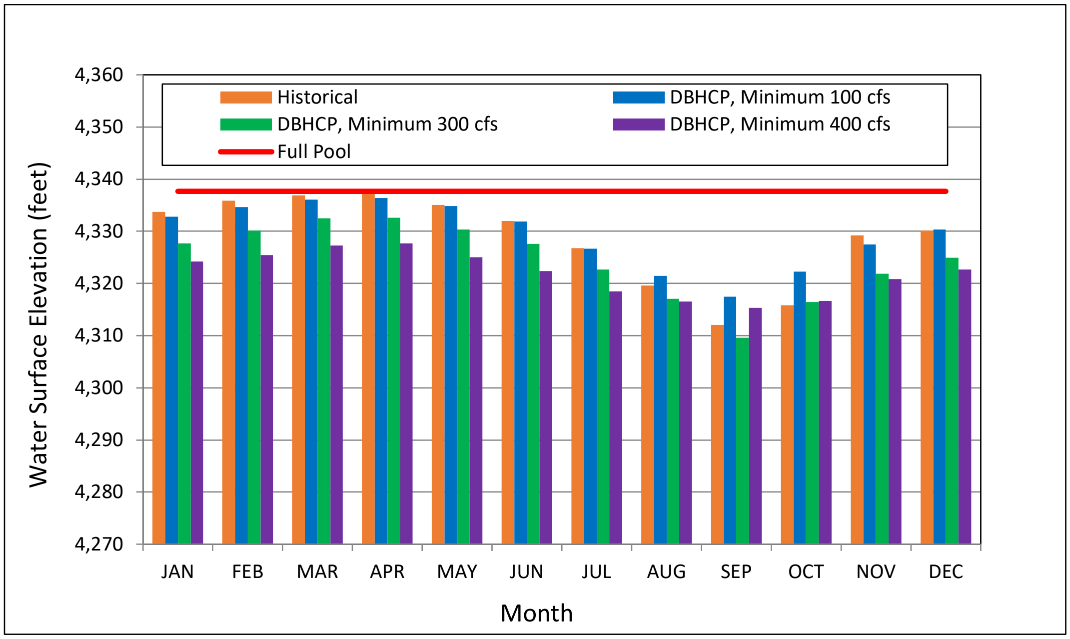


Figure 8-81. Monthly median water surface elevations in Wickiup Reservoir for historical (1983-2018) and DBHCP projected conditions. Sources: Reclamation 2020a, 2020c.

Conservation Measure WR-1 represents a necessary tradeoff between management for Oregon spotted frog habitat within Wickiup Reservoir and management for habitat along the Deschutes River downstream of the reservoir. Increases in winter flows from historical levels to support Oregon spotted frog overwintering along the Deschutes River will cause corresponding decreases in reservoir storage volumes, which will result in lower water depths in the reservoir during the Oregon spotted frog breeding season. In a similar way, the maintenance of target flows in the Deschutes River downstream of Wickiup Reservoir for Oregon spotted frog breeding and summer foraging (see Section 6.2.4, *Conservation Goal and Objectives for Wickiup Reservoir and the Upper Deschutes River*) will mean that water surface elevations in the reservoir will continue to drop rapidly during the spring and summer like they did historically. This tradeoff is unavoidable, but it will have limited overall negative impact because of the historically low numbers of Oregon spotted frogs in the reservoir. The negative impacts will be more than offset by improvements in habitat conditions in the Deschutes River downstream of the reservoir. Existing wetland habitats within the reservoir are largely artifacts of reservoir creation that raised water surface elevations more than 20 feet; they are not sustainable without the storage of water and the associated impacts to downstream flow. Due to the regime of storage and release under which Wickiup Reservoir has been operated since its construction 70 years ago, it is highly unlikely the reservoir ever supported Oregon spotted frogs in appreciable numbers. Riverine wetlands downstream of the reservoir, on the other hand, are assumed to be of natural origin and capable of supporting Oregon spotted frogs under proper hydrologic regimes. The documented presence of Oregon spotted frogs in a number of the Deschutes River wetlands is evidence of their potential to contribute to conservation and recovery. In contrast, the general absence of Oregon spotted frogs from most of Wickiup Reservoir, and the lack of any documented presence along that reach of the river prior to reservoir development (Hayes

1997), would make efforts to maintain or increase the number of frogs in the reservoir highly speculative.

Habitat Conditions

Wickiup Reservoir inundates 10 miles of the Deschutes River, has a surface area of 11,200 acres at full pool and supports an estimated 2,961 acres of vegetated wetlands (see Chapter 5, Table 5-13). The reservoir also encompasses an estimated 866 acres of upland forest that are inundated on an infrequent basis. The remainder of the reservoir at full pool is unvegetated open water.

Oregon spotted frog egg masses (evidence of breeding) have been detected intermittently and in limited numbers at two locations within the reservoir, although the reservoir has not been thoroughly or consistently surveyed. Wickiup Reservoir is not believed to support appreciable numbers of Oregon spotted frogs because annual fluctuations in water surface elevation of 20 feet or more have inhibited the development of well-vegetated emergent wetlands, disrupted Oregon spotted frog breeding, and provided limited opportunities for overwintering. Seasonal drawdown of the reservoir typically begins in April at a time when Oregon spotted frog egg masses would be developing in shallow wetlands (at an average depth of 7 inches) along the fringes of the reservoir (Pearl et al. 2009). The median water surface elevation of the reservoir has historically decreased over 2 feet from April to May (Figure 8-81), a drop that would almost certainly have precluded development of Oregon spotted frog eggs deposited in shallow water in April. Water surface elevation continues to decrease throughout the spring and summer, and by August the median surface elevation has been over 17 feet below the April level and the inundated margins of the reservoir have moved several hundred feet toward the center. Any young frogs that survived to reach tadpole stage in May would be required to move long distances to remain within the inundated portion of the reservoir during the summer, and the remaining inundated habitat would lack vegetation (for cover) due to water depths of 15 feet or more during the early part of the growing season. In October, when juvenile and adult frogs would be seeking overwintering habitats, the median water surface elevation of the reservoir has historically been as much as 25 feet below the April level and the surface area of the reservoir has been dramatically reduced. Oregon spotted frogs remaining in the reservoir in the fall would be required to overwinter amongst concentrated populations of predators (fish) with little or no vegetated cover.

The Deschutes River arm wetland is the only location within Wickiup Reservoir with consecutive years of documented Oregon spotted frog reproduction. The hydrology of this wetland was assessed in 2018 by placing water depth monitors (Leveloggers®) in the wetland and the adjacent Deschutes River channel (beneath the reservoir) in mid-April when the reservoir was nearly full (volume 195,200 acre-feet; water surface elevation 4,337.2 feet). The entire wetland and the adjacent reach of the Deschutes River channel were both inundated at the time of installation in April. Water depth in the reservoir was monitored at Hydromet Station WIC and flow in the river was monitored at Hydromet Station CRAO concurrent with collection of water depth data in the wetland and river. The results of the monitoring through September 12, 2018 are shown in Figures 8-82 and 8-83.

At the beginning of the irrigation season in April water depths in the wetland, river and reservoir all dropped in unison as storage was released from Wickiup Reservoir. After May 5, however, the rate of drop in the wetland decreased significantly while the reservoir and the river continued to go down. This indicates the wetland no longer had a surface connection to the river or reservoir after May 5 and was holding perched water. When the wetland was visited on May 22 the lack of surface connection was visually verified. Most of the wetland was still inundated on May 22, but the water depth had decreased about 1.5 feet. On about May 28 the reservoir dropped below the level of the river at the Levelogger® site and this portion of the river became free-flowing. Throughout May and June of 2018 water depth in the wetland continued to decline, but at a slower rate than the reservoir, suggesting water was being lost from the wetland through subsurface flow and evaporation. On about July 18 the wetland went dry as the water level dropped below the ground surface. Water level in the river remained largely stable from early June to mid-July due to relatively constant flow. When the release of storage from Crane Prairie Reservoir began on July 16, flow in the river increased to greater than 200 cfs. This produced an increase in the water surface elevation in the river of as much as 0.7 foot. The water level in the wetland, which was already subsurface by mid-July, showed no response to this increase in Deschutes River flow. By late August the water level at the wetland appeared to stabilize at about 1.4 feet below the ground surface.

As indicated by Figure 8-83, surface connection between the reservoir and the wetland exists above a storage volume of about 179,000 acre-feet (water surface elevation 4,335.7 feet), and the lowest point in the wetland (the wetland Levelogger® site) corresponds to a storage volume of about 140,000 acre-feet (water surface elevation 4,331.5 feet). Inundation of the river at the Levelogger® site exists above storage volume of about 139,000 acre-feet (water surface elevation 4,331.4 feet).

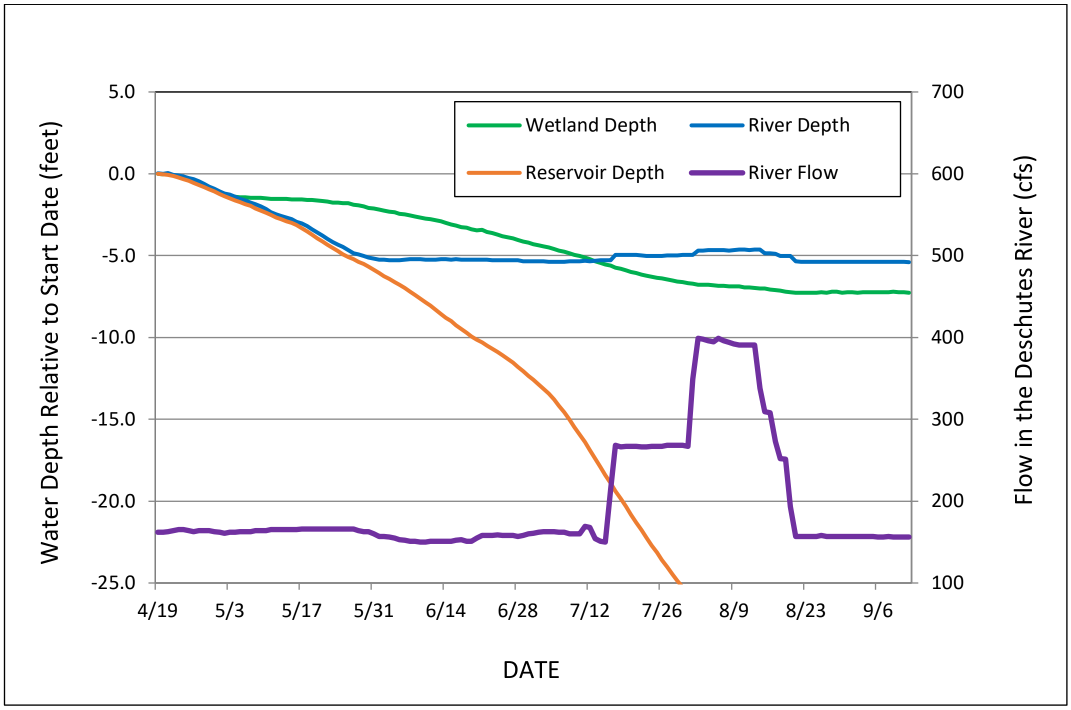


Figure 8-82. **Trends in river flow and water depth at selected locations associated with the Oregon spotted frog occupied wetland in the Deschutes River arm of Wickiup Reservoir in 2018.**

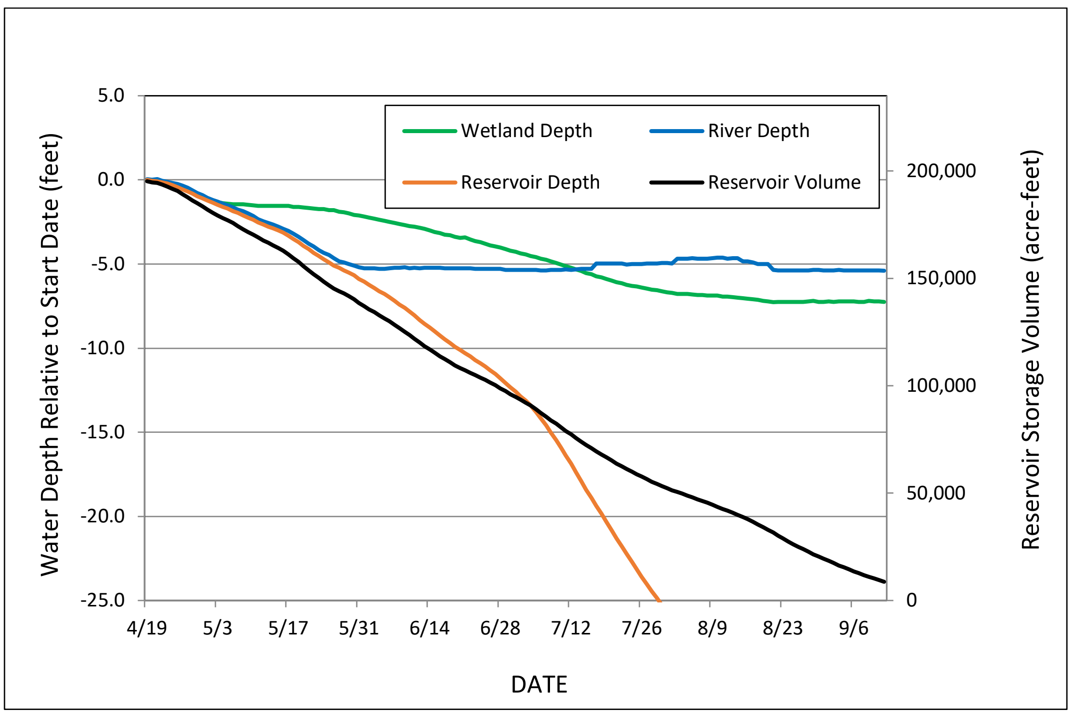


Figure 8-83. **Trends in reservoir storage volume and water depth at selected locations associated with the Oregon spotted frog occupied wetland in the Deschutes River arm of Wickiup Reservoir in 2018.**

The data in Figures 8-82 and 8-83 demonstrate: a) flow in this reach of the Deschutes River does not affect inundation level in the wetland, b) the surface connection between the reservoir and the wetland exists only above storage volumes of about 179,000 acre-feet, c) the reservoir is only able to influence the inundation level in the wetland when the storage volume is above about 140,000 acre-feet, and d) between storage volumes of 140,000 and 179,000 acre-feet, interchange between the reservoir and the wetland is subsurface and likely has a lag of several weeks. The wetland may also capture and temporarily hold local runoff in years when the reservoir does not fill above 140,000 acre-feet, but the data collected in 2018 cannot verify this because the data do not distinguish local runoff from reservoir inundation. Based on the observations in 2018, however, it appears unlikely the wetland would hold local runoff past mid-July if the reservoir is drawn down.

Historical operation of the reservoir probably provided Oregon spotted frog breeding habitat in the Deschutes River arm wetland in most years, although summer and overwintering habitat would have been limited. The median water surface elevation of the reservoir in April was historically 4,337.2 feet (Figure 8-81). This corresponds to a storage volume of about 194,000 acre-feet. The 80 percent exceedance level for April was 4,335.6 feet (177,691 acre-feet). Since the surface connection between the reservoir and the wetland exists above elevation 4,335.7 feet, the reservoir was of sufficient depth to inundate the wetland almost 8 out of 10 years, and at least half the time the water depth in the wetland was at least 1.5 feet over the surface connection. Visual observations in 2018 suggest a surface connection 1.5 feet deep would provide ample opportunities for Oregon spotted frog breeding in the wetland.

Based on observations in 2018, water was probably held in the wetland at least until late May in many years; this is sufficient time for Oregon spotted frog eggs to hatch. By mid-June, however, nothing but the small pool surrounding the 2018 Levelogger® location would have retained surface water to support Oregon spotted frogs through the summer. Overwintering habitats would have also been limited within the wetland because the reservoir typically would have just begun to refill in November and December from the late-summer low. In years when the reservoir reached sufficient volume to inundate the wetland, that usually didn't occur until late winter or early spring. Nearby, a number of small side channels to the Deschutes River that were under several feet of water in April 2018 remained at least partially wetted into November 2018, well after the reservoir had been drawn down, because of their direct surface connections to the river. These side channels have sparse aquatic vegetation and are accessible to fish (potential predators), but they could provide marginal habitat for Oregon spotted frogs after the wetland is dry for the summer.

Conditions for Oregon spotted frogs in Wickiup Reservoir will be even less favorable under the DBHCP than they have been historically. Implementation of the DBHCP will reduce the monthly median water surface elevation of the reservoir in almost every month of the year (Figure 8-81). Seasonal fluctuations in water surface elevation will continue to average more than 20 feet, and they could increase from historical levels due to the additional demand of maintaining specified flows downstream in the Deschutes River. The magnitude of this change from historical conditions will occur in steps in response to the increases in winter flow downstream of the dam in Years 8, and 13. The rate of change in water surface elevation in the spring (April and May) will also increase in years when it becomes necessary to release storage to meet the April 1 target of 600 cfs downstream of Wickiup Dam.

Shallowly inundated wetlands (potential breeding areas) that appear when the reservoir is near full pool in the spring will be available less frequently in the future because the reservoir will reach full pool in fewer years. Breeding at any reservoir level will be more difficult in years when the reservoir drops rapidly in April and May to support downstream flows. Lower overall water surface elevations throughout the summer will reduce the size of the reservoir pool and confine Oregon spotted frogs and their predators more than in the past. Vegetation in wetland areas accessible to Oregon spotted frogs throughout the year will be sparser, particularly during the early years of DBHCP implementation, because these areas were historically inundated to greater depths that precluded the development of vegetation.

Due to the bathymetry (bottom topography) of Wickiup Reservoir, the total area of potential Oregon spotted frog habitat (shallow vegetated wetland) will decrease and the magnitude of daily and seasonal change in wetland water depth will increase as monthly average storage volume decreases. This is because the average slope of the reservoir bottom is less near the shoreline of the reservoir than it is near the middle (i.e., closer to the original Deschutes River channel). Examination of the storage capacity curve for the reservoir indicates the magnitude of change in water surface elevation for a given change in storage volume is inversely proportional to total volume (Figure 8-84). For example, decreasing the volume from 150,000 to 145,000 acre-feet produces a drop in water surface elevation of only 0.6 feet, but a comparable decrease from 100,000 to 95,000 acre-feet results in a drop of 1.0 foot, and a decrease from 50,000 to 45,000 acre-feet causes a drop of 2.2 feet. Since the slope of the reservoir is greater near the center, the total area of shallow wetland is less and the change in water depth for a given change in volume is greater when total reservoir volume is reduced. This means there will be less overall area of potential Oregon spotted frog habitat in Wickiup Reservoir under the DBHCP, and the suitability of the habitat will be less because daily and seasonal fluctuations in water depth will be greater.

The Deschutes River arm wetland will be inundated less frequently and for shorter durations under the DBHCP than in the past. During the first 7 years of DBHCP implementation, when the winter minimum flow below Wickiup Dam will be 100 cfs, the wetland will receive surface inflow from the reservoir (storage volume ≥ 179,000 acre-feet) in about two years out of three. After Year 13, when the minimum winter flow below Wickiup Dam will be 400 cfs, the median water surface elevation of the reservoir in April will be 4,327.68 feet, which is more than 8 feet below the level needed to provide a surface connection to the Deschutes River arm wetland. Surface inflow from the reservoir will only reach the wetland in about one year out of three after Year 13, and periods of no inundation could last for as many as 10 consecutive years.

If Oregon spotted frogs are able to breed in the Deschutes River arm of Wickiup Reservoir under the DBHCP, summer and overwintering habitats will continue to be limited. Oregon spotted frogs could persist in the Deschutes River arm by utilizing marginal habitats and/or breeding in intermittent years, but numbers will almost certainly be lower than they were historically.

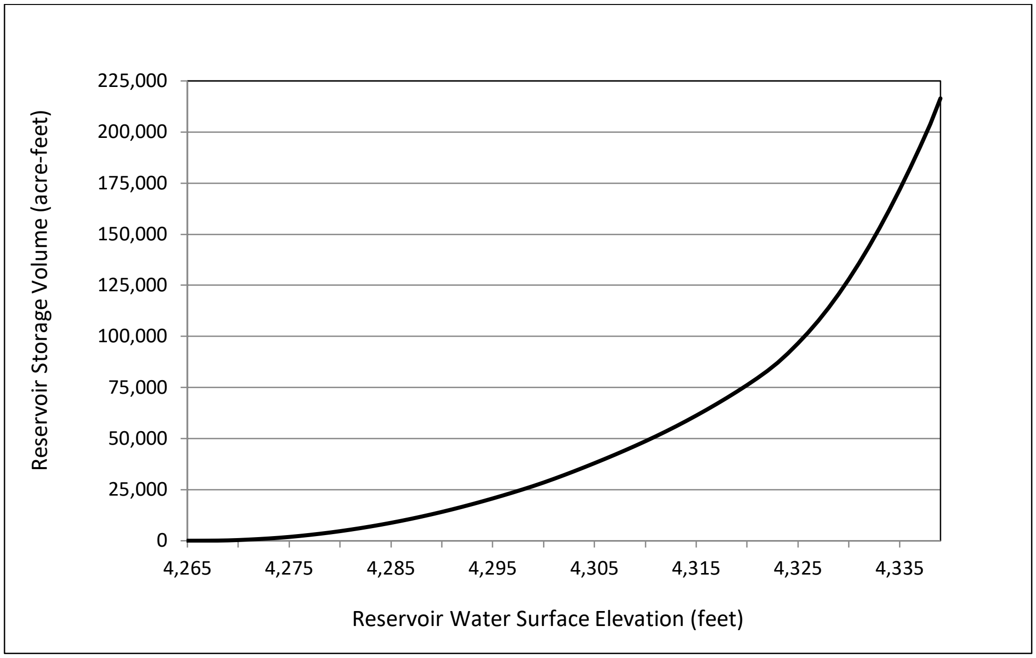


Figure 8-84. Wickiup Reservoir storage capacity curve. Source: OWRD 2017.

Oregon Spotted Frog Overwintering

Opportunities for Oregon spotted frog overwintering within Wickiup Reservoir will continue to be limited under the DBHCP. Water levels in the reservoir will be lower at all times of year than they have been in the past. As a consequence, Oregon spotted frogs attempting to overwinter in the reservoir will be concentrated into areas with little or no substrate vegetation (cover), where they will be at increased risk of predation. Water depths will increase 10 feet or more during most winters, forcing frogs to move repeatedly if they prefer depths of 2 feet or less (Pearl and Hayes 2004). Overwintering habitat may persist within the Deschutes River arm of Wickiup Reservoir, where side channels are kept wet by river flows when the reservoir is drawn down. These channels retained shallow water in the autumn of 2018 when the flow below Crane Prairie Dam was 140 cfs, but it is not known whether they will remain wetted at lower winter flows that will be required to manage Crane Prairie Reservoir under the DBHCP. To meet the requirements of Conservation Measure CP-1 and fill Crane Prairie Reservoir to at least 46,800 acre-feet by March 15, it will be necessary in many winters to reduce reservoir outflow (flow below Crane Prairie Dam) to 100 cfs or less (Figure 8-80). Such reductions will reduce water depth in the Deschutes River reach between Crane Prairie Dam and Wickiup Reservoir, including the side channels within the Deschutes River arm when the reservoir is low. This reduction will likely reduce the quality of overwintering habitat by concentrating frogs and increasing the potential for anchor ice to form around them.

Oregon Spotted Frog Breeding

Conditions for Oregon spotted frog breeding will deteriorate within Wickiup Reservoir under the DBHCP. The median water surface elevation in the reservoir at the onset of breeding in late March or early April will be lower than it has been in the past, moving the shallow waters (potential breeding habitat) away from emergent vegetation along the reservoir margins. The reservoir will continue to drop during the spring and summer as it always has, but the rate of drop during late March and early April (the most sensitive time for Oregon spotted frog eggs) will be greater than it has been in the past due to the requirement to maintain a flow of 600 cfs downstream of Wickiup Dam by April 1. This rapid drop in reservoir level will increase the potential for exposure and subsequent desiccation/freezing of the few Oregon spotted frog egg masses that may be present in any given year. The rapid drop in reservoir level may be delayed in some years, but it will inevitably come during the spring and put any Oregon spotted frog larvae that may be present at similar risk of stranding and desiccation. Breeding may still occur in some years within the emergent wetland in the Deschutes River arm, but the rapid drop in reservoir level in April and May will put even these eggs and larvae at risk. Overall, Wickiup Reservoir is not expected to support Oregon spotted frog breeding in appreciable numbers or with any regularity under the DBHCP.

Oregon Spotted Frog Summer Rearing and Foraging

Wickiup Reservoir provided a very limited amount of habitat for Oregon spotted frog summer rearing and foraging in the past, and this condition is not expected to change under the DBHCP. The rapid drop in water surface elevation during the irrigation season has limited potential summer habitat to a few small isolated pools that temporarily retain water. Under the DBHCP the reservoir will be generally lower in the spring than it was in the past, and it will drop faster and farther. This will make it less likely for isolated pools to support summer habitat in the future.

8.4.2 Upper Deschutes River (Wickiup Dam to Bend)

Oregon spotted frog presence has been documented at 12 sites along the 59 miles of Upper Deschutes River between Wickiup Dam and Bend (Table 8-28). Wetland habitat conditions in this segment of the river are heavily influenced by the hydrologic regime associated with operation of Wickiup Reservoir (see Section 6.2.6.2, *Effects of Historical Wickiup Reservoir Operation*). Winter flows and associated wetland inundation levels are typically quite low because water is actively stored in Wickiup Reservoir from November through March. Summer flows, on the other hand, can be quite high compared to unregulated conditions because the stored water is released from Wickiup Reservoir and conveyed downstream to Bend for diversion. Extremely low water levels in the winter have negative effects on Oregon spotted frog overwintering habitat in many of the riparian wetlands. Extremely high water levels in the summer support a number of wetlands that would not be inundated by unregulated flows, but the high flows have also widened the river channel and potentially modified associated riparian wetlands that may have existed prior to operation of the reservoir.

Conservation Measure WR-1 will alter the operating regime of Wickiup Reservoir in a number of ways to benefit Oregon spotted frogs. Flows below Wickiup Dam will increase during the winter in increments, starting with a minimum flow of 100 cfs in Year 1 of the DBHCP and reaching a minimum flow of 400 cfs after Year 13. Historically, the allowable minimum flow during the winter was 20.8 cfs, although flows were higher in years when inflow was more than sufficient to fill the reservoir. It is anticipated the increased winter flows will improve overwintering conditions for Oregon spotted frogs in the Upper Deschutes River.

An unavoidable consequence of the increased winter flows will be reduced storage in Wickiup Reservoir (see Section 8.4.2, *Wickiup Reservoir*), which in turn will result in lower flows between Wickiup Dam and Bend during the summer. As noted above, extremely high summer flows can be detrimental to the Deschutes River channel, and reduction in summer flows is anticipated to help reduce future modification and facilitate aquatic habitat restoration by other parties. However, reduced summer flows may also reduce the depth of inundation at a number of wetlands where Oregon spotted frogs have been documented.

Table 8-28. Upper Deschutes River reaches used for analysis of effects of Wickiup Reservoir operation on Oregon spotted frogs.

Analysis Reach	Upstream and Downstream Limits (river miles)	Total Length (miles)	Number of Known OSF Sites
1. Wickiup Dam to Fall River	227 – 205	22	4
2. Fall River to Little Deschutes River	205 – 193	12	2
3. Little Deschutes River to Benham Falls	193 - 182	11	1
4. Benham Falls to Dillon Falls	182 – 178	4	3
5. Dillon Falls to Lava Island Falls	178 - 174	4	0
6. Lava Island Falls to Central Oregon Diversion	174 – 171	3	0
7. Central Oregon Diversion to Colorado Street	171 – 168	3	2

Sources: USFWS 2019a and 2019b

In addition to the changes in winter and summer flow below Wickiup Dam, the timing and rate of transition from storage to release of water will be modified by Conservation Measure WR-1. While irrigation releases from Wickiup Reservoir historically did not begin until mid-April, sometimes well into the Oregon spotted frog breeding season, releases will now begin no later than April 1. Releases will also be held relatively constant during April, compared to historical fluctuations of up to several hundred cfs on a daily basis in response to changes in irrigation demand. These changes are intended to improve conditions for Oregon spotted frog breeding.

The Deschutes River between Wickiup Dam and Bend has been divided into seven reaches for analysis purposes (Figure 8-85). The reaches were delineated based on differences in hydrology and relative influence of reservoir operation on Oregon spotted frog habitat. The analysis of effects of the DBHCP considers each reach individually. The seven reaches combined contain an estimated 1,227 acres of vegetated wetlands that are potential Oregon spotted frog habitat (Table 8-29). This equates to an average of roughly 10.2 acres of emergent wetland per mile of river. The distribution of wetlands is not uniform, as portions of the seven reaches lack vegetated wetland altogether, while others contain large wetland complexes. These larger complexes are the focus of the following analysis because they are of sufficient size to potentially support sustainable numbers of frogs.

Table 8-29. Vegetated wetlands associated with the Deschutes River between Wickiup Reservoir and Bend that are affected by reservoir operation.

Analysis Reach	Vegetated Wetlands (emergent, forested, shrub, pond)
1. Wickiup Dam to Fall River	325
2. Fall River to Little Deschutes River	308
3. Little Deschutes River to Benham Falls	286
4. Benham Falls to Dillon Falls	198
5. Dillon Falls to Lava Island Falls	95
6. Lava Island Falls to Central Oregon Diversion	7
7. Central Oregon Diversion to Colorado Street	8
TOTAL	**1,227**

Source: USFWS 2017, Table 49.

*Additional wetland acres have been mapped along some reaches between Wickiup Dam and Bend, but those wetlands are associated with tributary inflows and/or they are perched above the Deschutes River floodplain where they are uninfluenced by reservoir operations.

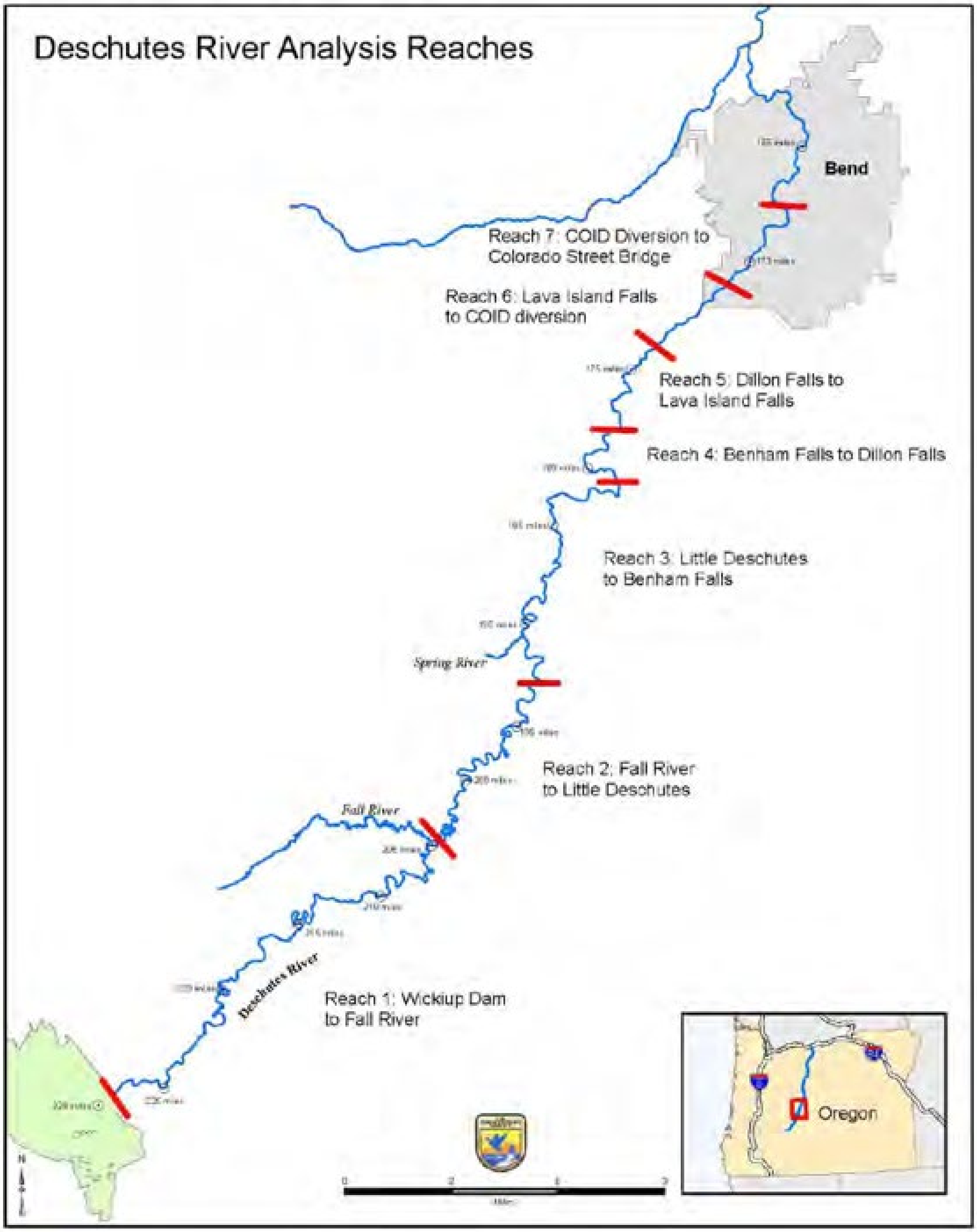


Figure 8-85. Analysis reaches of the Deschutes River between Wickiup Dam and Bend.
Source: USFWS 2017.

8.4.2.1 Deschutes River Reach 1 – Wickiup Dam to Fall River

Overview

Fall River is the first major source of inflow to the Deschutes River downstream of Wickiup Dam, and groundwater discharge to this reach of the river is very low (Gannett et al. 2001). Consequently, flows in the 22-mile reach between the dam and Fall River are determined largely by the amount of water passing through the dam, making the annual hydrograph for Hydromet Station WICO below the dam (see Chapter 6, Figure 6-14) representative of this entire reach. Flows have historically reached 1,500 cfs or higher in the summer and dropped to as little as 20 cfs in the winter. The reach supports an estimated 325 acres of vegetated wetlands that could potentially provide habitat for Oregon spotted frogs (Table 8-29), but the large seasonal fluctuations in water depth have limited habitat suitability by causing many of the wetlands to be dry for up to 6 months of the year. About 32 percent of the vegetated wetlands in this reach consist of emergent wetlands (R2 and Biota Pacific 2018); overall density of this wetland type is relatively low, averaging less than 4 acres per mile of river.

Oregon spotted frogs have been reported at four wetlands within this reach, two associated with La Pine State Park (RM 208), one at Bull Bend (RM 220), and one small wetland on private land near La Pine State Park (see Chapter 5, Table 5-12). Oregon spotted frog presence has been documented consistently at one of the La Pine State Park sites (Dead Slough) since 2013. In 2019 USFWS estimated the Dead Slough site contained a minimum of 178 breeding adults (see Chapter 5, Table 5-12). Considerably fewer frogs have been documented at the other three sites. The SW Oxbow site at La Pine State Park had documented presence in 6 of 7 years between 2013 and 2019, but with no more than seven egg masses reported per year, indicating a minimum adult population of 14. Documented use of the Bull Bend site is limited to five pre-metamorphic (tadpole) Oregon spotted frogs observed in August 2013. The small wetland on private land was discovered in 2018, when 18 egg masses (indicating at least 36 adults) were observed.

Habitat Conditions

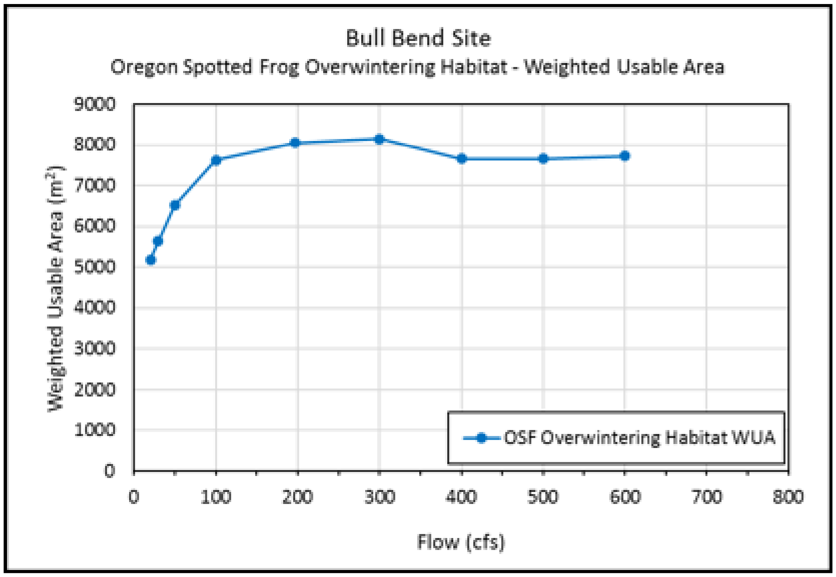
The relationships between instream flow and Oregon spotted frog habitat conditions in this reach of the Deschutes River have been examined in two recent studies. O'Reilly and Gritzner (USFWS 2017, Appendix) documented wetland habitat conditions photographically during the annual ramp-down of flows out of Wickiup Reservoir in October 2014. At Dead Slough, they observed that habitat conditions began to deteriorate due to decreasing inundation levels at flows of less than 900 cfs at WICO. At 683 cfs, emergent vegetation was no longer inundated, mudflats within the wetland were beginning to be exposed, and the surface connection between the wetland and the river was beginning to be cut off. Below about 300 cfs, the wetland no longer responded to further decreases in river flow and the inundated portion of the wetland was confined to a narrow, mostly unvegetated channel. They also observed that Dead Slough appears to receive groundwater discharge that maintains minimal inundation levels throughout the winter. The response to decreasing flows in October 2014 was similar at Bull Bend, except that by 300 cfs the wetland was completely dry due to the absence of local groundwater discharge to support it when the river is low.

The second study was a detailed assessment of Oregon spotted frog habitat at Bull Bend and Dead Slough as part of the Deschutes Basin Study (RDG 2017). Habitat suitability criteria (HSC) were developed for two Oregon spotted frog life stages (breeding and overwintering) based on four microhabitat variables (water depth, water velocity, substrate composition and proximity to edge of water). Hydraulic models were then developed to predict microhabitat conditions at various flows, and the combinations of HSC with hydraulic model outputs were used to calculate weighted usable area (WUA) for each of the two life-stages across a range of flows. The WUA methodology cannot be used to calculate actual occupied acres or numbers of animals under specific habitat conditions, but it can be a useful tool for comparing the relative amounts of habitat at a given location across a range of flows.

At Bull Bend, RDG (2017) estimated that WUA of overwintering habitat increases steadily from 20 to 100 cfs, peaks at 300 cfs, and declines slightly between 300 and 600 cfs (Figure 8-86A). They point out, however, that WUA mathematically combines habitat quantity and habitat quality, and that although WUA may not change appreciably between 100 and 600 cfs, the relative amount of high quality habitat increases with increasing flow within this range. For breeding habitat at Bull Bend they estimated low WUA at flows below 800 cfs, when most usable habitat is within the river channel, and rapidly increasing WUA above 800 cfs when the off-channel wetland becomes inundated (Figure 8-86B). Peak WUA occurs at 1,200 cfs.

At Dead Slough, RDG (2017) predicted the WUA of Oregon spotted frog overwintering habitat increases over the entire range of winter flows that were evaluated (20 to 600 cfs), and the rate of increase in WUA is greater above 400 cfs due to a prominent surface connection between the river and the wetland at the higher flows (Figure 8-87A). For breeding habitat at Dead Slough, RDG (2017) predicted low WUA from 20 to 300 cfs, gradually-increasing WUA between 300 and 1,200 cfs, and a dramatic increase in WUA above 1,200 cfs (Figure 8-87B).

A.



B.

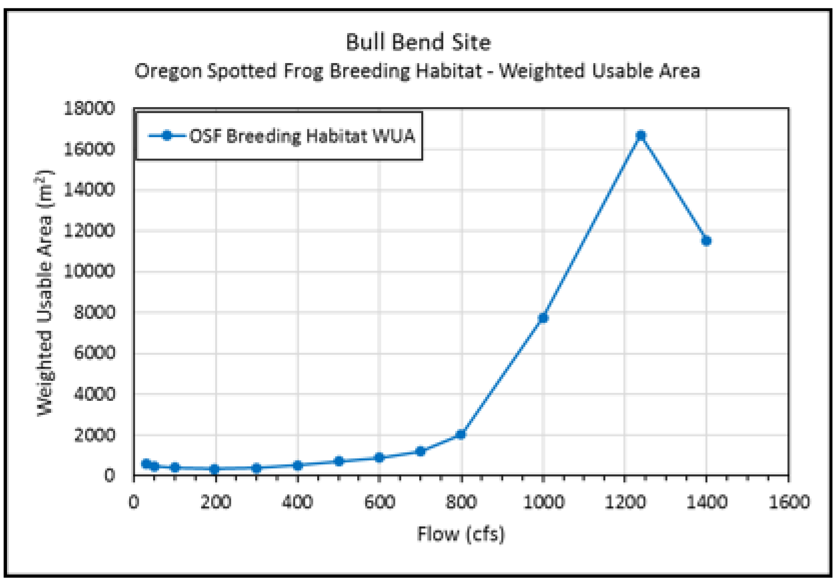
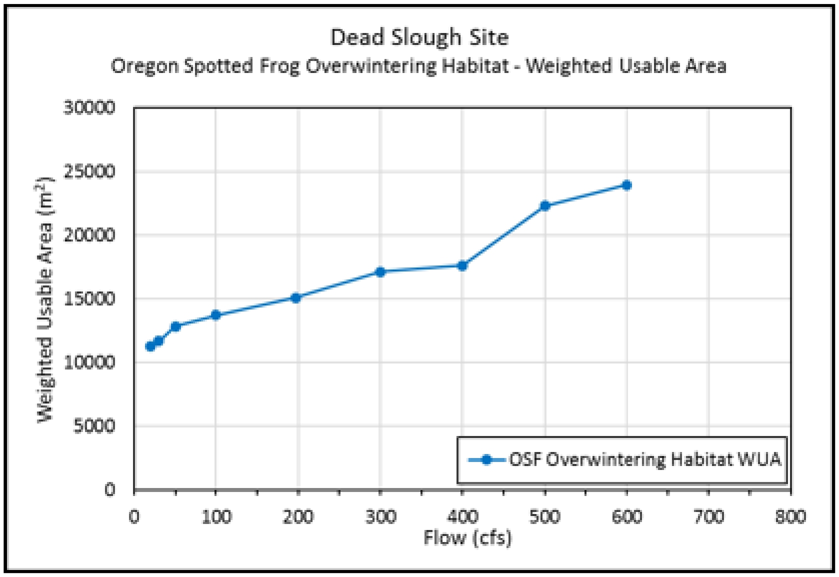


Figure 8-86. Predicted relationships between flow and Oregon spotted frog WUA at Bull Bend, Deschutes River Mile 220. Source: RDG 2017.

A.



B.

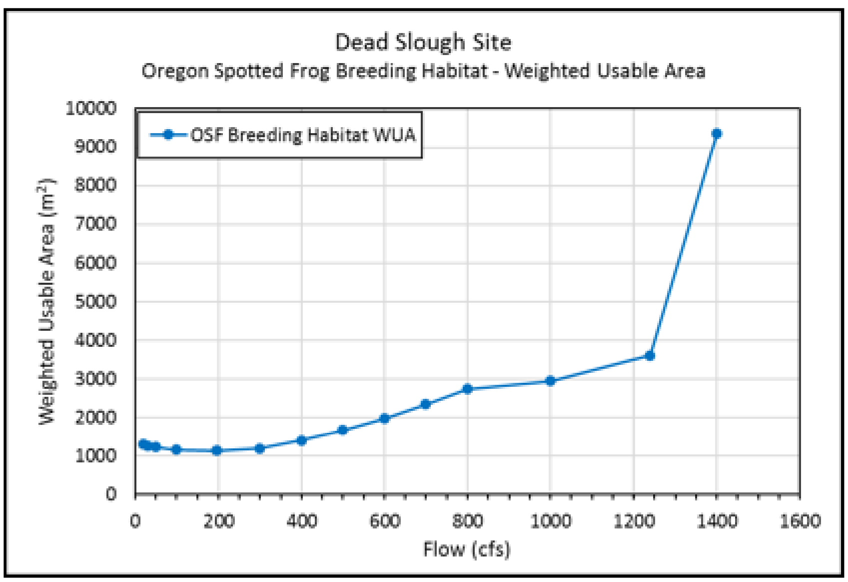


Figure 8-87. **Predicted relationships between flow and Oregon spotted frog WUA at Dead Slough, Deschutes River Mile 208.** Source: RDG 2017**.**

The DBHCP will increase minimum winter flows throughout this reach to 400 cfs over a period of 13 years. Interim minimum instream flows will be 100 cfs (through Year 7) and 300 cfs (through Year 12). Median flows during the winter will increase by corresponding amounts (see Chapter 6, Figure 6-19). In contrast, summer flows in the reach will undergo incremental decreases due to reduced storage in Wickiup Reservoir. Historically, summer flows downstream of Wickiup Dam were a combination of live (natural) flow and released storage. To meet downstream irrigation rights, all natural inflow is passed through the reservoirs during the irrigation season unless demand for water is less than inflow. Storage is added to natural flow when demand exceeds natural flow. As the average annual storage in Wickiup Reservoir decreases under the DBHCP, natural flow during the summer will remain the same but releases from storage will decrease. Minimum flows in the Deschutes River, which are determined largely by natural flow, will change very little under the DBHCP, but median summer flows will consistently decrease from Wickiup Dam to Bend. Predicted winter and summer flows before and after DBHCP implementation are shown in Table 8-30.

Table 8-30. Predicted flows in the Deschutes River between Wickiup Dam and Fall River under historical conditions and the DBHCP.

Analysis Period	Instream Flow Apr 1 – Sep 15 (cfs)			Instream Flow Sep 16 – Mar 31 (cfs)		
	Minimum	80% Exceedance	Median	Minimum	80% Exceedance	Median
Historical	23	816	1,280	8	28	109
DBHCP Years 1-7	600	728	1,136	100	200	250
DBHCP Years 8-12	600	689	1,035	300	300	300
DBHCP Years 13-30	405	647	960	400	400	400

Sources: OWRD2020i, Reclamation 2020a.

It is noteworthy that the DBHCP's target for minimum instream flows at WICO will be met or exceeded at least 80 percent of the time during all phases of implementation (see 80% exceedance levels in Table 8-30). Only after Year 13 will there be rare instances (less than 1% of the time) between April 1 and September 15 when the flow at WICO will be less than 600 cfs. These occasional shortfalls will be due to lack of available storage in Wickiup Reservoir to augment low natural flows during extremely dry years.

Oregon Spotted Frog Overwintering

DBHCP flows in the Deschutes River downstream of Wickiup Dam will be very consistent from day to day and year to year during Oregon spotted frog overwintering (Table 8-30). Minimum, median and 80 percent exceedance flows within each phase of DBHCP implementation are identical except during the first phase (Years 1-7) when the median will be greater than the required minimum of 100 cfs. This is because it is anticipated there will often be sufficient water to exceed the required 100-cfs minimum in those years. In all three phases, the flow will likely never need to be less than the required minimum (i.e., there will always be sufficient reservoir inflow and/or storage to maintain the winter minimum outflows).

Based on the WUA projections developed by RDG (2017), the amount of Oregon spotted frog overwintering habitat will increase at Bull Bend and Dead Slough in response to the increased winter flows (Figures 8-86A and 8-87A, respectively). The rate of increase in WUA will be relatively constant with increasing flow at Dead Slough, while most of the increase at Bull Bend will come from the first 100 cfs. At both locations and under all projected flow conditions, most of the overwintering habitat will be associated with increased depth of water in unvegetated portions of the wetlands. As noted previously, neither wetland experiences appreciable inundation of emergent vegetation at flows of less than 700 cfs.

While the DBHCP increases in winter flows may not provide optimal conditions for overwintering Oregon spotted frogs at Bull Bend or Dead Slough, they will improve conditions relative to historical flows. This is particularly true for Bull Bend, where most potential overwintering sites have historically gone dry in all but the wettest winters. With minimum winter flows of 100 to 300 cfs, overwintering habitat will consistently be available within the main channel of the Deschutes River at Bull Bend, and potentially at similar locations throughout the reach. When the minimum winter flow reaches 400 cfs in Year 13, existing beaver channels within the Bull Bend wetland (out of the main river channel) will remain inundated throughout the winter. River banks and beaver channels have both been identified as overwintering habitat for Oregon spotted frogs in riverine environments (Hayes et al. 2001; Shovlain 2005; Pearl et al. 2018). USFWS (2017) has noted that the one recent year of documented Oregon spotted frog breeding at Bull Bend (2013) followed a wet winter when flows in this reach of the river averaged 433 cfs and remained above 270 cfs for all but 7 days between October 1 and March 31 (OWRD 2020i). USFWS surmised the higher flows allowed Oregon spotted frogs from an established population at Dilman Meadow (3 miles upstream) to disperse to Bull Bend prior to the breeding season. It is equally possible that inundation of the beaver channels at Bull Bend enabled adult Oregon spotted frogs to persist there through the winter of 2012-13. The historical lack of consistent overwintering habitat has been identified as the likely cause for Oregon spotted frog absence from Bull Bend. The provision of overwintering habitat on a consistent basis under the DBHCP could lead to the establishment and persistence of breeding at the site.

Overwintering habitat at Dead Slough will increase gradually within increasing winter flows up to 400 cfs (Figure 8-87A) due to increases in the depth and width of the inundated area within the slough (RDG 2017). The net increase in WUA from 20 to 400 cfs minimum flow will be roughly 40 percent. Unlike Bull Bend, most of the increase in WUA will occur within the slough itself (outside the main channel of the Deschutes River). The inundated area will have a mostly unvegetated substrate, but Pearl et al. (2018) did not find a strong correlation between the presence of emergent wetland vegetation and overwintering use by Oregon spotted frogs at Dead Slough in 2016.

Seasonal movements between summer and overwintering habitats may be more difficult for Oregon spotted frogs in this reach of the Deschutes River under the DBHCP due to lower than historical flows during September and October (Table 8-31). The lower September and October flows will be an indirect result of increased winter flow; these increased winter flows will reduce storage in Wickiup Reservoir in many years, such that the summer release of the stored water will end earlier in the summer. Dead Slough will still retain a surface connected to the Deschutes River (flow at WICO of 400-500 cfs) for a median of 80 to 90 percent of the time in September and early October, thereby maintaining an aquatic travel corridor between the wetland and the river. However, the number of days with flows at WICO of at least 800 cfs (the approximate threshold for inundation of wetland vegetation in Dead Slough) will be 50 to 80 percent of what it was historically. This could leave Oregon spotted frogs exposed to greater potential for predation during the period of movement from summer to overwintering habitat.

Table 8-31. Predicted numbers of days exceeding various flow thresholds at Hydromet Station WICO during the period immediately prior to Oregon spotted frog overwintering (September 1 – October 15).

Flow Threshold	Median Annual Number of Days ≥ Flow Threshold / Percent of Total Days During Period ≥ Flow Threshold			
	Historical	DBHCP Years 1-7	DBHCP Years 8-12	DBHCP Years 13-30
300 cfs	45 days / 100%	42 days / 93%	45 days / 100%	45 days / 100%
400 cfs	43 days / 96%	41 days / 91%	39 days / 87%	45 days / 100%
500 cfs	42 days / 93%	38 days / 84%	36 days / 80%	35 days / 78%
600 cfs	41 days / 91%	34 days / 76%	31 days / 69%	30 days / 67%
700 cfs	39 days / 87%	28 days / 62%	25 days / 56%	24 days / 53%
800 cfs	35 days / 78%	19 days / 42%	18 days / 40%	18 days / 40%
900 cfs	27 days / 60%	15 days / 33%	14 days / 31%	14 days / 31%
1,000 cfs	22 days / 49%	14 days / 31%	13 days / 29%	12 days / 27%

Oregon Spotted Frog Breeding

Oregon spotted frogs begin depositing eggs in Upper Deschutes River wetlands as early as late March, and egg development can last until the end of April (USFWS 2017). Under the DBHCP the flow at WICO will reach 600 cfs by April 1 (roughly 2 weeks earlier than the historical ramp up of flows), and will remain between 600 and 800 cfs for the entire month of April. Flows will generally remain below 500 cfs during the pre-breeding period (March) in all phases of DBHCP implementation (Table 8-32), but the median numbers of days with flows of at least 600 cfs during breeding in April will nearly triple (Table 8-33). If the flow is increased above 600 cfs during April, it will not be subsequently reduced more than 30 cfs from the new high until May. These provisions in Conservation Measure WR-1 are intended to: a) inundate breeding sites for the beginning of the Oregon spotted frog breeding season, b) prevent over-inundation and flushing of egg masses during egg development, and c) prevent stranding and desiccation of eggs that might occur if flows are reduced.

Table 8-32. Predicted numbers of days exceeding various flow thresholds at Hydromet Station WICO during the period immediately prior to Oregon spotted frog breeding (March 1 – March 31).

Flow Threshold	Median Annual Number of Days ≥ Flow Threshold / Percent of Total Days During Period ≥ Flow Threshold			
	Historical	DBHCP Years 1-7	DBHCP Years 8-12	DBHCP Years 21-30
300 cfs	3 days / 10%	0 days / 0%	31 days / 100%	31 days / 100%
400 cfs	0 days / 30%	0 days / 0%	0 days / 0%	31 days / 100%
500 cfs	0 days / 30%	0 days / 0%	0 days / 0%	0 days / 0%

Table 8-33. Predicted numbers of days exceeding various flow thresholds at Hydromet Station WICO during the period of Oregon spotted frog breeding (April 1 – April 30).

Flow Threshold	Median Annual Number of Days ≥ Flow Threshold / Percent of Total Days During Period ≥ Flow Threshold			
	Historical	DBHCP Years 1-7	DBHCP Years 8-12	DBHCP Years 13-30
600 cfs	10 days / 33%	29 days / 97%	29 days / 97%	29 days / 97%
700 cfs	6 days / 20%	8 days / 27%	1 day / 3%	0 days / 0%
800 cfs	4 days / 13%	1 day / 3%	0 days / 0%	0 days / 0%

According to the WUA projections developed by RDG (2017), the amount of Oregon spotted frog breeding habitat will roughly double at Bull Bend and Dead Slough when the early April flow at WICO increases from 20 to 600 cfs (Figures 8-86B and 8-87B, respectively). As noted previously, however, habitat in both areas is of relatively low quality with unvegetated substrate at 600 cfs. Significant increases in the WUA of breeding habitat do not occur at either wetland until flows at WICO exceed 900 cfs (USFWS 2017). Habitat quality at Dead Slough is low at flows below 900 cfs, and emergent vegetation is no longer inundated below 683 cfs (USFWS 2017, Appendix). This means eggs deposited at Dead Slough when flow at WICO is 600 to 800 cfs could be in marginal habitat with little to no substrate vegetation. This condition could change over time if lower summer flows (and lower summer inundation depths) allow emergent vegetation to expand lower into the wetland where it will be inundated at flows below 683 cfs.

The timing of wetland inundation in the spring under the DBHCP (no later than April 1) will be an improvement over historical conditions and will enable breeding where it did not occur before, particularly at Bull Bend. Individual frogs that attempt to breed prior to April 1, however, may find no improvement from historical conditions. The precise trigger for the initiation of breeding in the Upper Deschutes River is not known, nor is the percentage of frogs that attempt to deposit eggs prior to April 1. It is possible, therefore, that at least some of the Oregon spotted frogs will deposit eggs prior to April 1 when flows are still being ramped up to 600 cfs, and the eggs will then be exposed to the potential for flushing as water levels rise.

Oregon Spotted Frog Summer Rearing and Foraging

Oregon spotted frog use of summer habitats along the Upper Deschutes River has not been extensively studied. The best available information on summer habitat conditions is the work of O'Reilly and Gritzner (USFWS 2017, Appendix) at Dead Slough, which documented declining wetland habitat conditions at WICO flows below 900 cfs and absence of inundated emergent vegetation altogether at flows below 683 cfs. Under the DBHCP the median flow at WICO during the spring and summer (April 1 through September 15) will decrease incrementally as winter flows increase (Table 8-30). Historically the median summer flow was 1,280 cfs, which fully inundated Dead Slough. The summer median will remain above 1,000 cfs through Year 12 of DBHCP implementation, but in Years 13-30 the median will drop to 960 cfs and the 80 percent exceedance flow will be 647 cfs. Based on the work of O'Reilly and Gritzner (USFWS 2017, Appendix) these water levels will result in less inundation of wetland vegetation at Dead Slough in most years, and complete lack of inundated vegetation in years with flows at or below the predicted 80 percent exceedance level. The median number of days during the summer (April 15 – Aug 31) with flows at WICO of 900 cfs or more will go down 5 percent in Year 1 of the DBHCP and as much as 23 percent by Year 13 (Table 8-34).

The presence of emergent vegetation such as sedges in seasonally inundated wetlands is a function of the timing and depth of flooding. Inundation that occurs only during the winter when plants are dormant can have little or no effect on growth, as evidenced by the presence of sedges and water-tolerant shrubs in portions of Crane Prairie and Wickiup reservoirs that are regularly flooded to depths of 2 feet or more for most of the winter. In contrast, inundation that continues into the growing season can inhibit growth and reduce plant height and density, and inundation that persists for the entire growing season can prevent plant growth altogether. Plants that are adapted to wetland conditions can persist even when inundated, with the tolerated depth of inundation varying by plant type (aquatic versus emergent) and plant species. The portions of the Dead Slough and Bull Bend wetlands that support emergent vegetation (mostly sedges) already experience inundation during the growing season, and it is likely the current limit of emergent vegetation was determined by the historical hydrological regime of the river. As the hydrology of the river changes and summer water depths decrease over time, there may be a corresponding downward shift of the emergent vegetation into areas that are currently unvegetated or vegetated by aquatic species. This could at least partially compensate for the lower water levels. The phased increase of minimum winter flows specified in Conservation Measure WR-1, and the corresponding phased decrease in summer flows, will allow time for emergent vegetation at Dead Slough and Bull Bend to respond to the changes.

Table 8-34. Predicted numbers of days exceeding various flow thresholds at Hydromet Station WICO during Oregon spotted frog tadpole rearing (April 15 – Aug 31).

Flow Threshold	Median Annual Number of Days ≥ Flow Threshold / Percent of Total Days During Period ≥ Flow Threshold			
	Historical	DBHCP Years 1-7	DBHCP Years 8-12	DBHCP Years 13-30
600 cfs	133 days / 96%	139 days / 100%	139 days / 100%	139 days / 100%
700 cfs	129 days / 93%	127 days / 91%	120 days / 94%	114 days / 82%
800 cfs	123 days / 88%	119 days / 86%	107 days / 77%	101 days / 73%
900 cfs	110 days / 79%	105 days / 76%	92 days / 66%	85 days / 61%
1,000 cfs	100 days / 72%	94 days / 68%	81 days / 58%	72 days / 52%
1,100 cfs	93 days / 67%	82 days / 59%	66 days / 47%	62 days / 45%
1,200 cfs	87 days / 63%	67 days / 48%	55 days / 40%	1 day / 4%
1,300 cfs	74 days / 53%	51 days / 37%	26 days / 19%	0 days / 0%
1,400 cfs	50 days / 36%	15 days / 11%	0 days / 0%	0 days / 0%
1,500 cfs	19 days / 14%	5 days / 4%	0 days / 0%	0 days / 0%

8.4.2.2 Deschutes River Reach 2 – Fall River to Little Deschutes River

Overview

Flows in this reach of the Deschutes River are determined largely by the combination of releases from Wickiup Reservoir and surface discharge from Fall River. There are no surface tributaries of appreciable size between Fall River and Little Deschutes River, and groundwater discharge into this reach is limited to 24 cfs (Gannett et al. 2001). Fall River, which originates from springs and travels fewer than 10 miles before entering the Deschutes River, has remarkably consistent flow. Monthly medians of daily average flows in Fall River vary only about 12 cfs from January to June (Figure 8-88). Flows in the Deschutes River Reach between Fall River and Little Deschutes River can be approximated by adding daily average flow in Fall River (OWRD Gage 15057500) and the estimated groundwater discharge of 24 cfs (Gannett et al. 2001) to the daily average flow below Wickiup Dam (Hydromet Station WICO). The results are shown in Figure 8-89 for historical and DBHCP flows.

This 12-mile reach of the Deschutes River, which lies mostly on private lands, supports an estimated 308 acres of vegetated wetlands (Table 8-29). Wetland density is higher in this reach than in the upstream 22 miles, averaging slightly over 13 acres of emergent wetland per mile of river. Emergent wetlands comprise about 53 percent of wetlands in the reach (R2 and Biota Pacific 2018). Low levels of Oregon spotted frog breeding (as evidenced by egg masses) have been detected intermittently at two small sites, but there have been few formal surveys of the reach due to inaccessibility of private lands. Fifteen egg masses were observed at one of the sites in 2019, and a single egg mass was discovered at the other site in 2016 (see Chapter 5, Table 5-12). Historical conditions for Oregon spotted frogs may have been slightly better than those upstream in the Deschutes River due to the presence of roughly 142 cfs of additional flow throughout the winter. Fluctuations between winter and summer flows in this reach are comparable to those upstream, however, suggesting that vegetated portions of wetlands most likely lie somewhat above elevations that would be inundated in the winter. As with the upstream reach, existing overwintering habitat for Oregon spotted frogs within this reach of the Deschutes River is probably limited to the main river channel and unvegetated portions of oxbow wetlands. Breeding and summer habitat conditions will depend on the depth and velocity of water in each wetland.

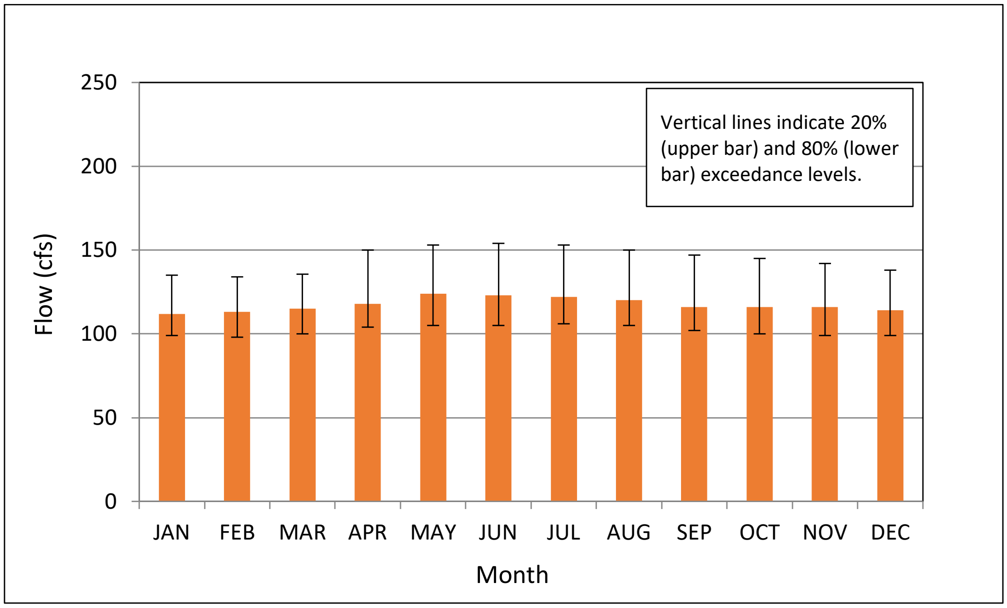


Figure 8-88. Monthly medians of historical daily average flows in Fall River (OWRD Gage 15057500) from 1981 through 2018. Source: OWRD 2020j.

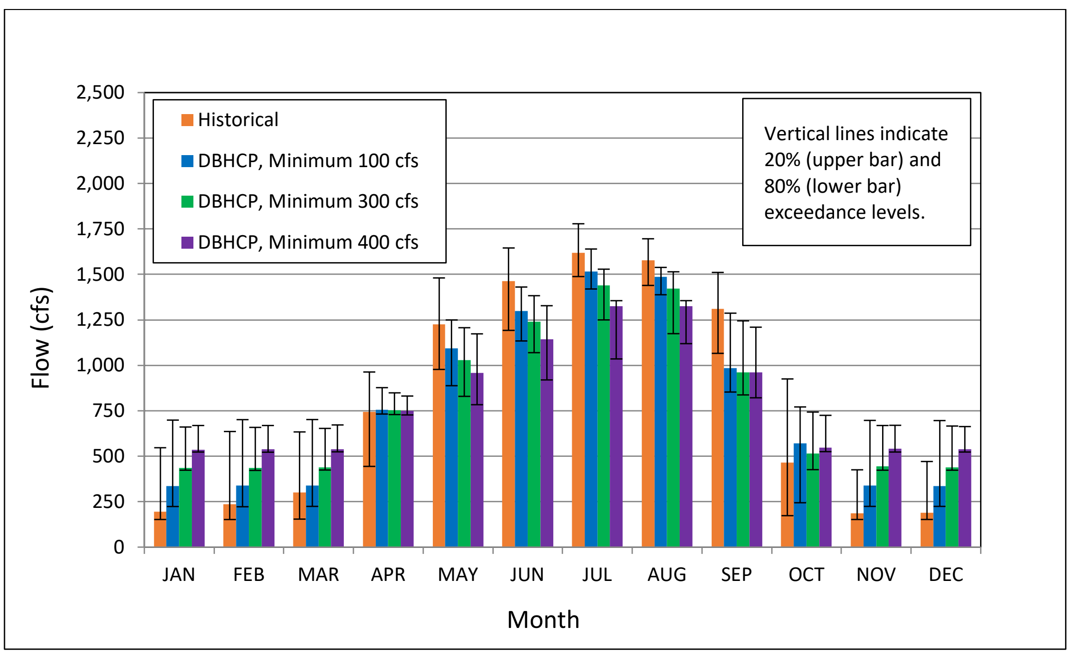


Figure 8-89. Estimated monthly medians of historical and DBHCP daily average flows in the Deschutes River between Fall River and Little Deschutes River from 1981 through 2018. Sources: OWRD 2020i, 2020j.

Habitat Conditions

Wetlands within the reach of the Deschutes River between Fall River and Little Deschutes River have not been extensively studied. Changes in flow within the reach under the DBHCP will be comparable to the changes described for the reach immediately upstream, the only difference being that total flows will be higher due to inflow from Fall River and groundwater discharge. DBHCP flows are illustrated by month in Figure 8-89 and summarized by season in Table 8-35.

Table 8-35. Predicted flows in the Deschutes River between Fall River and Little Deschutes River under historical conditions and the DBHCP.

Analysis Period	Instream Flow Apr 1 – Sep 15 (cfs)			Instream Flow Sep 16 – Mar 31 (cfs)		
	Minimum	80% Exceedance	Median	Minimum	80% Exceedance	Median
Historical	138	978	1,431	116	154	249
DBHCP Years 1-7	710	892	1,286	203	225	393
DBHCP Years 8-12	708	841	1,186	403	424	444
DBHCP Years 13-30	605	795	1,104	503	524	542

Source: OWRD 2020i, 2020j, Reclamation 2020a.

Oregon Spotted Frog Overwintering

Habitat for overwintering Oregon spotted frogs between Fall River and Little Deschutes River should improve under the DBHCP due to increased winter flows. The magnitude of increase in flow will be the same as described for the reach upstream of Fall River, but the total net flow will be greater because of the additional inflow from Fall River (Figure 8-89). The magnitude of change in overwintering habitat cannot be predicted in the absence of site-specific wetland information, but it is highly unlikely the change will be negative given that flows will be increasing.

Oregon Spotted Frog Breeding

Conditions for Oregon spotted frog breeding in this reach of the Deschutes River will be improved by the DBHCP due to increased flows (and associated water inundation levels) in April when the majority of breeding would occur. Median flows in April will not be substantially higher than they were historically (Figure 8-89), but minimum flows will be much higher. Whereas historical water levels may have been too low in early April of some years, and rapid water fluctuations during April may have been detrimental to egg survival, both situations will be addressed by Conservation Measure WR-1. The magnitude of benefit will depend on the geomorphology of occupied wetlands and the resulting inundation depths associated with increased flows, but the potential for adverse impacts from higher and more stable flows will be negligible.

Oregon Spotted Frog Summer Rearing and Foraging

The effects of the DBHCP on summer habitat for Oregon spotted frogs between Fall River and Little Deschutes River are unknown. Flows in this reach during May through September will be considerably lower than they were under historical operations (Figure 8-89), and depending on the geomorphology of the wetlands the change in flow could be positive or negative. If the new flows keep wetlands inundated to depths suitable for Oregon spotted frogs throughout the summer, the effects of the DBHCP will be neutral or positive. However, if the new flows reduce water depths to the point that wetlands are no longer suitable for the frogs the effects of the DBHCP will be negative. By Year 13 of the DBHCP, monthly median flows will be reduced from 16 percent (in August) to 22 percent (in June) (Figure 8-89). If there is roughly a 1:1 relationship between flow and water depth in this reach, a reduction of 22 percent in water depth could leave some wetlands too dry to support Oregon spotted frogs through the summer. As noted for the reach immediately upstream of Fall River, the adverse effects of lower summer flows could be offset if wetland vegetation responds to the lower flows. However, the opportunity for this to occur will depend on whether the existing wetlands include low-lying unvegetated areas capable of supporting emergent and rooted aquatic vegetation at lower inundation levels.

8.4.2.3 Deschutes River Reach 3 – Little Deschutes River to Benham Falls

Overview

The Deschutes River gains a substantial amount of flow within the 11 miles upstream of Benham Falls. The Little Deschutes River (confluence at RM 193) contributes over 100 cfs in most months. From 1981 to 2018 the long-term average flow in the Little Deschutes River at RM 26 (Hydromet Station LAPO) was 180 cfs, but flows vary considerably on a daily, monthly and yearly basis. The annual median for daily average flow at LAPO from 1981 to 2018 was 137 cfs, but the monthly median ranged from a low of 60 cfs in October to a high of 276 in May (Figure 8-90). Spring River contributes another 270 cfs to the Deschutes River on a more consistent basis at RM 191, just 2 miles downstream of the Little Deschutes River (Gannett et al. 2001). By the time the Deschutes River reaches Benham Falls at RM 182, the daily average flow is consistently at least 500 cfs higher than it is immediately below Wickiup Dam (Figure 8-91). This increased flow means the main channel of the Deschutes River and many of the side channels remain inundated year round, but the seasonal fluctuations between high (summer) and low (winter) flow are still substantial, and most vegetated wetlands lack inundation during the winter (USFWS 2017).

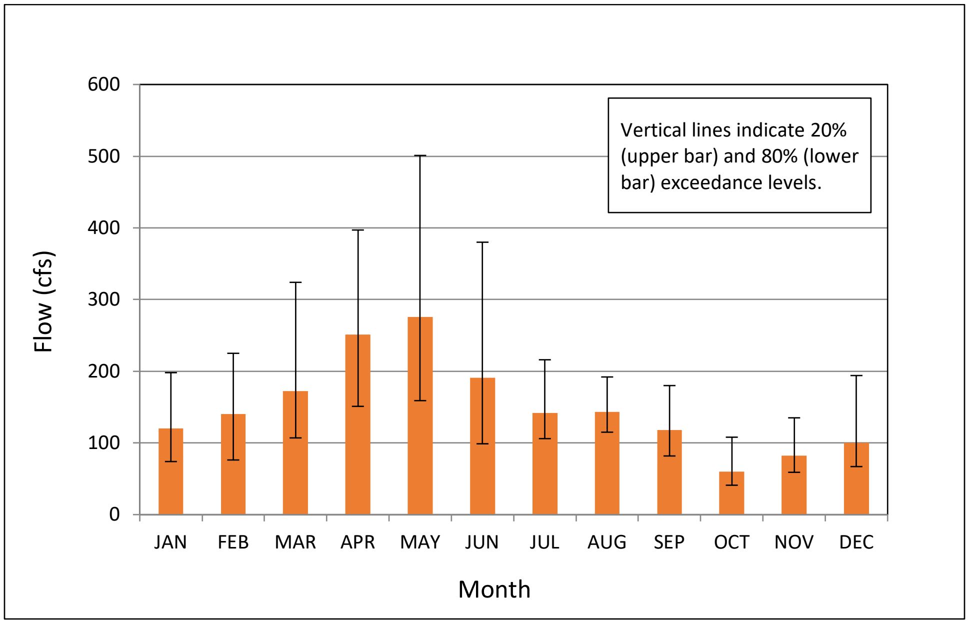


Figure 8-90. Monthly medians of daily average flows in Little Deschutes River (Station LAPO) at River Mile 26 from 1981 through 2018. Source: OWRD 2020k

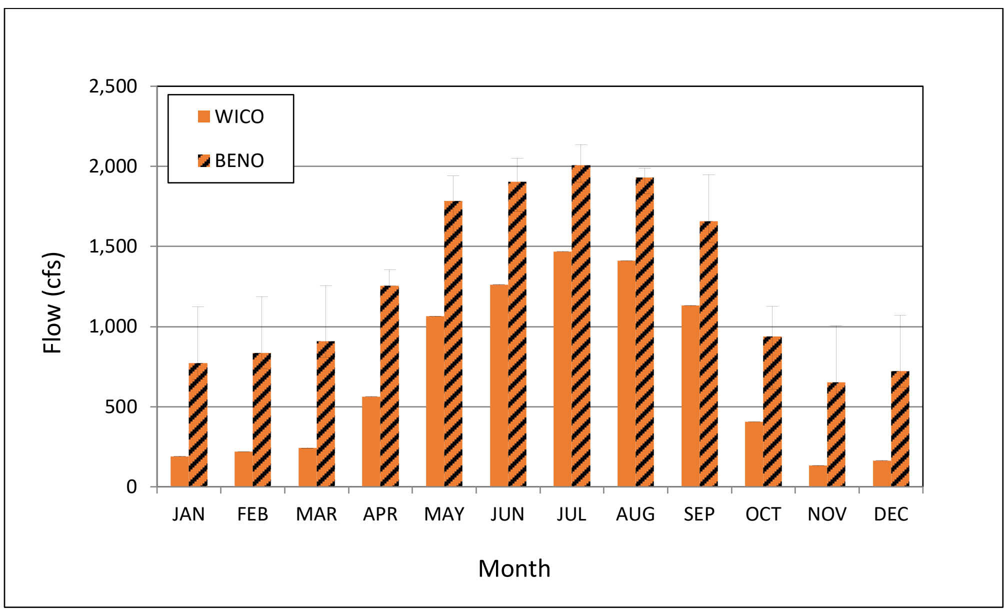


Figure 8-91. Comparison of monthly average flows in the Deschutes River below Wickiup Dam (Station WICO) and at Benham Falls (Station BENO) from 1981 through 2018. Sources: OWRD 2020i, 2020l

This 11-mile reach of the Deschutes River contains an estimated 286 acres of vegetated wetland habitat that are potentially influenced by the operation of Wickiup Dam (Table 8-29). About 69 percent of the wetlands are emergent and the density of this wetland type is about 21 acres per mile of river (R2 and Biota Pacific 2018). The reach also contains 115 acres of manmade and side channel wetlands at Sunriver, but water levels at Sunriver are controlled by a series of dikes and weirs that counteract the effects of Wickiup Reservoir operation as well as natural fluctuations in runoff to keep the wetlands inundated year round. The regulated wetlands at Sunriver support the largest known concentration of Oregon spotted frogs in the upper Deschutes Basin outside Big Marsh. The minimum adult breeding population in these wetlands was estimated to be 2,960 individuals in 2011 (see Chapter 5, Table 5-12). Numbers have decreased considerably in recent years due apparently to bull frog predation, and the estimated minimum adult breeding population in 2019 was 1,360 (see Chapter 5, Table 5-12). Oregon spotted frog breeding has not been documented at any other location along the Deschutes River between Sunriver and Benham Falls, although individual spotted frogs have been found using wetlands along the Deschutes River near Sunriver during the summer.

Habitat Conditions

USFWS (2017, Appendix) evaluated the relationship between river flow and inundation at an 11-acre wetland near the downstream end of this reach (a short distance upstream of Benham Falls). They observed the wetland to be dewatered when the flow at Benham Falls was below 1,100 cfs, and inundated when the flow was 1,274 cfs. USFWS (2017) has noted that at least one other wetland within this reach has remained partially inundated through the winter under historical operation of Wickiup Reservoir.

The DBHCP will have little or no effect on wetlands at Sunriver because those wetlands are buffered from changes in river flow by a series of dikes and impoundments. Other wetlands in the reach between Little Deschutes River and Benham Falls will experience increased median flows during the winter and decreased median flows during the summer (Table 8-36). During the winter the median DBHCP flows will not be high enough to inundate the wetland evaluated by O'Reilly and Gritzner (USFWS 2017, Appendix). During the summer, however, 80 percent exceedance flows projected for all phases of DBHCP implementation will be sufficient to keep the wetland inundated.

Table 8-36. Predicted flows in the Deschutes River at Benham Falls under historical conditions and the DBHCP.

Analysis Period	Instream Flow Apr 1 – Sep 15 (cfs)			Instream Flow Sep 16 – Mar 31 (cfs)		
	Minimum	80% Exceedance	Median	Minimum	80% Exceedance	Median
Historical	464	1,550	1,860	330	511	702
DBHCP Years 1-7	942	1,538	1,773	142	610	883
DBHCP Years 8-12	1,004	1,397	1,684	342	784	903
DBHCP Years 13-30	986	1,337	1,608	444	883	979

Sources: OWRD 2020l, Reclamation 2020a.

Oregon Spotted Frog Overwintering

Overwintering Oregon spotted frogs between Little Deschutes River and Benham Falls may benefit from increased flows under the DBHCP, but the magnitude of benefit will be small. Overwintering sites within the river channel may improve, but off-channel habitat will remain the same. If the 11-acre wetland evaluated by O'Reilly and Gritzner (USFWS 2017, Appendix) is typical of off-channel habitat throughout the reach, the continued absence of flows ≥ 1,200 cfs in the majority of years will keep off-channel habitat unavailable during the winter (Table 8-36). Seasonal movement from summer to overwintering habitats may be impacted by the decreases of 26 percent or more in the median numbers of days of inundation ≥ 1,200 cfs from September 1 through October 15 (Table 8-37), the period when Oregon spotted frogs in the Deschutes Basin have been observed initiating movement to overwintering sites (Pearl et al. 2018). The effects of this on seasonal movements are uncertain because the timing and routes of movement are unknown in this currently uninhabited reach. Within the main river channel, however, increased winter flows may benefit Oregon spotted frogs if the flows improve the quality of bank habitat. Stream banks, particularly in areas with beaver activity such as the Deschutes River, have been suggested as possible overwintering sites if they remain in contact with the wetted portion of the river (McAllister and Leonard 1997; Hallock and Pearson 2001; Watson et al. 2003). Pearl et al. (2018) documented Oregon spotted frogs at Dead Slough (upstream of this reach) overwintering in the bank of the Deschutes River. As winter flow increases under the DBHCP, a greater portion of the existing stream bank in this reach will remain in direct contact with the river where it could function as overwintering habitat.

Oregon Spotted Frog Breeding

The potential for Oregon spotted frog breeding will be facilitated in this reach of the Upper Deschutes River, as in the upstream reaches, by the ramp-up of irrigation releases no later than April 1 and the stabilization of flows below Wickiup Dam during the month of April. Flows will generally remain below 1,100 cfs during the pre-breeding period (March) in all phases of DBHCP implementation (Table 8-38). Median flows at Benham Falls in April will increase slightly, to over 1,300 cfs, and the 80 percent exceedance flows will increase more than 200 cfs, to be more than 1,100 cfs during all phases of implementation (Table 8-39). More importantly, the median numbers of days with flows of at least 1,200 cfs during April will increase from the historical 15 days to 27 days under the DBHCP (Table 8-40). These flows will provide sufficient water depth to inundate the riparian wetland in this reach evaluated by O'Reilly and Gritzner (USFWS 2017, Appendix). Measure WR-1 will also reduce flow fluctuations in this reach in April compared to historical conditions, but flows will continue to fluctuate more than upstream Deschutes River reaches due to the influence of the Little Deschutes River. Flows in the Little Deschutes River have historically fluctuated 100 cfs or more during the month of April (Figure 8-90).

Table 8-37. Predicted numbers of days exceeding various flow thresholds at Hydromet Station BENO during the period immediately prior to Oregon spotted frog overwintering (September 1 – October 15).

Flow Threshold	Historical	DBHCP Years 1-7	DBHCP Years 8-12	DBHCP Years 13-30
	Median Annual Number of Days ≥ Flow Threshold / Percent of Total Days During Period ≥ Flow Threshold			
1,000 cfs	43 days / 96%	37 days / 82%	36 days / 80%	35 days / 78%
1,100 cfs	42 days / 96%	35 days / 78%	33 days / 73%	32 days / 71%
1,200 cfs	39 days / 87%	29 days / 64%	29 days / 64%	27 days / 60%
1,300 cfs	34 days / 76%	21 days / 47%	20 days / 44%	19 days / 42%
1,400 cfs	27 days / 60%	18 days / 40%	15 days / 33%	14 days / 31%
1,600 cfs	19 days / 42%	12 days / 27%	11 days / 24%	10 days / 22%
	80 Percent Exceedance Level for Annual Number of Days ≥ Flow Threshold / Percent of Total Days During Period ≥ Flow Threshold			
1,000 cfs	38 days / 84%	35 days / 78%	32 days / 71%	31 days / 69%
1,100 cfs	35 days / 78%	32 days / 71%	30 days / 67%	29 days / 64%
1,200 cfs	31 days / 69%	27 days / 60%	23 days / 51%	20 days / 44%
1,300 cfs	27 days / 60%	18 days / 40%	16 days / 36%	14 days / 31%
1,400 cfs	20 days / 44%	14 days / 31%	4 days / 9%	2 days / 4%
1,600 cfs	13 days / 29%	8 days / 18%	0 days / 0%	0 days / 0%

Table 8-38. Predicted numbers of days exceeding various flow thresholds at Hydromet Station BENO during the period immediately prior to Oregon spotted frog breeding (March 1 – March 31).

Flow Threshold	Historical	DBHCP Years 1-7	DBHCP Years 8-12	DBHCP Years 13-30
	Median Annual Number of Days ≥ Flow Threshold / Percent of Total Days During Period ≥ Flow Threshold			
700 cfs	23 days / 74%	31 days / 100%	31 days / 100%	31 days / 100%
800 cfs	12 days / 39%	23 days / 74%	31 days / 100%	31 days / 100%
900 cfs	7 days / 23%	16 days / 52%	25 days / 81%	31 days / 100%
1,000 cfs	0 days / 0%	1 day / 3%	8 days / 26%	24 days / 77%
1,100 cfs	0 days / 0%	0 days / 0%	0 days / 0%	7 days / 23%
	80 Percent Exceedance Level for Annual Number of Days ≥ Flow Threshold / Percent of Total Days During Period ≥ Flow Threshold			
700 cfs	0 days / 0%	10 days / 32%	31 days / 100%	31 days / 100%
800 cfs	0 days / 0%	0 days / 0%	27 days / 87%	31 days / 100%
900 cfs	0 days / 0%	0 days / 0%	2 days / 6%	30 days / 97%
1,000 cfs	0 days / 0%	0 days / 0%	0 days / 0%	3 days / 10%
1,100 cfs	0 days / 0%	0 days / 0%	0 days / 0%	0 days / 0%

Table 8-39. Predicted flows in the Deschutes River at Benham Falls (Hydromet Station BENO) in April under historical conditions and the DBHCP.

Analysis Period	Instream Flow at Benham Falls in April (cfs)		
	Minimum	80% Exceedance	Median
Historical	464	930	1,290
DBHCP Years 1-7	939	1,199	1,340
DBHCP Years 8-12	939	1,191	1,321
DBHCP Years 13-30	986	1,182	1,310

Sources: OWRD 2020l, Reclamation 2020a.

Table 8-40. Predicted numbers of days exceeding various flow thresholds at Hydromet Station BENO during the Oregon spotted frog breeding season (April 1 – April 30).

Flow Threshold	Historical	DBHCP Years 1-7	DBHCP Years 8-12	DBHCP Years 13-30
	Median Annual Number of Days ≥ Flow Threshold / Percent of Total Days During Period ≥ Flow Threshold			
1,000 cfs	21 days / 70%	29 days / 97%	30 days / 100%	30 days / 100%
1,100 cfs	19 days / 63%	29 days / 97%	29 days / 97%	29 days / 97%
1,200 cfs	15 days / 50%	27 days / 90%	27 days / 90%	27 days / 90%
1,300 cfs	11 days / 37%	14 days / 47%	13 days / 43%	17 days / 57%
1,400 cfs	7 days / 23%	5 days / 17%	3 days / 10%	3 days / 10%
	80 Percent Exceedance Level for Annual Number of Days ≥ Flow Threshold / Percent of Total Days During Period ≥ Flow Threshold			
1,000 cfs	13 days / 43%	29 days / 97%	29 days / 97%	29 days / 97%
1,100 cfs	11 days / 37%	28 days / 94%	28 days / 94%	28 days / 94%
1,200 cfs	6 days / 20%	14 days / 47%	14 days / 47%	12 days / 40%
1,300 cfs	5 days / 17%	8 days / 27%	5 days / 17%	1 day / 3%
1,400 cfs	3 days / 10%	1 day / 3%	0 days / 0%	0 days / 0%

Oregon Spotted Frog Summer Rearing and Foraging

Flows will decrease between Little Deschutes River and Benham Falls during the summer under the DBHCP, but available data suggest the flows will still remain high enough to sustain summer habitat for Oregon spotted frogs in most years (Table 8-36). The wetland observed by O'Reilly and Gritzner (USFWS 2017, Appendix) is inundated when the flow at Benham Falls is at least

1,274 cfs. Under the DBHCP, the 80 percent exceedance flow will be at least 1,337 cfs during all phases of implementation. The median number of days at flows of 1,200 cfs or more will also increase to 100 percent under the DBHCP, providing an additional measure of stability to potential summer rearing habitat in this reach of the Deschutes River (Table 8-41).

Table 8-41. Predicted numbers of days exceeding various flow thresholds at Hydromet Station BENO during the Oregon spotted frog tadpole rearing period (April 15 – Aug 31).

Flow Threshold	Historical	DBHCP Years 1-7	DBHCP Years 8-12	DBHCP Years 13-30
	Median Annual Number of Days ≥ Flow Threshold / Percent of Total Days During Period ≥ Flow Threshold			
1,100 cfs	138 days / 99%	139 days / 100%	139 days / 100%	139 days / 100%
1,200 cfs	137 days / 99%	139 days / 100%	139 days / 100%	139 days / 100%
1,400 cfs	130 days / 94%	127 days / 91%	125 days / 90%	124 days / 89%
1,600 cfs	114 days / 82%	113 days / 81%	109 days / 78%	92 days / 66%
1,800 cfs	94 days / 68%	74 days / 53%	53 days / 38%	2 days / 1%
	80 Percent Exceedance Level for Annual Number of Days ≥ Flow Threshold / Percent of Total Days During Period ≥ Flow Threshold			
1,100 cfs	132 days / 95%	139 days / 100%	139 days / 100%	139 days / 100%
1,200 cfs	124 days / 89%	135 days / 97%	134 days / 96%	131 days / 94%
1,400 cfs	117 days / 84%	124 days / 89%	112 days / 81%	94 days / 68%
1,600 cfs	94 days / 68%	108 days / 78%	67 days / 48%	25 days / 18%
1,800 cfs	65 days / 47%	60 days / 43%	5 days / 4%	0 days / 0%

8.4.2.4 Deschutes River Reach 4 – Benham Falls to Dillon Falls

Overview

Flows in the Deschutes River between Benham Falls and Dillon Falls are similar to those reported for Benham Falls (Figures 6-15 and 6-20; Table 8-36), but slightly lower. The river loses an estimated 89 cfs to groundwater between Benham Falls and Bend (Gannett et al. 2001), but the total loss in the first 3 miles from Benham Falls to Dillon Falls is assumed to be relatively small.

This short reach of the Deschutes River contains an estimated 198 acres of vegetated wetlands (Table 8-29). About 55 percent of the wetlands are emergent, and the density of this wetland type is about 27 acres per mile of river (R2 and Biota Pacific 2018). Some wetlands in this reach have shown consistent Oregon spotted frog presence in recent years. Wetlands on both sides of the river at Slough Day Use Area (RM 189) have been monitored and found occupied every year since 2011 (see Chapter 5, Table 5-12). The 9-acre wetland on the west side of the river (SW Slough Camp) is perched above the main channel of the river and is supplied by local groundwater discharge (Figure 8-92). It remains inundated year round in most years, and does not respond to seasonal or daily changes in river flow (Figure 8-93); thereby putting it outside the area influenced by operation of the irrigation reservoirs. The data presented in Figure 8-93 suggest the wetland can go dry at times, although most of the wetland has been inundated to a depth of 1 foot or more in most years. The number of Oregon spotted frog egg masses detected in SW Slough Camp during spring breeding surveys has ranged from a low of 8 in 2014 and 2015 to a high of 27 in 2017 (see Chapter 5, Table 5-12).

Figure 8-92. Aerial image of Deschutes River wetlands between Benham Falls and Dillon Falls.

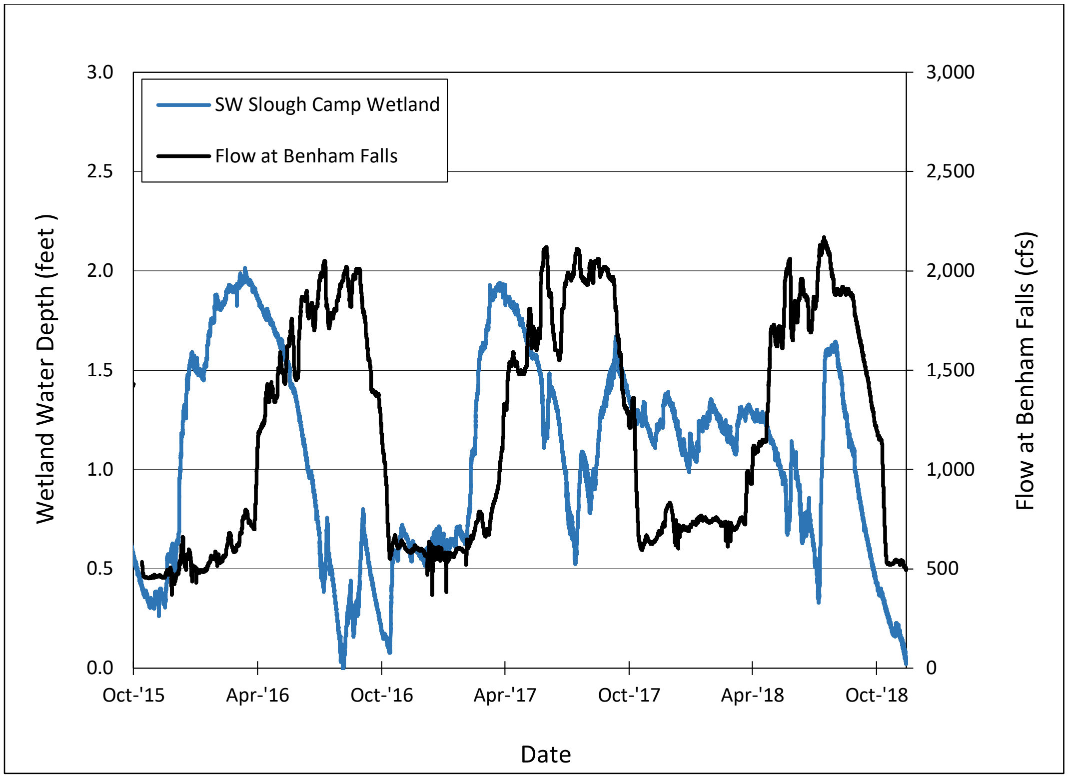


Figure 8-93. Comparison of water depth at SW Slough Camp wetland and flow in the Deschutes River at Benham Falls in 2015-16. Source: Biota Pacific and R2 2019.

The wetland complex on the east side of the Deschutes River at RM 189 is known as East Slough Camp. At an estimated 52 acres (O'Reilly pers. comm. 2019), it is considerably larger than the 9-acre SW Slough Camp. Much of the East Slough Camp complex lies within the seasonal floodplain of the Deschutes River where it is affected to varying degrees by changes in flow, including those changes caused by reservoir operation. Oregon spotted frog breeding surveys of the East Slough Camp complex in recent years detected a low of 10 egg masses in 2014 and a high of 100 egg masses in 2017 (see Chapter 5, Table 5-12).

The largest wetland within the East Slough Camp complex (Wetland A in Figure 8-92) has a direct surface connection to the Deschutes River and a sink hole within the wetland that drains to groundwater. This wetland is inundated with over 1 foot of water during the summer, but has historically been completely dry in the winter. The surface connection provides direct access for fish from the Deschutes River during the summer. Small numbers of Oregon spotted frog egg masses (evidence of breeding) have been found in the vegetated margins of this wetland in recent years, but the wetland is believed to have provided no overwintering habitat under historical Deschutes River flows because it goes dry. The remaining wetlands at East Slough Camp lack direct surface connections to the river most of the year. Several of these wetlands retain surface water year round and have had consistent use by Oregon spotted frogs in recent years (USFWS 2019b).

About 0.5 mile downstream of East Slough Camp is Ryan Ranch (Figure 8-92). Oregon spotted frogs were reported there in 1949, but surveys in the late 20th Century failed to detect their presence (Hayes 1997). Evidence of a single breeding female was reported at Ryan Ranch in 2013 (see Chapter 5, Table 5-12). The hydrology of Ryan Ranch was altered in 1947 through construction of a berm to isolate it from the Deschutes River. Portions of the site have continued to be seasonally inundated by local runoff since 1947, but the majority of the site has remained beyond the influence of the river and dry much of the year. The US Forest Service (USFS) has recently restored a surface connection between Ryan Ranch and the river. Preliminary studies have indicated the site is capable of holding surface water year round and providing up to 65 acres of emergent wetland habitat if inundated by the river. The precise relationship between Deschutes River flow and inundation level at Ryan Ranch is currently under investigation, but it is likely that wetland habitat conditions at the site will be influenced by Wickiup Reservoir operation (flow in the Deschutes River) if the ongoing USFS project is successful.

Habitat Conditions

The relationships between Deschutes River flows and water depths in the East Slough Camp complex were examined at five wetlands (Wetlands B through F in Figure 8-92) from September 2015 through October 2018. Water depths at all five wetlands correspond with flow at Benham Falls throughout the year, although the relationships between river flow and wetland depths appear stronger during the summer (Figure 8-94). All five wetlands retain open water year round, with depth of water varying from less than 1 foot to over 4 feet on a seasonal basis. Figure 8-94 indicates water levels dropping below the ground surface (negative depth) at some of the wetlands during the winter, but this is due to the locations of the monitoring devices. The open water area of these wetlands is reduced substantially during the winter (see details below), but portions of all wetlands lying lower in elevation than the monitoring devices remain inundated through the winter.

None of the wetlands illustrated in Figure 8-94 has a direct surface connection to the Deschutes River during the winter, but changes in wetland water depth that correspond with changes in flow during the winter suggest they all have subsurface connections. When the flow at Benham Falls increases above 700 cfs, water levels in all wetlands show corresponding increases in groundwater, with lag times of a few days to a few weeks. When the flow at Benham Falls exceeds roughly 1,800 cfs during the summer, all lag times are reduced to a few days or less, suggesting the existence of surface or shallow subsurface connections between the wetlands and the river at these higher flows.

Oregon spotted frog breeding attempts (deposited egg masses) were documented multiple years between 2011 and 2018 at Wetland B, but those attempts were not always successful. USFWS (2017) used time lapse photography and water level monitoring to determine Deschutes River flows necessary to support successful breeding at Wetland B (USFWS 2017, Appendix). They found that water levels reach the ground surface at the monitoring device when the flow at Benham Falls is about 1,400 cfs, consistent with the hydrological data presented in Figure 8-94. USFWS (2017) also noted that spring inundation of this pond is highly dependent upon winter precipitation, and in wet years, flows at BENO of 1,200 cfs can still coincide with shallow inundation of this site. Emergent vegetation in Wetland B begins to be inundated (i.e., it begins to resemble suitable Oregon spotted frog breeding habitat) at about 1,500 cfs, and the wetland is fully inundated at about 1,600 cfs. USFWS (2017) attributed intermittent breeding success at Wetland B to the fact that flows at Benham Falls have not consistently reached 1,500 cfs until May, whereas Oregon spotted frogs can begin to breed along the Deschutes River as early as mid-March. As indicated in Table 8-39, the median flow at Benham Falls in April from 1981 through 2018 was only 1,290 cfs. Flows at Benham Falls can be as high as 2,000 cfs in April, but they have historically only been at or above 1,500 cfs about 30 percent of the time. By May the median flow at Benham Falls has been over 1,800 cfs, and the daily average has rarely fallen below 1,500 cfs. Similar trends were observed at other East Slough Camp wetlands, which had minor to moderate differences in the magnitude of flow needed to initiate inundation in the spring (Figure 8-94).

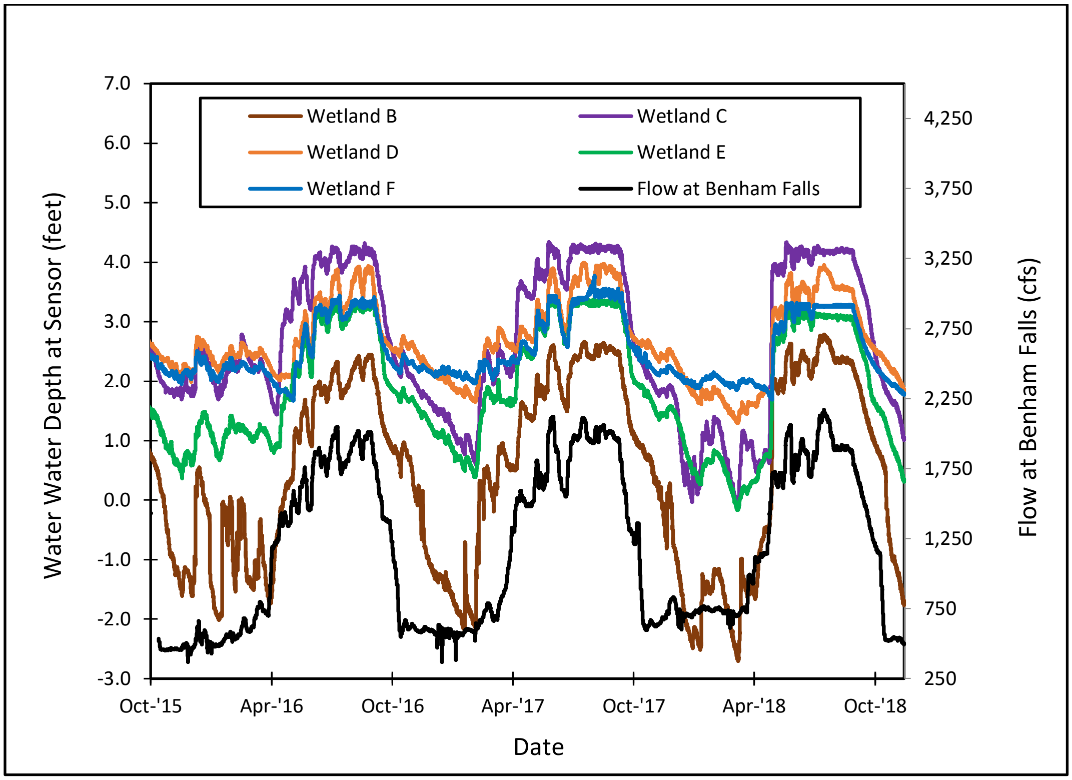


Figure 8-94. Comparison of water depths at East Slough Camp wetlands and flow in the Deschutes River at Benham Falls from October 2015 through October 2018.
Source: Biota Pacific and R2 2019.

Overwintering habitat at East Slough Camp has historically been negatively affected by low flows in the Deschutes River from October through March. Based on winter aerial photos, time lapse photography and ARC GIS, USFWS (2017) estimates that only about 10 percent of the wetland area at East Slough Camp remains inundated through the winter. The transition from summer to winter inundation can also be rapid, as indicated by the quick drops in flow during late September and October at Benham Falls (Figure 8-94).

Oregon Spotted Frog Overwintering

Pearl et al. (2018) studied adult Oregon spotted frog overwintering at East Slough Camp in 2011 and 2016 with the aid of radio-telemetry. They found that adults moved to overwintering sites between mid-September and late October. In 2011 adult frogs initiated movements to overwintering sites on September 14 when the flow at Benham Falls was still 1,800 cfs and the wetlands were still fully inundated. In 2016 adult frog movement to overwintering sites did not begin until September 23 when the fall ramp-down of releases from Wickiup Reservoir was well underway and the flow at Benham Falls had dropped to 1,380 cfs. This difference in the onset of movement between years suggests that habitat inundation level is not the only factor influencing adult Oregon spotted frog movement in the fall.

Of the 17 frogs Pearl et al. (2018) studied at East Slough Camp, three overwintered in aquatic habitats and the remaining 14 selected non-aquatic sites. Thirteen of the non-aquatic sites were within a lava flow adjacent to the wetland and the fourteenth site was a terrestrial location outside the lava flow. Pearl et al. (2018) also found that at SW Slough Camp (across the Deschutes River from East Slough Camp), where the wetland is inundated all winter, four of six adult Oregon spotted frogs selected what appeared to be upland sites for overwintering even though aquatic sites were available. While this was a preliminary study of relatively limited scope, it suggests that adult Oregon spotted frogs may not be entirely dependent on aquatic habitats for overwintering. The selection of upland sites for overwintering at East Slough Camp could be at least partially attributable to the general lack of inundated wetlands during the winter, but the selection of uplands at SW Slough Camp, where inundated sites were available the entire winter, suggests factors in addition to inundation level are important for overwintering.

Increases in winter flows below Wickiup Dam under the DBHCP will result in small changes to inundation levels in the wetlands between Benham Falls and Dillon Falls. Minimum flows of 100 to 400 cfs at Wickiup Dam from mid-September through March will result in median flows of 883 to 979 cfs at Benham Falls (Table 8-36). Conditions for overwintering within the main river channel may improve due to increased water depth, but conditions may also deteriorate if calm backwater areas within the main channel that have been present at low flows are eliminated by the higher flows.

Wetland A at East Slough Camp will continue to remain dry most of the winter under the DBHCP. The wetland was evaluated on October 3, 2016 when the flow at Benham Falls was 1,090 cfs. The seasonally-inundated portion of the wetland was largely exposed mudflat on that day, and water was flowing out through the surface connection to the river as well as into the sink hole near the center of the wetland. Median winter flows at Benham Falls of 883 to 979 cfs under the DBHCP (Table 8-36) are not likely to result in inundation of the wetland.

Overwintering conditions in Wetland B at East Slough Camp are also not likely to change under the DBHCP because water depth within the wetland does not increase appreciably until the flow at Benham Falls exceeds 1,400 cfs (Figure 8-94). Median winter flows of 883 to 979 cfs at Benham Falls (Table 8-36) may increase the groundwater level below Wetland B, but surface conditions in the wetland will not change.

The smaller wetlands at East Slough Camp may experience increases in winter water depth and inundated area under the DBHCP. As noted above, surface depths at some of these wetlands increase when the flow at Benham Falls exceeds 700 cfs. A median flow of 903 cfs and 80-percent exceedance flow of 784 cfs at Benham Falls starting in Year 8 (Table 8-36) could produce increases in winter water depths in Wetlands C through F, but the increases will likely be modest even when minimum winter flow below Wickiup Dam reaches 400 cfs in Year 13 and the median at Benham Falls is 979 cfs. As noted by USFWS (2017), emergent vegetation in Wetland F at the north end of East Slough Camp does not become fully inundated until the flow at Benham Falls reaches 1,600 cfs.

For Oregon spotted frogs that overwinter in upland sites, the DBHCP will have no effect. The changes in flow that will occur under the DBHCP will not alter habitat conditions within the lava flow that Pearl et al. (2018) identified as an overwintering site for adult Oregon spotted frogs at East Slough Camp or the shrub thicket with suspected overwintering use at SW Slough Camp.

Seasonal movements from summer to winter habitats at East Slough Camp may be more difficult for Oregon spotted frogs under the DBHCP because overall inundation levels (number of days with flows at Benham Falls of 1,000 cfs or more) in September and October will decrease during all phases of DBHCP implementation (Table 8-37). To the extent that Oregon spotted frogs require aquatic corridors to move between summer and winter habitats, these movements could be more difficult under the DBHCP. However, juveniles and adults were observed moving overland from the wetlands toward the river during the ramp-down of flows in early October 2016. This observation, combined with the findings of Pearl et al. (2018) suggests that at least some Oregon spotted frogs do not require aquatic corridors for seasonal movements, and are unaffected in this regard by the flows in the Deschutes River.

Oregon Spotted Frog Breeding

The East Slough Camp wetlands are influenced by local snowmelt in April, but USFWS (2017) has noted that conditions for breeding in Wetland B can be impaired in dry years when the flow at Benham Falls is less than 1,600 cfs. The wetland is inundated by river flows between 1,400 and 1,600 cfs, but conditions within this range are less than optimal. Historically, the daily average flow at Benham Falls infrequently reached 1,600 cfs by the end of April and breeding was heavily dependent on local snow melt. Under the DBHCP flows at Benham Falls will be increased during April (Table 8-39), although the median number of days over 1,400 cfs will still represent less than 17 percent of the month (Table 8-40). In most years the flow at Benham Falls will not reach 1,600 cfs until May. Breeding conditions at East Slough Camp may improve under the DBHCP because flows will increase at the beginning of April and wetland inundation levels will be higher than they have been historically. However, optimal river flows still won't be reached until May in the majority of years and local snowmelt will continue to be important.

Oregon Spotted Frog Summer Rearing and Foraging

The effects of reservoir operation on summer rearing and foraging habitat at East Slough Camp can be evaluated by examining the amount of time the daily average flow at Benham Falls is at or above 1,600 cfs (the level considered sufficient to fully inundate Wetland B) between April 15 and August 31. For the first 7 years of DBHCP implementation the median number of days per year with flows greater than 1,600 cfs will be only slightly lower than it was historically (Table 8-41), indicating little change in summer rearing habitat. After Year 7, the median number of days per year will show additional decrease, but it will still be 78 percent of the total days. Most of the days with flows of less than 1,600 cfs will be in April, as noted in the above discussion of breeding habitat. The monthly median of daily average flow at Benham Falls will remain at or above 1,600 cfs during May through August for the full term of the DBHCP, except for a minor drop below 1,600 cfs during May after Year 12 (Table 8-42). This slight drop below 1,600 cfs early in the season is not expected to result in measurable decrease in rearing habitat quality. The median number of days per year with flows of at least 1,400 cfs (the lower limit of suitability for Oregon spotted frog breeding and rearing at East Slough Camp Wetland B) will decrease from historical levels only slightly for the term of the DBHCP, indicating that East Slough Camp wetlands will continue to receive at least partial inundation on a consistent basis. Median flows in April will increase slightly under the DBHCP, but they will remain below 1,400 cfs. This is not anticipated to be detrimental to Oregon spotted frog breeding or rearing, however, because water levels in the East Slough Camp wetlands are more closely associated with local snowmelt in April, and less dependent of Deschutes River flows. Overall, summer rearing conditions in this reach are expected to be relatively unchanged under the DBHCP and the wetlands with historical Oregon spotted frog presence are expected to continue supporting summer rearing.

Table 8-42. Monthly medians and 80 percent exceedance levels for daily average flows at Benham Falls (Hydromet Station BENO) under historical conditions and projected DBHCP conditions.

Month	Monthly Median/80% Exceedance Level for Daily Average Flow at BENO (cfs)			
	Historical	DBHCP Years 1-7	DBHCP Years 8-12	DBHCP Years 13-30
April	1,290 / 930	1,340 / 1,199	1,321 / 1,191	1,310 / 1,182
May	1,820 / 1,580	1,667 / 1,570	1,618 / 1,508	1,583 / 1,437
June	1,900 / 1,680	1,791 / 1,717	1,738 / 1,620	1,648 / 1,476
July	2,010 / 1,860	1,915 / 1,831	1,818 / 1,693	1,672 / 1,450
August	1,940 / 1,820	1,877 / 1,820	1,819 / 1,579	1,684 / 1,514
September	1,680 / 1,410	1,376 / 1,300	1,346 / 1,300	1,325 / 1,240

8.4.2.5 Deschutes River Reach 5 – Dillon Falls to Lava Island Falls

Overview

The 4-mile reach of the Deschutes River between Dillon Falls and Lava Island contains an estimated 95 acres of vegetated wetlands (Table 8-29). About 12 percent of the wetlands are emergent and the density of this wetland type is about 2 acres per mile (R2 and Biota Pacific 2018). Flows in this reach are lower than immediately upstream due to limited surface inflow and continued losses to groundwater (Gannett at al. 2001). Up to 105 cfs are diverted from the river at the Arnold Diversion just upstream of Lava Island during the peak of the irrigation season (May 16 to September 15); diversions at other times of year are less than this (see Section 3.5.2, *Arnold irrigation District Activities*). Oregon spotted frog presence has not been documented in this reach of the Deschutes River.

Habitat Conditions

Wetland habitat conditions have not been extensively studied in this reach of the Deschutes River. USFWS (2017) suggested riverine wetlands along this reach become inundated when the flow at Benham Falls reaches somewhere between 1,270 and 1,530 cfs.

Oregon Spotted Frog Overwintering

Based on available information it is predicted the DBHCP will have minimal effect on Oregon spotted frog overwintering habitat between Dillon Falls and Lava Island. Median winter flows in this reach will continue to be less than 1,000 cfs (Table 8-36), which will be insufficient to inundate riverine wetlands that could potentially provide aquatic overwintering habitat. Increased winter flows could increase the depth of water within the river channel, but any benefits of increased depth could be counteracted by increased velocity in areas that have historically been calm or slow moving.

Oregon Spotted Frog Breeding

Oregon spotted frogs are not known to breed in this reach of the Deschutes River, but the potential for breeding could increase under the DBHCP due to increased flows in April (Table 8-40). The frequency of flows over 1,270 cfs in April will go up from historical conditions during all phases of DBHCP implementation, and this could increase the suitability of existing wetlands for Oregon spotted frog breeding.

Oregon Spotted Frog Summer Rearing and Foraging

Conditions for Oregon spotted frog summer rearing and foraging in this reach will likely remain constant under the DBHCP. Wetlands in this reach appear to become inundated when flows at BENO are about 1,300 cfs. While summer flows under the DBHCP will be less than they were historically, they will still remain at or above 1,300 cfs much of the time (Table 8-41). By similar measure, seasonal Oregon spotted frog movement between summer and over-wintering habitats will likely be unaffected since summer habitats will remain inundated well into September (Table 8-42).

8.4.2.6 Deschutes River Reach 6 – Lava Island Falls to Central Oregon Diversion

Overview

The hydrology of this 3-mile reach of the Deschutes River is similar to the reach immediately upstream, except for a flow reduction of up to 150 cfs at the Arnold Diversion during the summer. The reach has only 7 acres of vegetated wetland (Table 8-29). About 29 percent of the wetlands are emergent and the density of this wetland type is low (about 1 acre of wetland per mile of river) (R2 and Biota Pacific 2018). Until late 2016, the reach was not known to be occupied by Oregon spotted frogs. In September 2016 four juvenile Oregon spotted frogs were discovered in a small pond near RM 172. Nothing more is known about Oregon spotted frog use of the reach. Little is known about the relationship between flow and wetland inundation within the reach, other than that a portion of the occupied pond has remained inundated through the winter in recent years when the minimum flow at WICO has been between 100 and 200 cfs (USFWS 2020).

Habitat Conditions

The effects of the DBHCP on this reach are expected to be generally similar to those described for the reaches between Benham Falls and Lava Island. Winter flows will increase, which could increase the area of suitable overwintering habitat in the pond near RM 172. Summer flows will decrease, but the fact that the known occupied wetlands retains water when the flow at WICO is as low as 100 cfs suggests this reach would continue to function as summer rearing habitat under future DBHCP flows. Pre-wintering migration could benefit from less seasonal change between summer and winter flows.

8.4.2.7 Deschutes River Reach 7 – Central Oregon Diversion to Colorado Street

Overview

The last 3 miles of the Deschutes River within the current range of the Oregon spotted frog pass through the City of Bend. This is an urbanized reach with residential and commercial development along both banks. Water is diverted from this reach at the Central Oregon Diversion (up to 800 cfs) and three small irrigation district patron pumps (less than 1 cfs each). The river loses an estimated 89 cfs to groundwater from Benham Falls to the Central Oregon Diversion (Gannet et al. 2001) and gains very little for surface inflow.

The reach supports an estimated 8 acres of vegetated wetlands (Table 8-29). About 54 percent of the wetlands are emergent and the density of this wetland type is low (about 2 acres per mile of river) (R2 and Biota Pacific 2018). Oregon spotted frogs have been reported at two locations within the reach, both at the downstream end near the Colorado Street Bridge. A manmade retention pond on the east side of the river and a natural marsh on the west side were both found to be occupied in 2012. Oregon spotted frog breeding has been documented at both sites since 2013, with total egg mass counts ranging from 41 in 2013 to 2 in 2017 (see Chapter 5, Table 5-12). Reductions in breeding in recent years have been attributed to land use activities at both sites (USFWS 2017). In 2013 Bowerman (2014a, cited in USFWS 2017) estimated there were over 100 breeding adults and about 945 juvenile Oregon spotted frogs at the two sites combined. Bowerman (2014b, cited in USFWS 2017) also observed that frogs move between the sites seasonally and utilize the river during the winter.

The manmade pond on the east side of the Deschutes River is hydrologically isolated from the river and water levels within the pond are regulated. The storage, release and diversion of irrigation water covered by the DBHCP are not expected to influence the pond or Oregon spotted frogs residing within it.

The natural wetland on the west side of the river has a direct surface connection to the river that persists throughout the year, and water depth in the wetland is influenced by flow in the river. In addition to the hydrologic influences of the covered activities, the wetland is also influenced by backwater effects from a recreational park in the river immediately downstream at the Colorado Street Bridge. The water park includes a dam with a variable crest height that can be manipulated to control the rate and direction of flow for recreational kayakers.

Habitat Conditions

The general effects of the covered activities in this reach will be similar to upstream reaches; flows will be increased from historical levels during the winter and decreased from historical levels during the summer. Winter flows will increase as a result of the required minimum flows below Wickiup Dam, as well as by Conservation Measure DR-1 that will prevent daily average flows in this reach from falling below 250 cfs when stock water is being diverted at the Arnold and Central Oregon diversions. Summer flows will decrease due to reduced releases of storage from Wickiup Reservoir.

All flows in this reach will be lower than those predicted for the Deschutes River at Benham Falls because of diversions (Arnold Diversion, Central Oregon Diversion and three small patron pumps) and seepage losses. Historical and DBHCP projected flows at Colorado Street were estimated by subtracting daily average diversions at the Arnold Diversion and Central Oregon Diversion from daily average flows at Benham Falls (Hydromet Station BENO). To account for seepage losses between Benham Falls and Bend, 89 cfs were also subtracted from the daily average flows (Gannett et al. 2001). As indicated in Figure 8-95, the largest differences from historical flows will occur in May through September when DBHCP flows will be reduced by several hundred cfs, particularly when minimum winter flows reach 400 cfs.

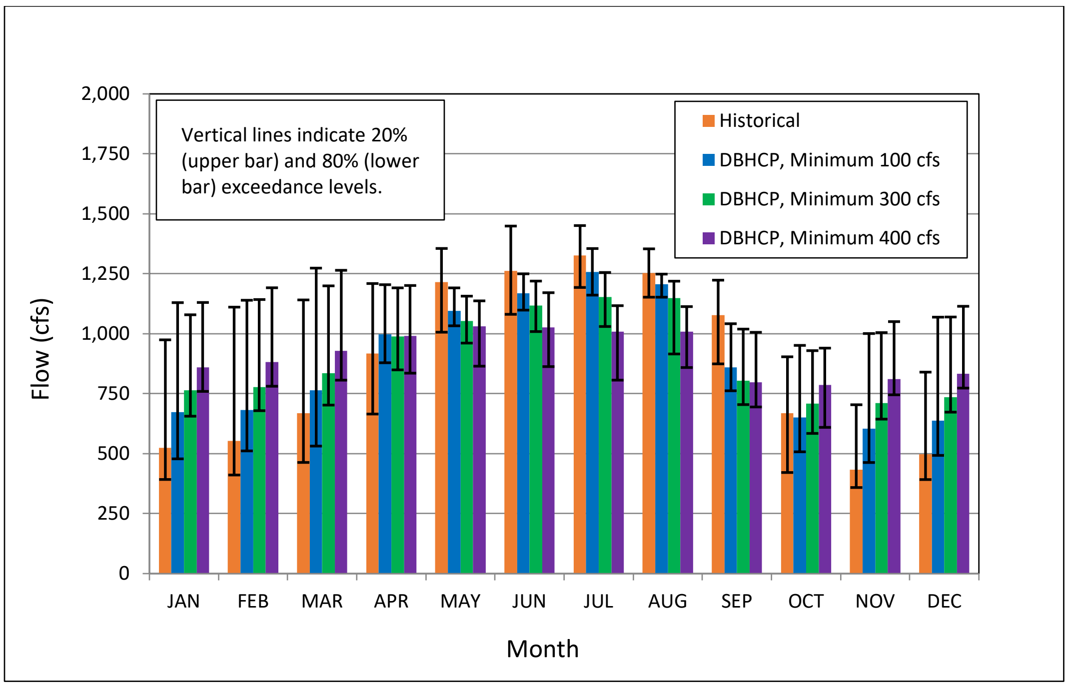


Figure 8-95. Monthly medians of estimated daily average flows in the Deschutes River at Colorado Street for historical (1981-2018) and DBHCP projected conditions. Sources: OWRD 2020l, 2020m, 2020n; Reclamation 2020a.

The relationships between Deschutes River flow, river stage and water depth in the west bank wetland were determined by monitoring all three on a continuous basis from late April 2018 to early April 2019. River flow and wetland water depth showed a strong seasonal fluctuation consistent with the storage of water in the winter and release of water into the Deschutes River the summer (Figure 8-96). The wetland remained inundated throughout the year, and water depth ranged from a low of 1 foot in mid-November to a high of 2.3 feet in July. Within seasons, wetland water depth was relatively stable. Average daily change in water depth from late April through September was only 0.3 inch and the maximum was 1.6 inches. Average daily change in water depth from October through March was 0.4 inch and the maximum was 2.2 inches. During the Oregon spotted frog breeding season (April and May), when eggs and larvae are particularly sensitive to changes in water depth, the average daily change was 0.5 inch and the maximum daily change was an increase of 1.6 inches when releases from Wickiup Reservoir ramped up at the beginning of the irrigation season. The maximum daily decrease in May was 1.3 inches when flows were reduced to accommodate changing irrigation demand. Net change in wetland water depth from late April to the end of May was an increase of 7 inches.

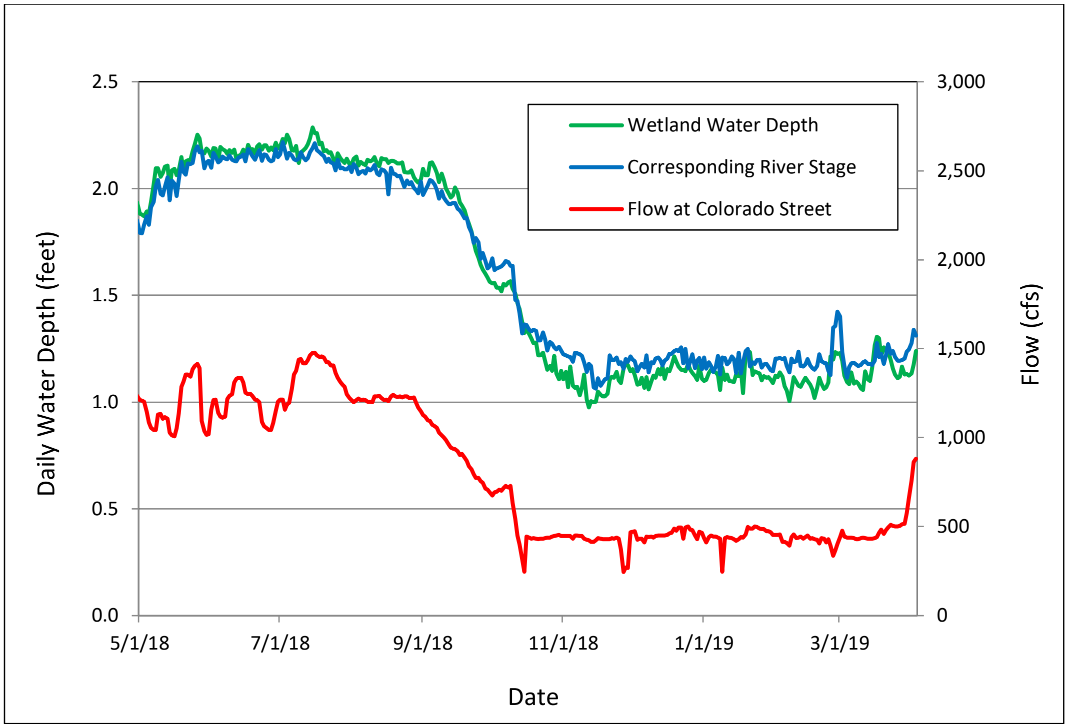


Figure 8-96. Trends in flow, river stage and wetland water depth in Deschutes River Reach 7 on a daily basis from April 27, 2018 to April 3, 2019.

Monitoring results showed a strong correlation between flow and wetland depth (Figure 8-97), although this relationship breaks down at certain flows and certain times of year, presumably due to the influence of the recreational dam. Within certain ranges of flow (such as 400 to 450 cfs and 1,000 to 1,400 cfs) river stage was observed to vary by as much as 0.4 foot (5 inches) for a given flow. Despite the influence of the manmade dam, the observed relationship in Figure 8-97 can be used to estimate wetland water depth at given flows with reasonable accuracy (coefficient of correlation = 0.921).

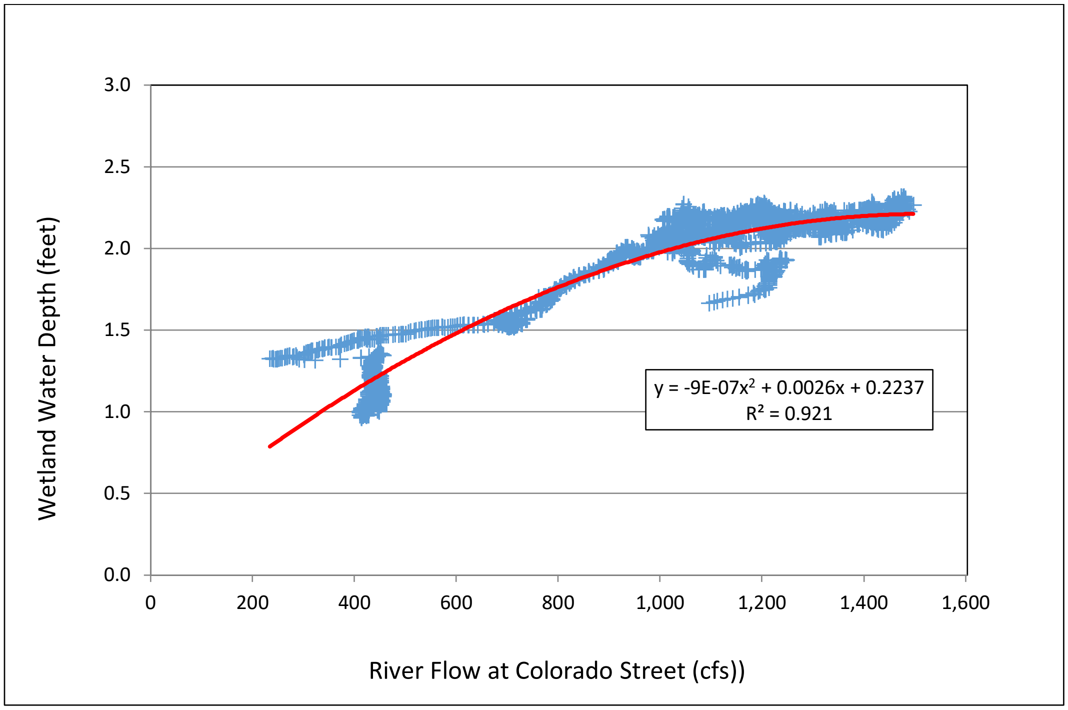


Figure 8-97. Relationship between river flow and wetland water depth in Deschutes River Reach 7 from April 27, 2018 to April 3, 2019.

The relationship between Deschutes River flow and water depth in the west bank wetland was used to predict wetland inundation levels under the DBHCP based on the flow predictions in Figure 8-95. As would be expected, median water depths in the wetland will increase during the fall and winter and decrease during the spring and summer compared to historical conditions (Figure 8-98). As minimum winter flows below Wickiup Dam increase over time under the DBHCP, the differences from historical wetland water depths will become more pronounced. The largest decreases in water depth during the first 12 years of DBHCP Implementation will occur in September, when the median depth will be about 3 inches lower than in the past. After Year 12, when irrigation storage will tend to be depleted earlier in the summer, wetland inundation levels will also decrease earlier in the summer, but the median water depth in July will still be within 2 inches of what it was historically. During the winter, median wetland water depths will increase 3.6 to 6.7 inches from historical levels. The largest increases will occur in November, which has historically been the month of lowest inundation. All differences will be small relative to total water depth, however, and the median water depth will still be at least 1.5 feet during all months except November, which will be only slightly less than 1.5 feet.

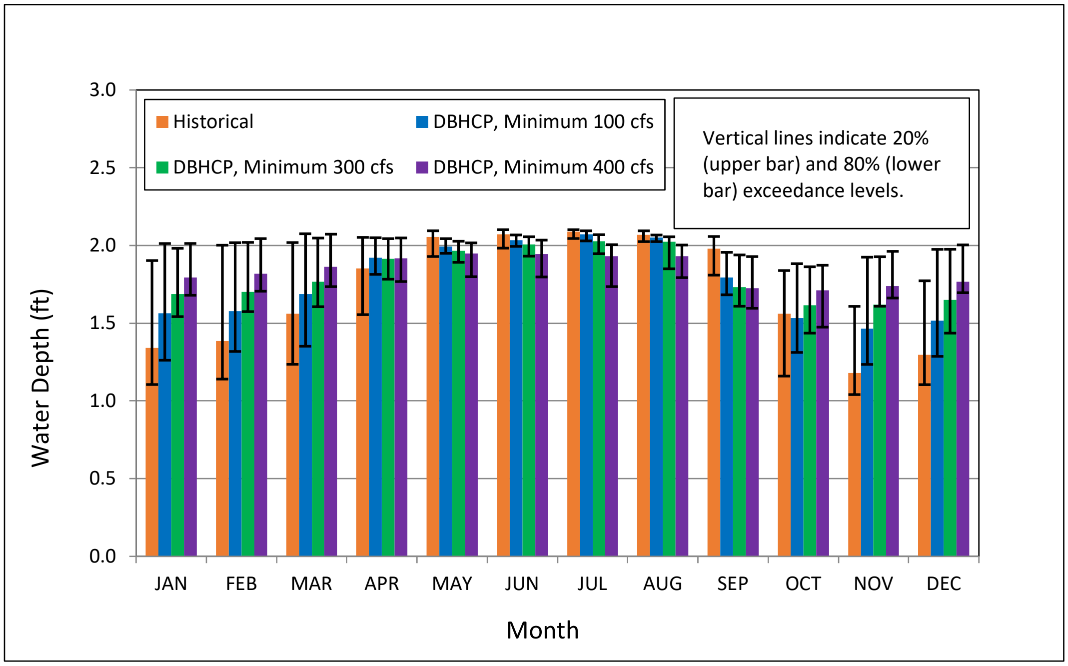


Figure 8-98. Monthly medians of estimated wetland water depth in the natural wetland at Colorado Street for historical (1981-2018) and DBHCP projected conditions.
Sources: OWRD 2020l, 2020m, 2020n; Reclamation 2020a.

Oregon Spotted Frog Overwintering

Conditions for Oregon spotted frog overwintering will improve in Reach 7 under the DBHCP due to increased wetland inundation levels. The west bank wetland has always retained water throughout the winter that could have supported overwintering frogs, but median inundation levels will increase roughly 4 to 7 inches under the DBHCP due to increased flows in the Deschutes River. The increased inundation will increase the useable area of the wetland slightly, and it will reduce the potential for the formation of anchor ice (complete freezing of the pond) during the coldest months of the winter. These changes should have a small positive effect on Oregon spotted frogs.

Oregon Spotted Frog Breeding

Breeding conditions for Oregon spotted frogs will improve in Reach 7 for two reasons. First, median water depth in the west bank wetland will increase up to 4 inches in March, thereby providing a small increase in potential breeding habitat. Second, water levels will be more consistent from day to day and year to year in March, April and May (see exceedance levels in Figure 8-98), thereby providing a more reliable source of breeding habitat. These changes may provide a small increase in breeding activity in the west bank wetland.

Oregon Spotted Frog Summer Rearing and Foraging

Water depths in the west bank wetland will be slightly lower under the DBHCP, but these changes will not be sufficient to appreciably alter habitat conditions for Oregon spotted frogs. Median water depth will remain above 1.5 feet throughout the summer, which is more than sufficient to maintain the open water component of the wetland and provide summer foraging habitat for Oregon spotted frogs.

8.4.3 Crescent Creek and Little Deschutes River

Overview

Crescent Lake Reservoir at RM 29 on Crescent Creek is the only covered activity in the Little Deschutes subbasin (Figure 8-99). Operation of the reservoir influences the timing and magnitude of streamflow in the lower 29 miles of Crescent Creek, the lower 57 miles of the Little Deschutes River, and 193 miles of the Deschutes River from its confluence with the Little Deschutes River to the Columbia River. The effects of operation are most apparent in Crescent Creek and the Little Deschutes River and are very small in the Deschutes River because the upper Crescent Creek watershed makes up only 3.2 percent of the Deschutes Basin above Benham Falls. The following evaluation of effects of Crescent Lake Reservoir operation therefore focuses on Crescent Creek and the Little Deschutes River. Any related effects downstream in the Deschutes River are included within the larger analyses of effects of the Upper Deschutes River reservoirs (Crane Prairie and Wickiup).

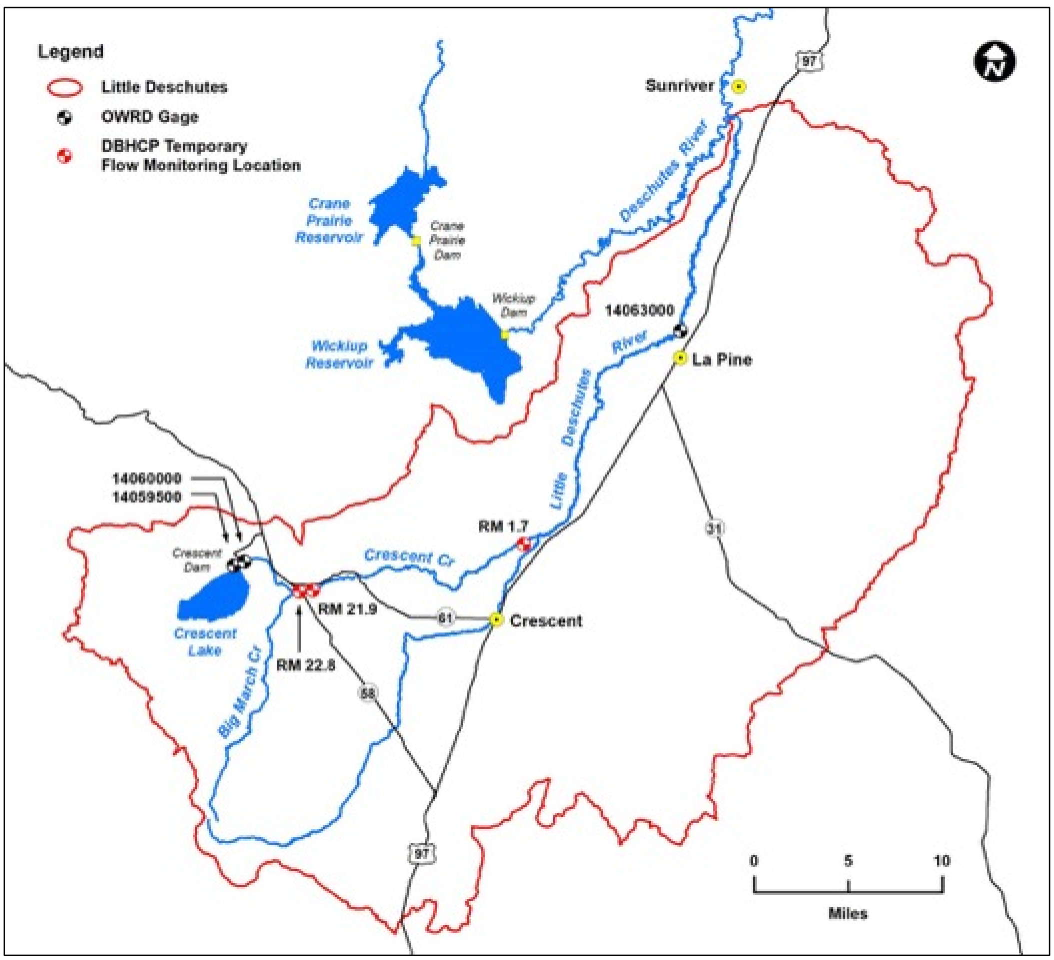


Figure 8-99. Map of the Little Deschutes River subbasin showing Crescent Creek and Crescent Lake Reservoir.

The analysis of effects for Crescent Creek and the Little Deschutes River compares future operation of Crescent Lake Reservoir under the DBHCP to natural (unregulated) flow conditions in Crescent Creek as well as flows under historical operation of the reservoir. As explained in Section 6.1.1, *DBHCP Approach to Minimization and Mitigation*, the comparison of the DBHCP to unregulated conditions is done to: a) illustrate the effects of the covered activities on Oregon spotted frogs in the subbasin and b) provide reference to the hydrologic potential of the covered waters (i.e., the limits of what can be done under the DBHCP). The comparison of the DBHCP to historical operations is done to demonstrate the benefits of the conservation measures in the DBHCP relative to continued operation of Crescent Lake Reservoir without the measures.

Crescent Lake Reservoir is operated to capture and store runoff from upper Crescent Creek in the fall, winter and spring (typically October through June) and release water from storage during the irrigation season (May through September, with peak months being July, August and September). This operation results in flows downstream of Crescent Dam that are lower than unregulated conditions during the storage season and higher than unregulated conditions during the irrigation season. Since water is stored over 9 months and released mostly over 3 months, the average reduction in flow during the storage season is roughly one-third the average increase in flow during the irrigation season. The summer increase in flow resulting from reservoir operation occurs at a time of year when unregulated flows in Crescent Creek and the Little Deschutes River would otherwise be at their lowest, thereby maintaining stream flows and wetland inundation levels that would not occur under natural conditions.

In addition to seasonal changes in flow, the presence of the reservoir moderates natural fluctuations that occur on a daily or weekly basis due to precipitation events and snowmelt. Conversely, when TID adjusts the outflow of Crescent Lake Reservoir to match irrigation demand, the flow downstream of the dam can change (increase or decrease) rapidly and the buffering effects of the reservoir can be negated, to the potential detriment of fish and wildlife.

Conservation Measure CC-1 will increase the minimum flow downstream of Crescent Dam to 10 to 12 cfs during the winter, depending on implementation phase (the previous minimum was 6 cfs). The increased winter flow will reduce annual storage in Crescent Lake Reservoir, and thus decrease the amount of water released during the irrigation season. Compared to historical operation of the reservoir, Oregon spotted frog habitats in lower Crescent Creek and lower Little Deschutes River will experience increases in water depth during the storage season and decreases in water depth during the irrigation season. Compared to unregulated conditions, however, median water depths will still be lower in the winter and higher in the summer under the DBHCP. Minimum water depths under the DBHCP will be higher than unregulated conditions in all seasons because the flow in Crescent Creek will not be allowed to go as low as it could naturally during dry conditions. This means the DBHCP will prevent extremely low wetland inundation levels along lower Crescent Creek and lower Little Deschutes River that could occur under natural (unregulated) conditions.

To preserve the existing benefits of reservoir operation to downstream habitats during the summer, Conservation Measure CC-1 will require a flow of at least 50 cfs below Crescent Dam at all times in July through September, and Conservation Measure CC-3 will restrict the annual ramp-down of releases to the months of September and October. TID’s irrigation demand is expected to require continued releases of storage from Crescent Lake Reservoir throughout the term of the DBHCP, but conservation projects by TID could reduce the amount of water needed in some months. Conservation Measure CC-1 will ensure that releases in July through

September will never drop below 50 cfs and ramp-down to winter flows will never occur before September. Without this measure, flows of less than 50 cfs in late summer and ramp-down before September 1 could eliminate summer habitats for Oregon spotted frogs prior to the time of year they have historically transitioned to overwintering. In addition, ramp-down after October 31 could drain habitats occupied by Oregon spotted frogs after they have selected them for overwintering and expose them to increased potential for freezing and/or desiccation.

Conservation Measure CC-1 also allocates a portion of the storage in Crescent Lake Reservoir to be used for Oregon spotted frog habitat management/enhancement (OSF storage). This water may be released in addition to required minimum flows and irrigation releases at any time of year to increase overall flow in lower Crescent Creek and lower Little Deschutes River. The hydrologic analysis described in Chapter 6 (Section 6.3.3.4, *Effects of DBHCP Measure CC-1 on Flow and Water Surface Elevation*) and evaluated here in Chapter 8 assumes the OSF storage would be released in early summer, prior to the irrigation season, to improve Oregon spotted frog summer rearing habitat. This is just one possible use of the OSF storage. Alternate uses of the OSF storage could include release during the winter to increase the minimum flow downstream of Crescent Dam above 10 cfs, and release in the fall to delay the drawdown of wetlands along lower Little Deschutes River.

Compared to historical operation of the reservoir the DBHCP will increase median creek and wetland water depths 0.3 to 1.8 inches during most of the storage season and decrease median water depths 0.6 to 1.3 inches during the irrigation season (see Section 6.3.3.4). The effects of these hydrologic changes on Oregon spotted frogs will be generally neutral. Differences of ±1 inch or less in median wetland depths during the fall, winter and early spring will result in very small changes to the total area of wetlands, the vegetative structure of wetlands, and the habitat suitability of wetlands associated with Crescent Creek and Little Deschutes River. Increased water depths (relative to unregulated conditions) in July through September have historically provided a benefit to Oregon spotted frogs by maintaining wetlands that would otherwise go dry during the summer. The DBHCP will continue to provide summer flows that are higher than the unregulated condition, but flows will be slightly less and water depths in the wetlands will be reduced up to 1.8 inches from historical conditions. If these changes have negative impacts on Oregon spotted frogs, the impacts can be eliminated through timed release of the OSF storage. Regardless of the use of the OSF storage, however, the minimum flow requirements of the DBHCP will eliminate extremely low flows that could otherwise occur at all times of year. This will reduce the potential for Oregon spotted frog reproductive failure and/or mortality during drought years.

Habitat Conditions

Oregon spotted frog habitats along lower Crescent Creek and lower Little Deschutes River are affected by operation of Crescent Lake Reservoir. The 29-mile affected reach of Crescent Creek supports an estimated 1,882 acres of vegetated wetlands, while the 57-mile affected reach of the Little Deschutes River supports 3,322 acres (see Chapter 5, Table 5-13). Emergent wetlands comprise about 34 percent of Crescent Creek vegetated wetlands and 55 percent of Little Deschutes vegetated wetlands in the affected reaches (R2 and Biota Pacific 2018). Density of emergent wetlands in the reaches is 17 acres per mile for Crescent Creek and 34 acres per mile for Little Deschutes River. Most wetlands in these reaches have not been investigated in detail and a large number are located on private lands. Three occupied wetlands along Crescent Creek (RM 22.8, RM 21.9 and RM 1.7) are used as indicators of the effects of operation of Crescent Lake Reservoir. The occupied wetlands at RM 22.8 (Figure 8-100) and RM 21.9 (Figure 8-101) have surface connections to the creek, but they lie outside the main creek channel and are influenced to varying degrees by local runoff and groundwater discharge. Trends in water surface elevation at these wetlands in 2015 are shown in Figure 8-102. The occupied wetland at RM 1.7 (Figure 8-103) is directly associated with the creek and fluctuates in surface elevation in unison with the creek.

Figure 8-100. Wetland occupied by Oregon spotted frogs at RM 22.8 on Crescent Creek.

Figure 8-101. Wetlands occupied by Oregon spotted frogs at RM 21.9 on Crescent Creek.

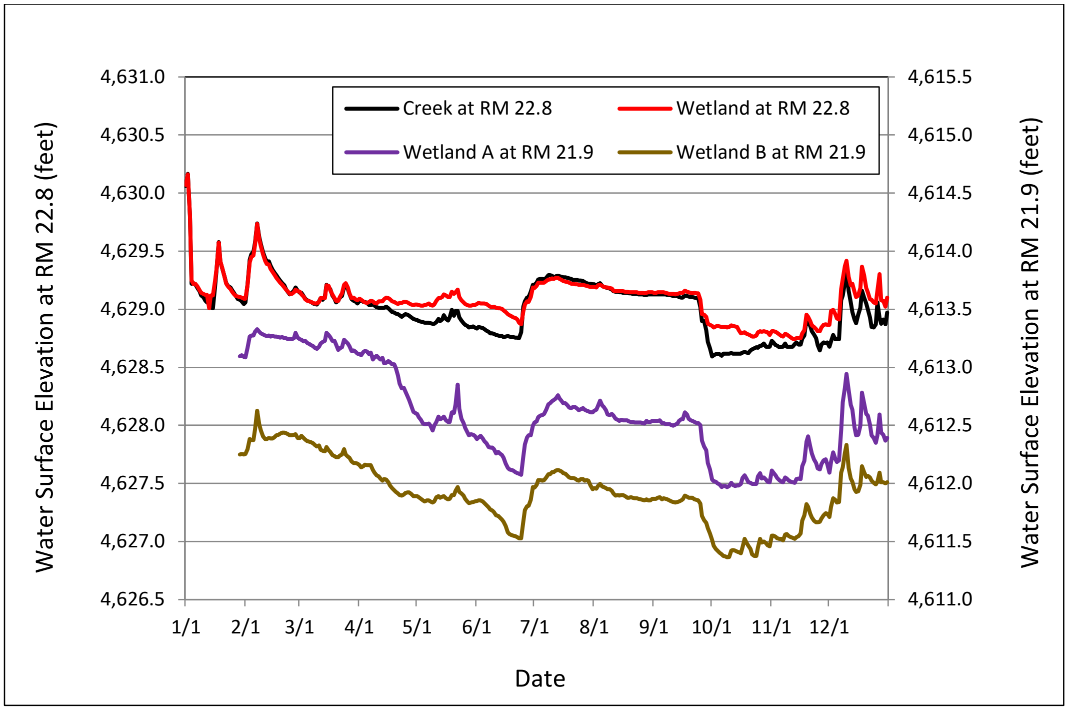


Figure 8-102. Daily average water surface elevations in wetlands associated with Crescent Creek at RM 22.8 and RM 21.9 in 2015. Source: R2 and Biota Pacific 2016.

Figure 8-103. Wetland occupied by Oregon spotted frogs at RM 1.7 on Crescent Creek.

In 2015, water levels in the wetland at RM 22.8 tracked directly with the creek until early April and showed spikes equal to those in the creek throughout the winter and early spring (Figure 8-102). From April through June and October through November the recorded water surface elevation of the RM 22.8 wetland was higher than that of the creek, but the wetland continued to show brief spikes in surface elevation directly proportional to those in the creek. This difference in elevation between the wetland and the creek is an artifact of gage location; the gage in the creek was located slightly downstream of (and thus slightly lower in elevation than) the gage in the wetland. Water enters the wetland from the creek a short distance upstream of the creek gage site and flows back into the creek near the gage. Throughout the year, the water surface elevation in the wetland is influenced by the water surface elevation in the creek on a daily basis. The wetland does not appear to retain water from peak events; rather, it drops in elevation immediately whenever the creek drops.

Two small wetlands were monitored at RM 21.9. Wetland A is within 150 feet of the creek and has a direct surface connection to the creek most of the year. Wetland B is roughly 200 feet from the creek and has a surface connection only during high flows. Crescent Creek flow does not change significantly between RM 22.8 and RM 21.9 (Gannett et al. 2001), so trends in water surface elevation of the creek at RM 22.8 serve as a general indicator of trends at RM 21.9 as well. When compared to water surface elevations in the creek, both wetlands at RM 21.9 stayed high longer than the creek in the spring of 2015, but fluctuated in direct response to the creek during the summer and fall (Figure 8-102). This suggests the wetlands were influenced primarily by local snowmelt and/or groundwater discharge in the spring that kept water levels higher than in the creek, and not by periodic flood flows. Neither wetland showed any sign of retaining water associated with periodic high flows in the creek. Overall, the 2015 data suggest the effects of reservoir management on wetland water surface elevations at RM 21.9 are comparable to those estimated for the creek at RM 22.8. It is possible the effects of reservoir management may be ameliorated at the RM 21.9 wetlands by local snowmelt and/or groundwater discharge in the spring, but there are insufficient data to conclude this.

The relative effects of reservoir management described for Crescent Creek at RM 22.8 are applicable to the wetlands at RM 22.8 and RM 21.9. When compared to unregulated conditions, DBHCP median water surface elevations in the wetlands will be 0.5 to 1.2 inches lower from November through May and 4.7 to 5.4 inches higher in July through September (Figure 8-104). Median water surface elevations will be 0.2 inch higher in June and no different from unregulated flows in October. Compared to historical conditions, the DBHCP will result in higher water surface elevations in the wetlands in all months except July through September. Low water surface elevations (80 percent exceedance levels) will be higher for the DBHCP than for unregulated and historical conditions in all months because extreme low flows will be eliminated by the requirement to maintain a minimum flow of 10-12 cfs. At the same time, fluctuations in wetland water surface elevation between seasons and within months (as indicated by 20 percent and 80 percent exceedance levels in Chapter 6, Figure 6-46) will be less under the DBHCP than unregulated conditions due to the dampening effect of Crescent Lake Reservoir. Fluctuations during the breeding season (March – April) could be reduced by half.

Under the DBHCP, the wetland at RM 1.7 will track directly with the creek. Median water surface elevation under the DBHCP will be 0.2 to 1.4 inches lower than unregulated levels in November through June (Figure 8-105). From July through September the DBHCP levels will be 6.1 to 6.7 inches higher than unregulated, and in October the increase will be only 0.5 inch.

Similar to RM 22.8 and RM 21.9, the 80 percent exceedance water surface elevations at RM 1.7 under the DBHCP will be higher than unregulated and historical conditions for all months.

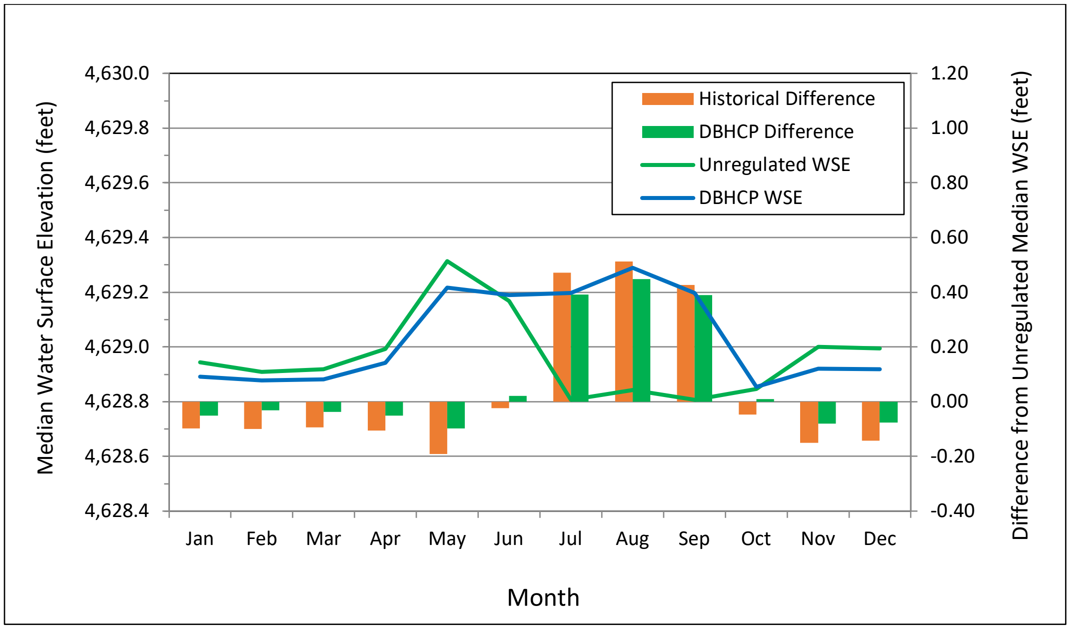


Figure 8-104. Median water surface elevation (WSE) of Crescent Creek at RM 22.8 from 1984 through 2015 for unregulated and projected DBHCP conditions (bar graphs show historical and DBHCP differences from the .unregulated median). Sources: R2 and Biota Pacific 2016, Reclamation 2020a.

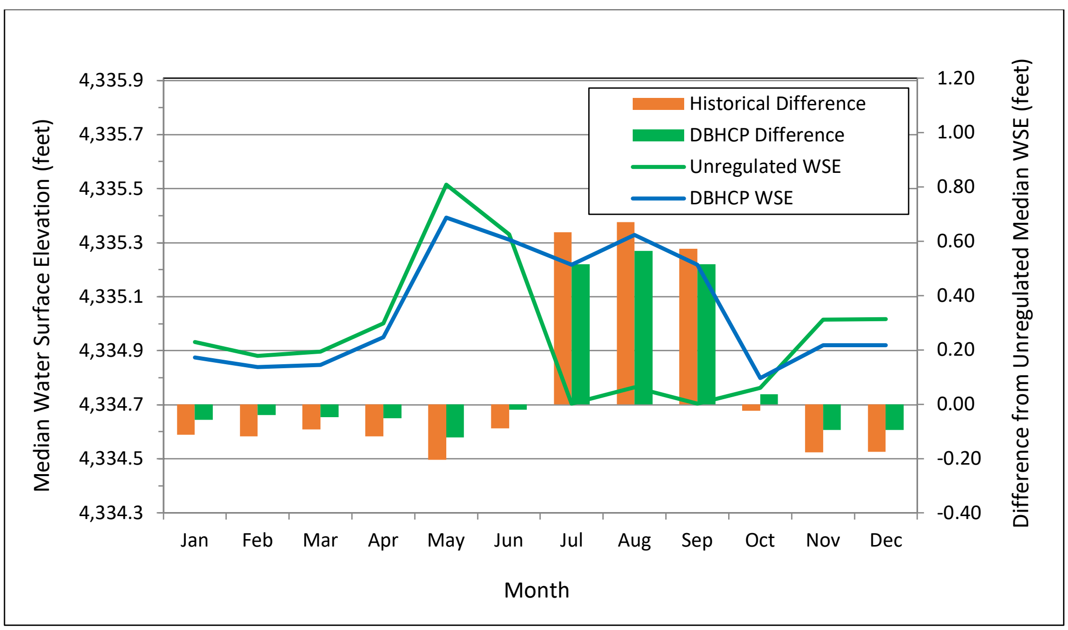


Figure 8-105. Median water surface elevation (WSE) of Crescent Creek at RM 1.7 from 1984 through 2015 for unregulated and projected DBHCP conditions (bar graphs show historical and DBHCP differences from the unregulated median). Sources: R2 and Biota Pacific 2016, Reclamation 2020a.

The monitored wetlands on Crescent Creek make up only a portion of the potential Oregon spotted frog habitat between RM 22.8 and the mouth, but they are considered representative of the majority of potential habitat. The wetland at RM 1.7 is representative of wetlands that lie in calm backwaters directly within the main creek channel, although it is probably larger than most. The wetlands at RM 21.9 represent those with surface connections to the creek that are also influenced by local sources of water that dampen or ameliorate the effects of changes in creek flow. The wetland at RM 22.8 characterizes off-channel wetlands with direct surface connection to the creek and little or no influence from local runoff.

The changes in water surface elevation (wetland water depth) caused by operation of Crescent Lake Reservoir under the DBHCP are not expected to cause measurable reductions in the quantity or quality of habitat for Oregon spotted frogs. The Crescent Creek floodplain is relatively confined and the associated wetlands are relatively steep-sided (Figures 8-115, 8-116 and 8-118). The small anticipated changes in total water depth translate to very small changes in total wetted area, while the reductions in short-term fluctuation of water depth will be beneficial during months when Oregon spotted frogs occupy the shallow margins of the wetlands.

Oregon Spotted Frog Overwintering

Overwintering by Oregon spotted frogs in the Little Deschutes basin occurs typically from November through March. Compared to unregulated conditions, the DBHCP will represent a reduction of 1.4 inches or less in median water depth (Figures 8-104 and 8-105), and an increase of at least that magnitude in the 80 percent exceedance water depth of occupied wetlands during overwintering. Compared to historical conditions (recent operation of the reservoir), the DBHCP will represent an increase in both the median and the 80 percent exceedance levels for water depth during overwintering. This means average water depths in these wetlands will be roughly 1 inch or less below where they would be without the reservoir, but up to 1 inch higher than they have been over the past several decades. In addition, extremely low water levels will be much less frequent under the DBHCP than they would be in the absence of the reservoir, or as they have been in previous years with operation of the reservoir, because the minimum flow below the dam will never drop below 10-12 cfs.

Oregon spotted frogs have been generally shown to overwinter in wetlands up to 1.11 meter (42 inches) deep (Hayes et al. 1997) with surface water connections to streams and springs (Hayes et al. 2001). Deep, calm backwater wetlands along Crescent Creek and Little Deschutes River, such as those at RM 22.8 and RM 1.7, meet this definition and are likely to support overwintering. A reduction of 1 inch or less in the median depth of these wetlands will not alter their ability to support overwintering or threaten the Oregon spotted frogs present during the winter. As indicated in Figures 6-40 and 6-41, water depths in Crescent Creek can fluctuate 1 foot or more during the winter, even with the dampening effects of Crescent Lake Reservoir. A shift of 1.1 inch or less in the median water surface elevation will not produce a meaningful change in the total area of wetlands, reduce the depth of wetlands to a degree that is likely to impact their quality, or cause wetlands to become disconnected from the creek at any greater frequency than unregulated or historical conditions. However, the reduced frequency of extremely low flows under the DBHCP will reduce the likelihood for wetlands to become shallow and/or isolated from the creek or cause Oregon spotted frogs to experience desiccation, freezing and/or hypoxia during dry winters.

Flows and water levels in Crescent Creek and Little Deschutes River can fluctuate widely during the winter in response to storms (see Chapter 6, Figures 6-34 through 6-37). The effects of these fluctuations on Oregon spotted frogs have not been studied, but they are unlikely to be substantial because the frogs are generally inactive at the bottoms of deep wetland pools from November through February (Hayes et al. 2001; Cushman and Pearl 2007). Impacts could occur, however, if flood flows reached sufficient magnitude to scour occupied wetlands. The magnitude of flood flow required to scour an occupied wetland would be highly site-specific and would depend on the depth and location of the wetland relative to the main channel of the creek. Oregon spotted frogs overwintering directly within the main channel of Crescent Creek or Little Deschutes River could be dislodged by even modest increases in flow. Frogs overwintering in floodplain wetlands away from the main channels might not experience any potential for scouring, and could benefit from the periodic inundation provided by floods.

When a flood event threatens to exceed the capacity of Crescent Lake Reservoir, flows below the dam will be increased as needed to prevent overtopping. This is anticipated to be an infrequent event under the DBHCP because of the increased releases of storage for Oregon spotted frogs. When it does occur, however, Measure CC-2 will limit the rate at which the releases can be increased to 30 (±2) cfs per 24-hour period. Since natural flood flows in the creek typically increase much faster than this (as much as several hundred cfs per day), the effect of Measure CC-2 will be to decrease the downstream magnitude of floods and spread the hydrologic effects of floods out over several days. This will reduce the potential for scouring of occupied wetlands, while allowing the beneficial effects of floods, such as inundation of floodplain wetlands, to continue.

Oregon spotted frogs in the Deschutes Basin enter the overwintering phase between late September and early November (Chelgren et al. 2008; Bowerman pers. comm. 2016; Pearl et al. 2018). During the winter the frogs' activity levels are greatly reduced and they spend most of their time in or near the muddy bottoms of wetlands. They have been observed overwintering in wetlands up to 42 inches deep in Washington, where they made mid-winter movements apparently in search of higher dissolved oxygen levels (Hayes et al. 2001). Small decreases in water levels during the winter probably don't impact overwintering Oregon spotted frogs because the deep waters they typically occupy would remain inundated after a drop of a few inches or less. Larger decreases in water level, however, could increase the potential for direct exposure (complete loss of water above the overwintering site), freezing of the entire pond, and/or disconnection of a pond from flowing waters that provide oxygen and/or facilitates movement during the winter.

Unregulated water surface elevations in lower Crescent Creek and lower Little Deschutes River would typically reach their lowest levels of the year in July or August. However, historical irrigation releases from Crescent Lake Reservoir, which will continue under the DBHCP, will keep wetlands inundated through late summer and water surface elevations will not reach their annual low until October. After October, unregulated and historical water surface elevations generally remained constant until spring or increased in response to fall and winter precipitation; and this will continue under the DBHCP. This means that overwintering Oregon spotted frogs are unlikely to experience water levels lower than those at the time they selected overwintering sites between late September and early November. Without Measure CC-3, this could change if the operating regime of Crescent Lake Reservoir were modified to delay the ramp-down of irrigation releases into November. Such a change could result in frogs selecting overwintering sites that would become exposed and/or isolated when water levels continued to drop. Measure CC-3 will eliminate this possibility by requiring that the ramp-down of irrigation releases be completed no later than October 31.

Oregon Spotted Frog Breeding

In Crescent Creek and the Little Deschutes River, Oregon spotted frog breeding can begin as early as mid-March and incubation of eggs can continue until early May. For several weeks after emergence, tadpoles have limited mobility and spend most of their time in the cover of submerged vegetation at or very near the site of incubation. Throughout this time (from egg deposition through early tadpole development) the young are highly susceptible to fluctuations in water surface elevation. Compared to unregulated conditions, DBHCP median water depths in Crescent Creek wetlands will be 0.5 to 0.6 inch lower in March, 0.6 inch lower in April, and up to 1.4 inches lower in May (Figures 8-104 and 8-105). These are very small differences that are not expected to produce measurable changes in breeding habitat. Compared to historical conditions, DBHCP water depths will be higher in all 3 months. Under all flow scenarios (unregulated, historical and DBHCP) water depths increase from March through May and fluctuate up to 6 inches within months due to spring snowmelt and rainfall. Operation of the reservoir under the DBHCP will result in a more constant flow below the dam that will dampen short-term fluctuations in water depth. In addition, the frequency of extremely low water levels in March and April will be reduced by the release of at least 10-12 cfs from the reservoir at all times. This will reduce the potential for breeding failure during dry years.

Overall, the effects of reservoir operation on Oregon spotted frog breeding in Crescent Creek and Little Deschutes River will be neutral or positive. A reduction in median water depth of up to 0.6 inch, compared to unregulated conditions, at the beginning of the breeding season may reduce the area of breeding wetlands slightly, but it will simply represent a shift in the shallow breeding zone toward the center of each wetland. Water depths in Crescent Creek wetlands vary by several inches annually in response to weather conditions, and vegetated substrates sought by breeding adults typically extend to depths of over 1 foot. Consequently, a shift of 1.4 inches or less in median water depth from unregulated conditions will still be within the range of water depths that has occurred historically, and it will not move shallow waters away from suitable substrate conditions. In fact, breeding season water depths under the DBHCP will represent increases from historical conditions, so although they may be lower than unregulated conditions they will remain well within the range of conditions Oregon spotted frogs have successfully bred in for several decades.

Concurrent with increases in water depth during the breeding season (relative to historical conditions), operation of the reservoir under the DBHCP will continue to reduce the amplitude of fluctuations in water depth that occur naturally. Oregon spotted frog eggs are notably susceptible to fluctuations in water depth because they are deposited in shallow waters (Licht 1974). Throughout the range of the species, natural fluctuations in water depth during the breeding season have been cited as a primary limiting factor for reproduction (Hallock 2013). By continuing to reduce the amplitude of these fluctuations, reservoir operation under the DBHCP will continue to have a positive effect on Oregon spotted frog breeding in Crescent Creek and the Little Deschutes River.

Oregon spotted frogs can be impacted in two ways by flow fluctuations during the breeding season. First, a sudden and substantial decrease in flow during egg development can strand eggs out of water. Oregon spotted frogs deposit eggs in waters where they are characteristically vulnerable to receding water levels (Licht 1974). Decreases in water levels of 2 inches or more during incubation can cause eggs at the shallow edges of wetlands to become desiccated and fail to develop. The second potential for impact occurs when flows increase to the point that calm waters containing free-floating egg masses and young larvae become flowing waters that flush eggs and tadpoles downstream.

Under the DBHCP, flows below Crescent Dam will be constant (10-12 cfs) during March through May of most years. Flows could increase during these months in some years if TID requires release of storage prior to June, but this is not expected to occur on a regular basis. At the same time, flows from other tributaries such as Big Marsh Creek and upper Little Deschutes River will show typical fluctuations in response to rain events and periods of alternating warm and cold weather. The net result will continue to be fluctuating flows in downstream reaches occupied by Oregon spotted frogs, but the magnitude of those fluctuations will be reduced by the operation of the reservoir. When releases from Crescent Lake Reservoir are held constant at 10-12 cfs, the downstream waters will be buffered from natural flow fluctuations occurring upstream of the dam. This will reduce the potential for stranding and flushing of eggs and tadpoles compared to unregulated conditions. When releases are increased to meet irrigation demands, the maximum rate of increase will be 30 (±2) cfs per 24-hour period. If it becomes necessary to decrease releases from the reservoir (an unlikely event in the spring), the maximum rate of decrease will be 20 (±2) cfs per 48-hour period.

Oregon Spotted Frog Summer Rearing and Foraging

Oregon spotted frog juveniles and adults spend much of the summer months in deep, perennial, moderately-vegetated wetland pools (Watson et al. 2003), but they are also known to utilize meadow habitat during wet conditions (Licht 1986, Pearl and Hayes 2001). Direct surface connections from summer habitat to breeding and overwintering habitats are important for this highly-aquatic species (Hallock 2013). The wetlands at RM 22.8, RM 21.9 and RM 1.7 on Crescent Creek all support adult and juvenile Oregon spotted frogs during the summer. Numerous wetlands along the Little Deschutes River are also known to be inhabited by the frogs during the summer.

The overall effect of Crescent Lake Reservoir operation has been and will continue to be an improvement of summer habitat for Oregon spotted frogs in lower Crescent Creek and lower Little Deschutes River. Under natural (unregulated) conditions, flows in Crescent Creek and the Little Deschutes are quite low in the late summer. The hydrology of the Little Deschutes River basin (including the Crescent Creek subbasin) is dominated by snowmelt in the spring. Unregulated flows rise rapidly from March through May and drop to annual lows in July through September (see Chapter 6, Figures 6-34 through 6-37). Unregulated monthly median water surface elevations in lower Crescent Creek can drop as much as 9 inches from May to July (see Chapter 6, Figures 6-46 and 6-47). Under these conditions, many of the perennial wetland pools currently known to support Oregon spotted frogs would become seasonally dry in the summer or would be significantly reduced in size. Some historically perennial wetlands could also lose surface connections with breeding and overwintering habitats.

The DBHCP will continue the historical pattern of offsetting naturally-low summer flows downstream of Crescent Dam, but median wetland water depths under the DBHCP could be as much as 2 inches lower than historical levels in July through September as a direct result of increased flows (reduced storage) during the winter. These reductions in summer flows are not expected to have adverse effects on Oregon spotted frogs, however, because flows and associated wetland water depths will still be at their annual high points during the months of July through September.

The largest rate of increases in flow in Crescent Creek will occur from April to May, due largely to natural increases in runoff in Big Marsh Creek and other unregulated tributaries. There may also be increases in outflow from Crescent Lake Reservoir during May to meet irrigation demand, although storage will continue through June in most years. When water is released from the reservoir, flow increases attributable to reservoir operation can be as much as 30 (±2) cfs per 24-hour period, which equates to as much as 3 inches in water surface elevation per day in occupied wetlands. In May, these could be concurrent with natural flow increases. Rapid increases early in May could be detrimental to larval Oregon spotted frogs that have only recently emerged from eggs are have limited mobility. Increases in late May, June and July will have less effect on summer rearing and foraging because the increases will occur well after eggs have hatched and tadpoles have been growing for 1 month or more. Tadpoles, juveniles and adults will be physically capable of moving within wetlands to seek preferred depths as water levels rise. Any negative effects of increasing irrigation releases will be offset by the positive effects of maintaining more overall habitat for rearing and summer foraging than would otherwise be present with unregulated flows.

Under normal operation, irrigation releases from Crescent Lake Reservoir will cease at the end of the irrigation season in late September or early October, and the flow below Crescent Dam will be reduced from 100 cfs or more to the allowable minimum of 10-12 cfs after September 30. A decrease of 100 cfs can result in a drop in water surface elevation of as much as 10 inches. Measure CC-2 limits the rate at which flows can be decreased to 20 cfs per 48-hour period, which is equivalent to a decrease of about 1 inch in water surface elevation per day.

Rapid decreases in water levels at the end of the irrigation season create the potential for stranding of juvenile and adult frogs in isolated pools before they can migrate to overwintering sites. The majority of Oregon spotted frog tadpoles will have completed metamorphosis by the end of August, but juvenile and adult frogs will be present in wetlands that will experience decreases in water depth. As a precautionary measure, the rate of decrease in the fall under the DBHCP will be limited to roughly 2 inches per two-day period to allow frogs to complete necessary movements. Given the possibility that frogs may prefer to make movements at night (Bowerman pers. comm. 2016), Measure CC-2 will allow for at least one night between incremental decreases of 2 inches.

Oregon spotted frog juveniles and adults spend summer months in and near perennial, moderately-vegetated wetland pools (Watson et al. 2003). Throughout the range of the species, including the upper Deschutes Basin, water levels in rearing and foraging habitats recede in late summer, requiring frogs to relocate to maintain preferred water depths. For unregulated conditions in Crescent Creek and Little Deschutes River, this recession would occur in July and August as annual snowmelt runoff ends. As the wetted area and depth of summer habitats decrease, Oregon spotted frogs must move to deeper portions of those habitats or relocate to persistent ponds for overwintering. Direct surface connections from summer habitat to overwintering habitat are important due to the highly-aquatic nature of the species (Hallock 2013). Juvenile and adult Oregon spotted frogs in the upper Deschutes Basin are believed to move at least short distances to seek wetted habitat as water levels recede in the fall, but tadpoles that have not complete metamorphosis do not have this option. If water levels recede prior to the completion of metamorphosis, which lasts into July or later for most Oregon spotted frogs in the upper Deschutes Basin, the result can be mortality. At the very least, decreases in the quantity and quality of rearing and foraging habitat in mid-summer can reduce the overall ability of the landscape to support Oregon spotted frogs. Tadpoles, juveniles and adults alike can become concentrated in smaller ponds where they compete for food resources and become more vulnerable to predation.

Under historical conditions in lower Crescent Creek and lower Little Deschutes River the period of inundation of summer rearing and foraging habitats has been extended through September. This has allowed Oregon spotted frogs of all life stages to remain in those wetlands until most tadpoles have completed metamorphosis and adults and juveniles alike begin to seek overwintering sites. The total area of rearing and foraging habitat in late summer has been increased by the operation of the reservoir, and mortality of tadpoles has likely decreased.

TID's overall demand for storage will go down over time due to its conservation projects, but TID will still require the release of water from Crescent Lake Reservoir on a regular basis. In most years under the DBHCP the demand for irrigation water from Crescent Lake Reservoir will continue into September and flows will remain high enough to inundate the wetlands in lower Crescent Creek and Little Deschutes River where Oregon spotted frogs summer. In the event that irrigation demand ends early, however, Conservation Measure CC-1 will require the continued release of at least 50 cfs from Crescent Lake Reservoir through September. This will provide more overall summer rearing and foraging habitat than would be present if flows were allowed to drop to winter levels in September, and it will maintain those conditions until most Oregon spotted frog tadpoles have completed metamorphosis and are capable of at least short overland movements when water levels recede in the fall. If the 50-cfs minimum flow is not sufficient for frogs to successfully transition from summer to overwintering habitats, water from OSF storage in Crescent Lake Reservoir can be used to extend the summer releases and/or decrease the rate of ramp-down. This is anticipated to be the most likely use of OSF storage because observations in recent years have suggested frogs may need additional time in their summer rearing habitat in late September before they transition to overwintering sites.

8.4.4 Summary of Effects on Oregon Spotted Frogs

Oregon Spotted Frog Overwintering

The effects of the DBHCP on Oregon spotted frogs will vary by location and by season within the covered lands, but some general trends will occur (Table 8-43). Overwintering habitat for Oregon spotted frogs will improve or remain the same in most areas affected by the covered activities, with a few notable exceptions. Conditions for overwintering will improve in Crane Prairie Reservoir, the Deschutes River from Wickiup Dam to Benham Falls (Reaches 1, 2 and 3 in Figure 8-85) and the Deschutes River from Central Oregon Canal to Colorado Street (Reach 7); all due to increased inundation of wetlands during the winter. Improvements in overwintering habitat will be most pronounced in Crane Prairie Reservoir because emergent wetlands that were historically dry in the winter will now remain inundated year round. Flows in Crescent Creek and the Little Deschutes River will be increased from those that occurred prior to 2015, but will be slightly less than those that occurred from 2015 through 2020. Overall, however, the differences between historical, recent and future DBHCP conditions in Crescent Creek and Little Deschutes River during the winter will be negligible because the resulting differences in wetland inundation will be roughly 1 inch or less; this amount will be imperceptible to overwintering frogs. Improvements along the Deschutes River will be modest because new inundation levels will reach only to the main channel of the river and some unvegetated riverine oxbows. Winter flows will not be sufficient to reach emergent (sedge) wetlands.

Table 8-43. Trends in Oregon spotted frog habitat conditions in the upper Deschutes Basin under the Deschutes Basin HCP, by life stage.

Area/Reach Affected by the DBHCP	Oregon Spotted Frog Life Stage			
	Overwintering	Breeding	Summer Rearing and Foraging	Movement to Overwintering
Crane Prairie Reservoir	↑	↑	↑	↑
Deschutes River: Crane Prairie Dam to Wickiup Reservoir	≈	≈	≈	≈
Wickiup Reservoir	↓	↓	↓	↓
Deschutes River: Wickiup Dam to Fall River	↑	↑	?	?
Deschutes River: Fall River to Little Deschutes River	↑	↑	?	?
Deschutes River: Little Deschutes River to Benham Falls	↑	↑	↑	?
Deschutes River: Benham Falls to Dillon Falls	≈	↑	≈	≈
Deschutes River: Dillon Falls to Lava Island	≈	↑	≈	≈
Deschutes River: Lava Island to Central Oregon Diversion	↑	↑	≈	↑
Deschutes River: Central Oregon Diversion to Colorado Street	↑	↑	≈	≈
Crescent Creek: Crescent Dam to Mouth	≈	↑	↑	↑
Little Deschutes River: Crescent Creek to Mouth	≈	↑	↑	↑

Legend:
↑ indicates increase in habitat quality
↓ indicates decrease in habitat quality
≈ indicates no substantive change in habitat quality
? indicates effects to habitat quality uncertain

Conditions for overwintering will remain roughly the same along the Deschutes River from Benham Falls to Central Oregon Diversion (Reaches 4, 5 and 6 in Figure 8-85) because the winter flow increases under the DBHCP will not be of sufficient magnitude to materially increase the quantity or improve the quality of aquatic habitats.

Overwintering habitat will decrease within Wickiup Reservoir and the free-flowing reach of the Deschutes River between Wickiup Reservoir and Crane Prairie Dam. Conditions will deteriorate in Wickiup Reservoir because it will be consistently lower (with less storage volume) during the winter than it was historically. Lower storage volumes will confine overwintering frogs to a smaller area with less substrate vegetation, making them increasingly vulnerable to predation. Conditions in the Deschutes River reach upstream of the reservoir will decline because flows will be lower throughout the winter due to the need to begin storing water in Crane Prairie Reservoir almost immediately after the end of the irrigation season each October.

The net effect of the DBHCP on overwintering Oregon spotted frogs in the upper Deschutes Basin will be positive because the area with the greatest anticipated improvement (Crane Prairie Reservoir) is the area with the highest concentrations of habitat and highest numbers of known Oregon spotted frogs on the covered lands. Based on recent survey data and associated estimates of the numbers of breeding females (USFWS 2019a) Crane Prairie Reservoir supports roughly 62 percent of the known Oregon spotted frogs on the covered lands. Using the highest number of egg masses reported by USFWS (see Chapter 5, Table 5-12) at each known site on the covered lands (excluding managed wetlands at Sunriver) from 2016 to 2019, the estimated minimum number of adult females in the upper Deschutes Basin (including the Little Deschutes and Crescent Creek subbasin) is 1,482. Of these, 915 adult females were reported from sites directly influenced by the covered activities at Crane Prairie Reservoir. As water levels in Crane Prairie Reservoir remain higher and more stable during the winter under the DBHCP, the number of adults supported by the reservoir is anticipated to increase. More importantly, the area with historically low numbers of overwintering Oregon spotted frogs (Deschutes River from Wickiup Dam to Bend) is expected to show improvement as well due to substantial increases in winter flows under the DBHCP.

Oregon Spotted Frog Breeding

Breeding conditions for Oregon spotted frogs will improve on all covered lands except Wickiup Reservoir and the reach of the Deschutes River between Crane Prairie Dam and Wickiup Reservoir (Table 8-43). Improvements will be due to a) increased flows and associated wetland inundation levels at the beginning of the Oregon spotted frog breeding season and b) reduced fluctuation in flows during the breeding season. Oregon spotted frogs on the covered lands will have greater access to preferred breeding habitats (shallowly inundated emergent wetlands) and they will be less exposed to fluctuations in water level that can lead to stranding, desiccation or flushing. The improvements will be most pronounced at Crane Prairie Reservoir where habitat conditions will be consistently favorable for breeding in all years. Improvements on Crescent Creek and Little Deschutes River will be more subtle because conditions are already conducive to breeding along both waters. Improvements along the Deschutes River will vary by reach, but will be greatest in the reaches with the largest known numbers of Oregon spotted frogs (Reaches 1 and 4 in Figure 8-85).

Breeding conditions in Wickiup Reservoir will deteriorate under the DBHCP because water levels (storage volumes) will be consistently lower at the onset of breeding and they will drop faster during egg and larval development than they did historically. Frogs attempting to breed in

Wickiup Reservoir will have to utilize marginal habitats, and their eggs and larvae will be consistently exposed to elevated risk of desiccation, freezing and predation. Breeding conditions along the Deschutes River between Crane Prairie Dam and Wickiup Reservoir will be hampered by flows that are lower and more variable from day to day than they were in the past. Flows in this reach will be dictated by the need to hold water levels in Crane Prairie Reservoir relatively constant as inflows to the reservoir fluctuate. Natural fluctuations in reservoir inflow during spring storms and snowmelt, which were historically held in Crane Prairie Reservoir for irrigation storage, will now be passed downstream to Wickiup Reservoir. The result will be that the reach of Deschutes River between the reservoirs will see considerably more fluctuation in flow and depth during the breeding season.

Oregon Spotted Frog Summer Rearing and Foraging

Summer rearing and foraging habitat for Oregon spotted frogs will improve on some of the covered lands, remain constant on lands that are already suitable, and deteriorate slightly on others (Table 8-43). Improvements will be most apparent in Crane Prairie Reservoir where water levels will be managed to maintain suitable conditions through the completion of larval development in late summer. Current suitable conditions will be maintained along Crescent Creek and Little Deschutes River due to the continued release of irrigation water from Crescent Lake Reservoir through September.

Deteriorating conditions will occur in Wickiup Reservoir for the term of the DBHCP, and constant or slightly deteriorating conditions will occur in most reaches of the Deschutes River on a temporary basis. Summer rearing and foraging habitat in Wickiup Reservoir will deteriorate because the storage volume in the reservoir will be consistently low by mid-summer. Summer rearing along the Deschutes River may also be impacted by flows lower than those needed to keep wetlands inundated throughout the summer in some years. Flows will be sufficient to keep wetlands inundated and support breeding in the spring and early summer of most years, but the chronic shortage of storage in Wickiup Reservoir will drive Deschutes River flows low by mid-summer in some years and make at least some of the wetlands less suitable for Oregon spotted frog rearing and foraging. These deteriorating conditions are not expected to be long-lived, however. Natural expansion of wetland vegetation into previously inundated areas, along with active enhancement of stream and wetland habitats supported by the Upper Deschutes Basin Conservation Fund (Conservation Measure UD-1) are expected to increase Oregon spotted frog summer rearing habitat along the Upper Deschutes River during the term of the DBHCP.

Due to the large areas of emergent wetlands and large number of breeding Oregon spotted frogs in Crane Prairie Reservoir, Crescent Creek and Little Deschutes River, the favorable conditions for summer rearing and foraging that will be maintained and enhanced in these areas will offset the minor and temporary reductions in habitat quality and quantity likely to occur along the Deschutes River.

Upper Deschutes Basin Conservation Fund

Conservation Measure UD-1 requires Districts to contribute $150,000 to the Upper Deschutes Basin Conservation Fund each year for the term of the DBHCP. This fund will be managed by a third-party selected by USFWS. The fund will be used to support a wide variety of activities, all with the common objective of improving conditions for Oregon spotted frogs in the Upper Deschutes Basin. These activities can include, but will not be limited to, river/stream restoration, wetland creation/enhancement/revegetation, invasive plant control and invasive predator control. In addition to the anticipated benefits to Oregon spotted frogs from the substantial flow improvements required under the DBHCP, the conservation fund will enable USFWS and others to enhance the overall benefits of the DBHCP (e.g., through restoration of river channels to more effectively accommodate new flow regimes) and address myriad threats to Oregon spotted frogs unrelated to the covered activities (e.g., reed canarygrass and bullfrogs). It is anticipated the combined effects of improved flow regimes and activities supported by the conservation fund will mitigate the impacts of the covered activities to the standards of ESA Section 10 and lead to overall increase in the likelihood for survival and recovery of the Oregon spotted frog in the Deschutes Basin.

8.4.5 Effects on Critical Habitat for the Oregon Spotted Frog

8.4.5.1 Designated Critical Habitat

Section 3 of the ESA defines critical habitat as:

> (1) *The specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the Act, on which are found those physical or biological features (a) essential to the conservation of the species, and (b) which may require special management considerations or protection; and (2) Specific areas outside the geographical area occupied by the species at the time it is listed, upon a determination that such areas are essential for the conservation of the species.*

In May 2016, USFWS described critical habitat for the Oregon spotted frog and designated a total of 65,038 acres across the range of the species (USFWS 2016). The designation included 53,475 acres within Oregon, of which 35,065 acres (54% of the range-wide total) are in the upper Deschutes Basin. The activities covered by the DBHCP have the potential to influence 22,690 acres of the designated critical habitat (35% of the range-wide total). Critical habitat within the upper Deschutes Basin is subdivided into three geographic areas: Subunit 8A (Upper Deschutes River below Wickiup Dam), Subunit 8B (Upper Deschutes River above Wickiup Dam) and Unit 9 (Little Deschutes River, including Crescent Creek). The distribution of critical habitat on the covered lands is shown in Table 8-44.

Concurrent with the designation of critical habitat, USFWS describes the primary constituent elements (PCE) of the critical habitat. PCEs are the specific elements of the physical or biological features that provide for a species' life history processes and are essential to the conservation of the species. The PCEs of critical habitat for the Oregon spotted frog were identified in the final designation (USFWS 2016) and subsequently interpreted for the specific conditions of the upper Deschutes Basin in 2017 (Table 8-45).

Table 8-44. Designated critical habitat for the Oregon spotted frog on lands covered by the Deschutes Basin HCP.

Designated Critical Habitat Unit/Subunit (acres)[1]	Area on DBHCP Covered Lands (acres)[2]
Subunit 8A – Deschutes River below Wickiup Dam	
Wickiup Dam to Fall River	610
Fall River to Little Deschutes River	521
Little Deschutes River to Benham Falls	371
Benham Falls to Dillon Falls	259
Dillon Falls to Lava Island	163
Lava Island to Central Oregon Canal	0
Central Oregon Canal to Colorado Avenue	37
Subunit 8A Total	**1,961**
Subunit 8B – Deschutes River above Wickiup Dam	
Crane Prairie Reservoir	4,982
Crane Prairie Dam to Wickiup Reservoir	153
Wickiup Reservoir	10,231
Subunit 8B Total	**15,366**
Unit 9 – Little Deschutes River (including Crescent Creek)	
Little Deschutes River	3,428
Crescent Creek	1,935
Unit 9 Total	**5,363**
Total All Covered Lands	**22,690**

Sources: [1] USFWS 2016, [2] Biota Pacific 2019.

Table 8-45. Characteristics of Oregon spotted frog critical habitat.

Habitat Type	Habitat Characteristics
Primary Constituent Element 1	
Nonbreeding	• Total surface area with less than 50 percent vegetative cover • An absence or low density of nonnative predators
Breeding and Rearing	• Inundated for a minimum of 4 months per year • If ephemeral, areas are hydrologically connected by surface water flow to a permanent water body • Shallow-water areas, less than or equal to 12 inches (30 cm), or water of this depth over vegetation in deeper water • Herbaceous wetland vegetation (i.e., emergent, submergent, and floating-leaved aquatic plants), or vegetation that can structurally mimic emergent wetland vegetation through manipulation • Shallow-water areas with high solar exposure or low (short) canopy cover • An absence or low density of nonnative predators
Overwintering	• Inundated from October through March
Primary Constituent Element 2	
Aquatic Movement Corridors	• Ephemeral or permanent bodies of fresh water that have one or more of the following characteristics: • Less than or equal to 3.1 mi (5 km) linear distance from breeding areas; • Impediment free (including, but not limited to, hard barriers such as dams, impassable culverts, lack of water, or biological barriers such as abundant predators, or lack of refugia from predators).
Primary Constituent Element 3	
Refugia	• Nonbreeding, breeding, rearing, or overwintering habitat or aquatic movement corridors with habitat characteristics (*e.g.,* dense vegetation and/or an abundance of woody debris) that provide refugia from predators (*e.g.,* nonnative fish or bullfrogs)

Source: USFWS 2017.

The final designation of critical habitat for the Oregon spotted frog (USFWS 2016) identified the following threats to critical habitat within each designated unit or subunit, and the special management considerations or protections that may be required to address those threats.

"Subunit 8A (Deschutes River below Wickiup Dam): *All of the essential physical or biological features [of critical habitat] are found within the subunit but are impacted by hydrologic modification of river flows, reed canarygrass, nonnative predaceous fish, and bullfrogs. The* *essential features within occupied habitat within this subunit may require special management considerations or protection to ensure maintenance or improvement of the existing nonbreeding, breeding, rearing, and overwintering habitat, aquatic movement corridors, or refugia habitat, as well as to address any changes that could affect these features*."

"Subunit 8B (Deschutes River above Wickiup Dam): *All of the essential physical or biological features are found within the subunit but are impacted by vegetation succession and nonnative predaceous fish. Physical and biological features found within the reservoirs in this unit are affected by the storage and release of water for irrigation. The essential features within this subunit may require special management considerations or protection to ensure maintenance or improvement of the existing nonbreeding, breeding, rearing, and overwintering habitat, aquatic movement corridors, or refugia habitat, as well as to address any changes that could affect these features."*

"Subunit 9 (Little Deschutes River, including Crescent Creek): *Additionally, the essential physical or biological features are found within the unit but are impacted by hydrologic manipulation of water levels for irrigation, nonnative predaceous fish, reed canarygrass, and bullfrogs. The essential features within occupied areas within this unit may require special management considerations or protection to ensure maintenance or improvement of the existing nonbreeding, breeding, rearing, and overwintering habitat, aquatic movement corridors, or refugia habitat, as well as to address any changes that could affect these features."*

The final designation went on to identify six categories of specific actions that may affect critical habitat for the Oregon spotted frog. Two of these six categories (1 and 5) are relevant to the activities covered by the DBHCP:

> *"(1) Actions that would significantly alter the structure and function of the wetland, pond, channel, lake, oxbow, spring, or seasonally flooded areas morphology, geometry, or water availability/permanence. . . These activities may lead to changes in the hydrologic function of the aquatic habitat and alter the timing, duration, water flows, and water depth. These changes may be designed to benefit the Oregon spotted frog and actually increase habitat in the long term, or may degrade or eliminate Oregon spotted frog habitat and could lead to the reduction in available breeding, rearing, nonbreeding, and overwintering habitat necessary for the frog to complete its life cycle. If the permanence of an aquatic system declines so that it regularly dries up, it may lose its ability to support Oregon spotted frogs. If the quantity of water declines, it may reduce the likelihood that the site will support a population of frogs that is robust enough to be viable over time. Similarly, ephemeral, intermittent, or perennial ponds can be important stop-over points for frogs moving among breeding areas or between breeding, rearing, dry season, or wintering areas. Reducing the permanence of these sites may reduce their ability to facilitate frog movements. However, in some cases, increasing permanence can be detrimental as well, if it creates favorable habitat for predatory fish or bullfrogs that otherwise could not exist in the system. Reservoir operations such as the storage and release of water could be timed to support breeding, rearing, and overwintering habitat within occupied reservoirs and downstream of dams."*

The list of category 1 actions includes "*reservoir water storage and release*," which is the primary mechanism by which the DBHCP covered activities may affect critical habitat for the Oregon spotted frog. Category 1 also includes "*groundwater pumping*, *water diversion* and *water withdrawal*," but the vast majority of water diversion and withdrawal activities covered by the DBHCP occur downstream of Oregon spotted frog critical habitat and have no potential to affect the habitat. Only 37 acres of designated critical habitat (less than 0.2% of the total on the covered lands) lie downstream of water diversions covered by the DBHCP. "*Construction or destruction of dams or impoundments"* is included within category 1 as well, but the covered activities are limited to existing dams and involve no new construction or destruction.

> *"(5) Actions and structures that would physically block aquatic movement corridors."*

Dams are identified in category 5 as structures that could block aquatic movement corridors. Two of the dams covered by the DBHCP (Crane Prairie and Wickiup) lie within designated critical habitat and have the potential to interrupt the movement of Oregon spotted frogs.

The following analysis of effects on critical habitat under the DBHCP is organized by geographic unit. For each unit, the baseline condition of the PCEs is described along with the changes that are expected to occur to those conditions as a result of performance of the covered activities under the terms and conditions of the DBHCP. For all subareas, the baseline condition is defined as those habitat conditions resulting from historical operation of the Crane Prairie, Wickiup, and Crescent reservoirs from 1981 through 2018. Operation of the reservoirs changed slightly in 2016 due to early implementation of some of the conservation measures now included in the DBHCP, but those changes did not appreciably alter average or median conditions for the 38 years of operations used to characterize baseline conditions. Also note that Critical Habitat acres vary from Affected Habitat acres (Chapter 5, Table 5-13 and effects to covered lands discussion, above) because USFWS did not include areas under other management agreements (e.g., Sunriver) in the Critical Habitat acreage.

8.4.5.2 Critical Habitat Subunit 8A

Upper Deschutes River (Wickiup Dam to Bend)

Baseline Condition: The 59-mile reach of Upper Deschutes River between Wickiup Dam and Colorado Avenue in Bend contains 1,961 acres of designated critical habitat for the Oregon spotted frog (Table 8-44). Of this total, 468 acres are emergent wetland, 74 acres are pond (aquatic bed), 507 acres are forest and shrub wetland, and the remainder is open water (lake, river or unknown) (Table 8-46). Habitat conditions within this reach of the Deschutes River are heavily influenced by the seasonal storage and release of water at Crane Prairie, Wickiup and Crescent Lake reservoirs. Water is stored in all three reservoirs during the winter, causing flows within this river reach to be lower than they would be naturally. When stored water is released in the summer it combines with natural flow to produce unnaturally high flows between Wickiup Dam and Bend. Irrigation storage was historically maximized by withholding and later releasing nearly all inflow to the reservoirs, resulting in downstream flows that were extremely low during the winter and extremely high during the summer. After more than 70 years of this altered flow regime the erodible sections of the Deschutes River channel (those not bounded by exposed lava flow) have become widened. Oregon spotted frogs are present within this reach in a small number of widely-spaced wetlands. Some of the occupied wetlands are isolated from the river channel and supported by local hydrology, while others lie within the floodplain where they are inundated to varying degrees on a seasonal basis during high summer flows. Wetlands and ponds with water regulation for frogs are located at Sunriver and Old Mill Pond; these sites are excluded from designated critical habitat and this critical habitat analysis (USFWS 2017).

Table 8-46. Designated critical habitat for the Oregon spotted frog on lands covered by the Deschutes Basin HCP, divided by wetland type.

Critical Habitat Unit/Subunit	Area (acres) by Wetland Type						
	Emergent	Forest /Shrub	Pond	Lake	River	Unknown	Total
Subunit 8A							
Wickiup Dam to Fall River	88	199	0	0	323	0	610
Fall River to Little Deschutes River	155	134	8	0	224	0	521
Little Deschutes River to Benham Falls	105	59	7	0	200	0	371
Benham Falls to Dillon Falls	110	53	35	0	61	0	259
Dillon Falls to Lava Island	10	62	24	0	67	0	163
Lava Island to Central Oregon Canal	0	0	0	0	0	0	0
Central Oregon Canal to Colorado Avenue	0	0	0	37	0	0	37
Subunit 8A Total	468	507	74	37	875	0	1,961
Subunit 8b							
Crane Prairie Reservoir	629	112	3	4,238	0	0	4,982
Crane Prairie Dam to Wickiup Reservoir	24	15	0	103	11	0	153
Wickiup Reservoir	2,376	682	0	7,173	0	0	10,231
Subunit 8B Total	3,029	809	3	11,514	11	0	15,366
Unit 9							
Little Deschutes River	1,783	1,471	11	0	118	45	3,428
Crescent Creek	523	1,319	2	0	48	43	1,935
Unit 9 Total	2,306	2,790	13	0	166	88	5,363
Total All Covered Lands	**5,803**	**4,106**	**90**	**11,551**	**1,052**	**88**	**22,690**

Sources: USFWS 2017 and Biota Pacific 2019.

USFWS has identified critical habitat in the reach of the Deschutes River between Wickiup Dam and Bend as impaired for all three primary constituent elements of Oregon spotted frog critical habitat (USFWS 2017):

- PCE 1. Breeding habitat in the seasonally-inundated wetlands can be negatively impacted by the timing of irrigation releases, which often come after the onset of breeding. Prior to irrigation season flow releases, egg masses may be deposited in shallow water that is unvegetated, where they are exposed to high predation risk and effects of wind. Once irrigation flows are released, egg masses may be flushed into deeper water with cooler temperatures and increased predation risk to emerging tadpoles. Rapid decreases in water levels due to changes to irrigation releases can leave egg masses stranded, where they may desiccate before larvae emerge. Nonbreeding and summer rearing habitats (PCE 1) were the least impacted by the historical hydrologic regime because occupied wetlands generally remained well inundated by reservoir releases from April through September. The lack of overwintering habitat (PCE 1) is believed to be a limiting factor for Oregon spotted frogs in this reach, particularly in the portion upstream of the confluence with the Little Deschutes River where winter flows have been as low as 20 cfs in the past.
- PCE 2. Aquatic movement corridors between summer and winter habitats (PCE 2) are also impacted by the low winter flows that disconnect occupied wetlands from the river, and by the rapid transition from summer to winter flows in October of each year.
- PCE 3. Refugia are present within breeding, rearing and nonbreeding habitats, particularly those that lack direct surface connections to the river and therefore do not support predatory fish. However, the lack of refugia may be a limiting factor during the winter when most breeding and nonbreeding habitats become dry; at this time spotted frog habitats are limited to the Deschutes River and adjacent wetlands supported by springs or perched water table that are sustained through the winter.

Effects of the DBHCP: The magnitude of effect of the DBHCP on Oregon spotted frog critical habitat will vary by location within the Upper Deschutes River, but the overall trend will be the same throughout the 59-mile reach. The effects of the DBHCP on PCE 1 will be variable (Table 8-47). Increased winter flows will improve overwintering habitat, but overwintering conditions will still remain less than optimal because the new winter flows will not fully inundate all potentially occupied wetlands along the river. At the same time, corresponding decreases in summer flows, particularly in later years of the DBHCP when the minimum winter flow reaches 400 cfs, may cause minor reductions in the quantity and quality of rearing and summer foraging habitat in some of the same wetlands. Flows will increase roughly 2 weeks earlier in the spring than they did historically, to improve breeding habitat conditions, but the new April 1 target of 600 cfs may not be sufficient to fully inundate some potential breeding areas.

The DBHCP will represent a substantial change in the seasonal flow regime of the Upper Deschutes River by modifying the extremes of the historical reverse-hydroperiod toward a water regime that will be timed to improve critical habitat conditions during breeding, rearing, and overwintering seasons for Oregon spotted frogs. However, it is impossible to maximize PCE 1 for all Oregon spotted frog life stages simultaneously in all reaches due to the conflicting demands on a finite source of water to support both winter and summer habitats.

Overwintering habitat conditions within the Upper Deschutes River will improve as minimum winter flows below Wickiup Dam increase from 100 to 400 cfs over the next 13 years, particularly in oxbows and off-channel wetlands that will be maintained at higher water levels throughout the winter. However, overwintering conditions will remain less than optimal even at 400 cfs because water depths in the river will still not be sufficient to reach all wetlands that have historically been inundated only during the summer. Overwintering habitat within the river channel and immediately adjacent wetlands should improve with the increased flows and more extensive wetted areas, but overwintering conditions will not improve in all floodplain wetlands, as some rely on flows higher than the DBHCP can provide in most years.

Table 8-47. Summary effects of the Deschutes Basin HCP on designated critical habitat for the Oregon spotted frog.

Critical Habitat Unit/ Subunit	Change in Condition of Critical Habitat under the DBHCP		
	PCE 1 (Habitat)	PCE 2 (Corridors)	PCE 3 (Refugia)
Subunit 8A			
Wickiup Dam to Colorado Avenue	Variable	Variable	Variable
Subunit 8B			
Crane Prairie Reservoir	Improvement	Improvement	Improvement
Crane Prairie Dam to Wickiup Reservoir	Decline	Decline	No Change
Wickiup Reservoir	Decline	Decline	Decline
Unit 9			
Little Deschutes River and Crescent Creek	Improvement	Improvement	Improvement

Breeding habitat will benefit from the earlier onset of irrigation releases under the DBHCP (≥ 600 cfs at Hydromet Station WICO no later than April 1), as this will reduce the historical impact of increasing flows mid-way through Oregon spotted frog breeding. However, 600 cfs will not be sufficient to fully inundate some key breeding habitats, and this earlier release of water in the spring combined with increased releases during the winter will reduce overall reservoir storage and thus reduce peak summer releases to the point that conditions may deteriorate for some established rearing habitats in some years. The short-term impacts of reduced summer flows on rearing habitat will be minimized by multiple provisions within Conservation Measure WR-1, and long-term impacts will be reduced or eliminated through habitat restoration and enhancement projects supported by the Upper Deschutes Basin Conservation Fund.

Some aspects of aquatic movement corridors (PCE 2) will be improved by the DBHCP while others will be unaffected. Oregon spotted frog movements within the main channel of Deschutes River during the fall and winter will be improved by generally higher flows at this time of year. Movement between winter and summer habitats may show minor improvement with the deeper water in the main channel, although winter flows will not be sufficient in some areas to maintain direct surface connections between winter and summer habitats.

Refugia habitat (PCE 3) may improve during the winter if the higher instream flows provide calm, shallow habitat along the vegetated benches of the Deschutes River that are dry during the winter under the baseline condition. Conversely, some benches may experience increased water depths and velocities that make them unsuitable for Oregon spotted frogs. In all other respects, refugia habitat in this reach of the Deschutes River will be unchanged by the DBHCP.

8.4.5.3 Critical Habitat Subunit 8B

Crane Prairie Reservoir

Baseline Condition: All 4,982 acres of Crane Prairie Reservoir are designated critical habitat for the Oregon spotted frog, including an estimated 629 acres of emergent wetland, 112 acres of forest and shrub wetland, 3 acres of pond, and 4,238 acres of lake and pond (Table 8-46). Historically, Crane Prairie Reservoir fluctuated up to 6 feet or more between spring and fall, but it was often at or near its full storage volume of 50,000 acre-feet from April through June. This pattern of inundation for up to half the growing season enabled the development of extensive emergent wetlands in shallows on the alluvial fans associated with the tributary streams along the north shore of the reservoir. Oregon spotted frog breeding has been documented in the emergent wetlands associated with the primary tributaries, the Deschutes and Cultus rivers, consistently since regular surveys began in 2013 (USFWS 2019a and 2019b). Breeding has been observed intermittently at emergent wetlands associated with several of the smaller tributary streams and along the southeast shore. Breeding has also been documented in a number of ponds that lie adjacent to the reservoir. The ponds have no direct surface connections to the reservoir, but they are hydrologically influenced by reservoir fluctuations through shallow subsurface movement of water.

USFWS (2017) identified Crane Prairie Reservoir as having degraded conditions for all three primary constituent elements of Oregon spotted frog critical habitat. The reservoir is degraded with respect to PCE 1 (nonbreeding, breeding, rearing and overwintering habitat) because seasonal fluctuations in water surface elevation impact shallow emergent wetlands favored by Oregon spotted frogs. If the reservoir level is extremely high in the spring, emergent wetlands lie under several feet of water and adult frogs are forced to breed within inundated upland forest where eggs are shaded from direct sunlight and can experience delayed development. If the reservoir is extremely low in the spring, emergent wetlands are dry and eggs are deposited in open water where they are vulnerable to wind dispersal and predation. Rapid increases in water depth during egg development can dislodge egg masses and set them adrift. Rapid decreases in water depth can desiccate eggs and strand young tadpoles. If the reservoir is too low in the winter, emergent wetlands are dry and frogs are forced to overwinter in areas lacking substrate vegetation where they are potentially at increased risk of predation.

Crane Prairie Reservoir is degraded with respect to PCE 2 (aquatic movement corridors) because the seasonal fluctuations in water level make it difficult for Oregon spotted frogs to move between summer and winter habitats. The reservoir is degraded with respect to PCE 3 (refugia habitat) because of the presence of non-native predatory fish.

Effects of the DBHCP: The DBHCP will improve critical habitat within Crane Prairie Reservoir with respect to PCE 1, PCE 2 and PCE 3 (Table 8-47). The baseline degraded conditions of PCE 1 and PCE 2 are due to seasonal fluctuations in water depth that result from irrigation storage and release. Under the DBHCP, seasonal fluctuations will be reduced to levels conducive to the maintenance of favorable wetland conditions and support of all Oregon spotted frog life stages. The adaptive management provisions of the DBHCP will be used to make further adjustments to the seasonal fluctuations, as necessary, to achieve the desired habitat conditions. The baseline degraded conditions of PCE 3 are due to the presence of non-native fish within Crane Prairie Reservoir. While the Permittees have no direct control over the fish populations in the reservoir, USFWS anticipates a portion of the Upper Deschutes Basin Conservation Fund provided by the Permittees will be used to address the problem of non-native fish. Should the entities responsible for fish management in the reservoir choose to eradicate non-native fish species from Crane Prairie Reservoir in the future, the DBHCP will in no way hinder those efforts. Such efforts can also be supported logistically by the provision in Conservation Measure CP-1 that allows for additional lowering of the reservoir in a limited number of years.

As described in Conservation Measure CP-1, the water surface elevation of Crane Prairie Reservoir will be managed to stay between 4,441.23 feet and 4,443.48 feet, for a maximum annual fluctuation of 2.25 feet. The reservoir will be held at a constant elevation (within operational limits) during the Oregon spotted frog breeding season, and allowed to drop at a rate of no more than 0.1 foot per day at the end of the summer. The result of Measure CP-1 will be the consistent availability of non-breeding, breeding, rearing and overwintering habitat (PCE 1; Table 8-45) and aquatic corridors for movement between these habitats (PCE 2). The reservoir will still be allowed to fluctuate up to 2.25 feet under the DBHCP because a constant water surface elevation could adversely alter the vegetative composition of the emergent wetlands utilized by Oregon spotted frogs. However, if monitoring indicates the number of breeding Oregon spotted frogs is decreasing due to annual reservoir fluctuations of 2.25 feet, Adaptive Management Measure CP-1.1 will allow the annual fluctuation to be decreased. If the rate of transition from summer to winter water surface elevations is adversely impacting Oregon spotted frogs, the timing and/or rate of transition may be adjusted according to Adaptive Management Measure CP-1.2. Lastly, if the magnitude or timing of reservoir fluctuation is found to be less than optimal for maintaining favorable wetland vegetation, Adaptive Management Measure CP-1.3 will allow for the seasonal fluctuation to be increased. It is anticipated the combination of Conservation Measure CP-1 and Adaptive Management Measures CP-1.1, CP-1.2 and CP-1.3 will eliminate the degraded condition of Crane Prairie Reservoir with respect to PCE 1 and PCE 2, while use of the Upper Deschutes Basin Conservation Fund to manage non-native fish in the reservoir will help reduce the degraded condition with respect to PCE 3.

Upper Deschutes River (Crane Prairie Dam to Wickiup Reservoir)

Baseline Condition: A total of 153 acres of wetland, lake, and riverine habitat along the reach of the Deschutes River between Crane Prairie Dam and Wickiup Reservoir are designated critical habitat for the Oregon spotted frog (Table 8-46). This reach of the river is largely a confined channel with a substrate of boulders and gravel. The river current is generally swift and not conducive to supporting Oregon spotted frogs. Most (over 65%) of the designated critical habitat lies within the lower portion of the reach where it is seasonally inundated by Wickiup Reservoir. The seasonally-inundated portion is included as part of Wickiup Reservoir in Section 8.5.2, *Wickiup Reservoir*, but it is described as a separate reach here to be consistent with the geographic partitioning used in the final designation of critical habitat (USFWS 2016) and assessment of effects on PCEs (USFWS 2017).

Most of the emergent wetland in this reach occurs as a single large complex within the area seasonally inundated by Wickiup Reservoir. Oregon spotted frog breeding and summer rearing have been documented in this wetland. Prior to 2018 it was not clear whether the wetland was influenced hydrologically by Deschutes River flow, Wickiup Reservoir storage, or a combination of the two. Monitoring of water surface elevations during the spring and summer of 2018 demonstrated that water levels in this wetland are determined by storage volumes in Wickiup Reservoir (see Section 8.5.2, *Wickiup Reservoir*). The wetland has a subsurface connection to Wickiup Reservoir when storage volume is over 140,000 acre-feet and a surface connection at storage volumes over 179,000 acre-feet. In years when total storage in Wickiup Reservoir does not exceed 140,000 acre-feet by early April, this wetland likely does not support Oregon spotted frog breeding. Overwintering is unlikely in this wetland because it is almost always dry by late summer.

A series of small, largely unvegetated side channels and beaver runs exists between the occupied emergent wetland and the main channel of the Deschutes River. These side channels remained wetted throughout the summer of 2018 when flows in the river dropped as low as 140 cfs. They may provide sub-optimal summer rearing and/or overwintering habitat for Oregon spotted frogs, but the relationship between water depth in these channels and Deschutes River flows below 140 cfs is not known.

This reach of the river has degraded, partially degraded, or partially impaired conditions for all three primary constituent elements of Oregon spotted frog critical habitat:

- PCE 1 (nonbreeding, breeding, rearing and overwintering habitat) is degraded within this reach of the Deschutes River because the single wetland complex known to support Oregon spotted frog breeding is not inundated at the onset of breeding in some years and it is dry by mid-summer in nearly all years.
- PCE 2 (aquatic movement corridors) is partially degraded within this reach. The Deschutes River provides a good aquatic corridor throughout the year, despite seasonal changes in the rate of flow. However, the emergent wetland known to be used by breeding Oregon spotted frogs loses its surface connection to the river in mid-spring when developing tadpoles still have limited mobility and are not likely to move to the river. When the wetland goes dry in mid-summer, any tadpoles that have not metamorphosed are likely to perish.
- PCE 3 (refugia habitat) is partially impaired within this reach by the presence of non-native predatory fish within Wickiup Reservoir and the Deschutes River. Predatory fish may also be present within the emergent wetland during periods when it has a direct surface connection to the reservoir and river.

Effects of the DBHCP: The impairment of PCE 1 and PCE 2 of Oregon spotted frog critical habitat between Crane Prairie Dam and Wickiup Reservoir will increase under the DBHCP due to decreased seasonal storage in Wickiup Reservoir (Table 8-47). Historically, the occupied wetland received surface inflow from Wickiup Reservoir about three years out of four. Under the DBHCP it will receive inundation less than one year out of three, and periods without inundation will last 5 or more consecutive years. In the remaining years the wetland will receive only local runoff, and it will likely be dry by mid-spring. The DBHCP will have no effect on PCE 3 within this reach.

Wickiup Reservoir

Baseline Condition: USFWS has designated 10,231 acres of critical habitat within Wickiup Reservoir, not including the emergent wetland and riverine habitat in the Deschutes River arm of the reservoir already addressed for the reach between Crane Prairie Dam and Wickiup Reservoir. Of the 10,231 acres, 2,376 acres (23%) have been identified as emergent wetland (Table 8-46). Habitat conditions within Wickiup Reservoir are determined by the dramatic fluctuations in storage volume and associated water surface elevation between spring and fall. Water is stored in the reservoir during the winter, up to a maximum volume of 200,000 acre-feet, and released each summer beginning in April. The fluctuation in a single year can exceed 130,000 acre-feet (more than 20 feet in water surface elevation). Not only does the seasonal fluctuation prevent the establishment of emergent wetlands of the type favored by Oregon spotted frogs, but the changes in volume and water depth occur at critical times for eggs and tadpoles. The annual drop in water level begins during Oregon spotted frog breeding in March and April, and continues at a rapid rate through the summer. Oregon spotted frog eggs and larvae are generally unable to tolerate these rapidly-changing conditions. When juvenile and adult frogs are seeking overwintering habitat in the fall, the reservoir is at its annual low and available habitat is concentrated toward the center of the reservoir where substrate vegetation (cover) is sparse or lacking altogether. Wickiup Reservoir has been operated in this manner since it was completed in 1949 and, given the lack of vegetated emergent wetlands that remain inundated throughout the breeding and rearing seasons, it is unlikely to have supported life stages of the Oregon spotted frog on a regular basis.

The three primary constituent elements of Oregon spotted frog critical habitat are either absent or of poor quality in Wickiup Reservoir:

- PCE 1 is largely absent within Wickiup Reservoir due to historical management. Based on the steep sides and generally confined nature of the original river channel through the reservoir, it is unlikely this reach of the Deschutes River ever provided a significant amount of nonbreeding, breeding, rearing or overwintering habitat for Oregon spotted frogs.
- An aquatic corridor (PCE 2) exists through the reservoir, but it is of poor quality because: a) vegetative cover is generally lacking at most times of year, and b) Wickiup Dam creates a barrier to movement from the reservoir to downstream reaches of the Deschutes River. Movements between shoreline wetlands and the main body of the reservoir are also impaired when the reservoir is drawn down.
- Refugia habitat (PCE 3) is generally absent from Wickiup Reservoir due to the sparse substrate vegetation and high numbers of aquatic predators.

Effects of the DBHCP: All PCEs of critical habitat for the Oregon spotted frog will remain in their degraded conditions within Wickiup Reservoir under the DBHCP, and they may decline (Table 8-47). The magnitude and rate of seasonal fluctuation, which already limit Oregon spotted frog use of the reservoir, will increase under the DBHCP as a result of the requirement to meet flow objectives for the Deschutes River downstream of Wickiup Dam. The potential for Oregon spotted frogs to find suitable nonbreeding, breeding, rearing and overwintering habitat in the reservoir will decrease. Aquatic movement corridors will be more concentrated toward the center of the reservoir, and there will be fewer refugia from fish and avian predators.

8.4.5.4 Critical Habitat Unit 9

Little Deschutes River and Crescent Creek

Baseline Condition: Of the 22,690 acres of designated critical habitat for the Oregon spotted frog on lands covered by the DBHCP, 5,363 acres (24%) lie within the Little Deschutes subbasin (Table 8-46). The concentration of emergent wetlands is higher along the Little Deschutes River and Crescent Creek than the average density of emergent wetland along the Deschutes River from Wickiup Dam to Colorado Street in Bend. Of the 5,803 acres of critical habitat classified as emergent wetland on the covered lands, 2,306 acres (40%) are associated with the 86 miles of Crescent Creek and the Little Deschutes River between Crescent Dam and Sunriver, while only 468 acres (8%) are found along the 59 miles of Deschutes River between Wickiup Dam and Bend. As would be expected, surveys since 2013 have detected higher numbers of Oregon spotted frogs along Crescent Creek and Little Deschutes River than on mapped critical habitat along the Deschutes River between Wickiup Dam and Bend.

USFWS (2016, 2017) identified multiple factors as contributing to the degraded condition of critical habitat in the Little Deschutes subbasin, including agriculture, cattle grazing, riparian development, hydrologic manipulations of water levels for irrigation, invasive plants (reed canarygrass), and predators (bullfrogs and brown trout). Hydrological manipulations include the historical operation of Crescent Lake Reservoir by TID and multiple irrigation diversions unrelated to the reservoir by entities other than TID. The effects of reservoir operation include a) decreased flows during the fall, winter and early spring (storage season), b) increased flows during the late summer, and c) rapidly changing flows between late summer and fall.

The three primary constituent elements of Oregon spotted frog critical habitat are as follows in the Little Deschutes and Crescent Creek:

- In past years the reduced fall, winter and spring flows have impacted overwintering and breeding habitat (PCE 1) in lower Crescent Creek, but had relatively little effect on Little Deschutes River that receives inflow from multiple unregulated tributaries. Increased summer flows, which counteract natural declines in streamflow in Crescent Creek and Little Deschutes River, have been beneficial in maintaining rearing and nonbreeding habitat (PCE 1) into late summer when it would not otherwise be available.
- Seasonal transitions (reductions) in flow from late summer to fall are suspected of creating barriers to aquatic movement (PCE 2) as Oregon spotted frogs move to overwintering habitats.
- Low winter flows may also have reduced the availability of refugia from predators in some areas (PCE 3).

The impacts of reservoir operation on overwintering habitat in the lower creek could be unintentionally overestimated by comparing historical summer flows to historical winter flows, as this type of comparison would overlook the fact that high summer flows (which are beneficial to Oregon spotted frogs) are only made possible by the storage of water in Crescent Lake Reservoir that reduces downstream winter flows. If flows were not reduced in the winter (i.e., if water were not stored), flows could not be increased in the summer, and the overall quantity and quality of rearing and nonbreeding habitat would decrease in the 86 miles between Crescent Lake Dam and Sunriver. The appropriate comparison for determining the effects of reservoir operation on overwintering habitat is average winter flows with reservoir operation versus average winter flows under natural (unregulated) conditions. Historically, this difference has been relatively small (see Section 6.3.3.2, *Effects of Historical Crescent Lake Reservoir Operation on Flow*).

Effects of the DBHCP: All PCEs of critical habitat for the Oregon spotted frog will show improvement under the DBHCP (Table 8-47), but the degraded conditions will persist due to the multiple threats posed by activities and factors unrelated to the operation of Crescent Lake Reservoir. The principal change to reservoir operation under the DBHCP will be to increase the minimum flow in Crescent Creek below the dam during the storage season (October through June) from the historical 6 cfs to the new 10-12 cfs. The new minimum flow will be only slightly less than the natural median flow during most of these months, but considerably higher than the natural minimum flow. These increased flows will improve conditions for overwintering, breeding, nonbreeding and early summer rearing habitat (PCE 1). Continuation of irrigation releases in July through September will occur at less than historical levels (due to reductions in storage), but will remain well above natural flows and will continue to support summer rearing and nonbreeding habitat (PCE 1) as they have in the past. The release of a constant 10-12 cfs from Crescent Lake during the Oregon spotted frog breeding season (PCE 1) will buffer natural flow fluctuations that originate in unregulated tributaries and are detrimental to egg and larvae development. Since summer flows will be lower and fall flows will be higher than they historically were, the transition from summer to fall flows previously identified as an impact to aquatic movement (PCE 2) will be reduced. The DBHCP also includes provisions to control the rate of increases and decreases in flow to further reduce the potential for isolating and stranding Oregon spotted frogs. The higher winter flows may also increase the availability of refugia (PCE 3) during winter months, although the differences from historical levels will likely be small. Finally, OSF storage provided under Conservation Measure CC-1 will enable USFWS and TID to strategically provide additional flow in lower Crescent Creek and lower Little Deschutes River to address remaining flow-related impacts to Oregon spotted frogs.

8.4.6 Role of the Covered Lands to the Conservation of the Oregon Spotted Frog

The DBHCP covered lands occupy the lower two-thirds of the elevation range of the Oregon spotted frog in the Deschutes Basin, where they play an important role in maintaining the current geographic distribution of the species. Historically, Oregon spotted frogs were known to occur from Hosmer Lake (elevation 4,966 feet) near the Cascade crest to Lower Bridge (elevation 2,605 feet) on the Deschutes River (Hayes 1997). The species has been extirpated from the Deschutes River downstream of Bend, and the lowest elevation site with confirmed occupancy is now the Old Mill District at elevation 3,600 feet. The covered activities affect the hydrology of most known occupied Oregon spotted frog sites below elevation 4,450 on the Deschutes River, below elevation 4,635 on Crescent Creek and below elevation 4,325 on the Little Deschutes River. The management of flows within these affected reaches will be integral to the continued presence and recovery of the Oregon spotted frog across its current range in Central Oregon.

The distribution of critical habitat for the Oregon spotted frog on the covered lands mirrors the geographical distribution of those lands. Roughly two-thirds (22,690 acres) of the designated critical habitat for the Oregon spotted frog in the Upper Deschutes and Little Deschutes units lies on the DBHCP covered lands (Table 8-44). Of this total, about 11,525 acres (51 percent of the total designated critical habitat on the covered lands) consists of two man-made reservoirs

(Crane Prairie and Wickiup Reservoir) and the 0.9 mile reach of river between them. The remaining 11,165 acres on the covered lands (32 percent of the total designated critical habitat on the covered lands) are mostly natural habitats associated with the reservoirs (3,841 acres) and downstream of the reservoirs (7,324 acres below Wickiup Dam) (Table 8-46). The operation of the reservoirs under the DBHCP will play a key role in determining the ability of habitats within and downstream of the reservoirs to sustain populations of Oregon spotted frogs.

USFWS (2014b, 2017) identified numerous threats to the survival of the Oregon spotted frog in Central Oregon. Most of the identified threats are unrelated to operation of the irrigation reservoirs, but without addressing the reservoirs and their underlying effects on hydrology there would be limited benefit to addressing the other threats. The DBHCP will address the threats to Oregon spotted frogs associated with reservoir operation in the Deschutes Basin so that other threats can also be addressed with a reasonable expectation of achieving long-term survival and recovery of the species. To assist USFWS and others in addressing those other threats, Districts will provide $150,000 per year for the term of the DBHCP to the Upper Deschutes Basin Conservation Fund.

While the threats identified by USFWS (2014b) present obstacles to ensuring the long-term survival of the Oregon spotted frog, the current trend for the species in Central Oregon is unknown. Hayes (1997) reported a significant range contraction from historical conditions for the species in the Deschutes Basin, but his estimate of range contraction was likely overstated for a number of reasons. Hayes (1997) surveyed for Oregon spotted frog presence at all known historical sightings in the basin and reported the absence of frogs at 9 of 21 previously occupied sites. However, subsequent to 1997, three of his nine unoccupied sites have been found to be occupied and two of those (Crane Prairie Reservoir and Sunriver) now support some of the largest populations in the basin. Hayes (1997) also reported Oregon spotted frog presence at four previously-unknown sites, and surveys since 1997 have documented another 39 sites that were unknown to Hayes.

The absence at some of the historical sites reported by Hayes (1997) was undoubtedly due to permanent extirpation, likely as a result of habitat modification. However, absence at other sites could easily be attributed to the fact that these 1997 surveys were conducted during and immediately after an extended drought that left many wetlands in the basin temporarily dry. Hayes (1997) reported these dry conditions, and also noted low detection rates for most other species of amphibians in the survey areas. At best, the work of Hayes (1997) and the results of surveys for Oregon spotted frog presence in the Deschutes Basin subsequent to 1997 (USFWS 2019b) are inconclusive as to the current population trend. While it is logical to plan for the possibility that identified threats to the species could result in population decline, there are no data available to indicate whether the population actually has declined appreciably over the past 100 years or is declining at the present time.

Hayes (1997) report of range contraction was also enlarged by his inclusion of the entire length of the Deschutes River (to the confluence with the Columbia River; elevation 100 feet) as part of the historical range, although the species has not been reported downstream of Lower Bridge (elevation 2,605 feet). If Oregon spotted frogs did occur downstream of Lower Bridge, their natural distribution would have been restricted to a very narrow corridor of riparian wetland because the Deschutes River is confined to a steep canyon through an arid landscape most of the way from Bend to the Columbia River. Quantifying range contraction solely on river miles as Hayes (1997) did overstates the importance of the Lower Deschutes River where wetland habitat density is much lower than along the Upper Deschutes River and its tributaries where Oregon spotted frogs persist.

The covered lands support almost one-third of the known Oregon spotted frogs in the upper Deschutes Basin. Using the highest number of egg masses reported by USFWS (see Chapter 5, Table 5-12) at each known site in the Upper Deschutes Basin from 2016 to 2019, the estimated minimum number of adult females in the upper Deschutes Basin (including the Little Deschutes and Crescent Creek subbasins) is 5,078. Of these, 1,482 adult females (29 percent) were reported at sites directly or indirectly influenced by the covered activities. Although the number of frogs varies from year to year, the habitat provided by the covered lands is substantial.

It is unclear whether any hydrologic regime for the irrigation reservoirs could sustainably increase the numbers of Oregon spotted frogs from current levels on the covered lands, but it is certainly feasible to sustain current numbers by reducing the threats associated with altered hydrology. Since historical population numbers in the basin are unknown (historical records indicate only presence) it is also unknown whether the basin was ever capable of sustaining higher numbers of Oregon spotted frogs than it currently supports. In addition, modifications to river channel morphology over the past 70 years now limit the amount of wetland habitat than can be supported with the available water, regardless of irrigation practices. Proposals have been made to restore the river channel through physical alteration, but in the absence of site-specific engineering it is impossible to predict whether these activities would result in more habitat on a sustainable basis. Consequently, the management regime provided by the DBHCP is designed to sustain the current population and reduce the potential for local extirpation by removing (or eliminating altogether in some locations) the threats created by historical hydrology and providing favorable habitat conditions on a more regular basis than occurred in the past. Oregon spotted frog numbers may well increase over time as a result of the DBHCP, but increasing the population is not the primary objective. The primary objective of the DBHCP is to prevent a decline.

8.4.7 Effects of Climate Change on the Implementation and Effectiveness of the DBHCP for the Oregon Spotted Frog

The DBHCP conservations measures for the Oregon spotted frog are designed to be implemented without interruption and without diminished effectiveness in the context of climate change. The conservation measures specify reservoir storage volumes and instream flows that will be provided to support Oregon spotted frogs. In all cases, the required volumes and flows for frogs take precedence over other uses of the water. If less water becomes available in the future due to climate change, the conservation measures will still be fully implemented and the amount of water available for irrigation will be reduced.

Climate change prediction is an inexact science, and predictions for the upper Deschutes Basin range from increases in average annual precipitation to decreases. Reclamation and OWRD (2019) modeled climate change over the next 10 to 50 years as part of the Deschutes Basin Study and concluded that:

- Median annual precipitation will increase about 6 percent, with a potential range from 3 percent decrease to 13 percent increase in annual precipitation.
- Average temperatures may increase up to 3.9°C (7.0°F).

- The timing of precipitation may change, with an increase in winter precipitation. Increased precipitation, combined with higher temperatures, could shift peak runoff earlier in the year than it has occurred historically.

Reclamation and OWRD were not able to model specific streamflow conditions in the basin under the effects of climate change, but the implications to the conservation measures for the Oregon spotted frog can be estimated by the general trends that are anticipated. The potential effects of climate change on the effectiveness of the DBHCP for the Oregon spotted frog are addressed according to the geographic subsets of the covered lands where the frogs are present. For each geographic area the analysis addresses potential changes in both precipitation and temperature.

Crane Prairie Reservoir

Amount and Timing of Precipitation: An increase in precipitation upstream of Crane Prairie Reservoir (i.e., increased reservoir inflow) would have no negative effect on implementation of the DBHCP. Conservation Measure CP-1 requires the reservoir to be filled during the winter, and excess inflow is passed downstream to Wickiup Reservoir. An increase in inflow would simply increase the amount of water that is passed through, without affecting habitat conditions in Crane Prairie. Similarly, a small (up to 3 percent) decrease in annual precipitation would have no negative impact. Under the DBHCP, Crane Prairie Reservoir has priority over Wickiup Reservoir for filling during the winter, and the natural inflow to Crane Prairie is more than enough to meet the storage volume targets of the DBHCP even in historically dry years. A reduction of 3 percent to inflow would not prevent the requirements of Measure CP-1 from being met.

A shift in the timing of inflow would also have no negative effect on Oregon spotted frogs in Crane Prairie Reservoir. COID begins refilling the reservoir each year after the end of the irrigation season (late October). An earlier inflow to the reservoir would simply mean the reservoir would fill sooner during the winter and the excess water would be passed through to Wickiup Reservoir.

Increased Temperature: Higher air temperatures in the upper Deschutes Basin would not alter aquatic habitat conditions within Crane Prairie Reservoir, but they could alter Oregon spotted frog use of those habitats. The initiation of breeding by Oregon spotted frogs is brought about in part by air and water temperatures. Warmer temperatures in the late winter and spring could cause frogs in Crane Prairie Reservoir to begin breeding earlier. The implication of this to the DBHCP is that it may be necessary to meet the breeding season reservoir volume of 46,800 to 48,000 acre-feet earlier than the specified date of March 15. If Oregon spotted frogs start breeding earlier than they have in the past, this would be detected by effective monitoring conducted in accordance with Adaptive Management Measure CP-1.1, and the target date for reaching the storage volume target would be moved to as early as March 1.

Wickiup Reservoir

Amount and Timing of Precipitation: An increase in annual precipitation could be beneficial to Oregon spotted frogs in Wickiup Reservoir. The requirement to maintain winter flows in the Deschutes River downstream of the reservoir (Measure WR-1) will substantially reduce the potential for Oregon spotted frog presence in the reservoir. Any increase in annual runoff that could be stored in Wickiup Reservoir while the downstream flow requirements are also being met would increase the potential for frogs to breed and overwinter in the reservoir. Overall, however, the potential for Oregon spotted frogs in Wickiup Reservoir will be quite low under the DBHCP, and an increase in median annual inflow of up to 13 percent wouldn't be likely to change that. Similarly, a reduction in inflow of as much as 3 percent would be relatively inconsequential to habitat conditions within the reservoir because they are already quite limited.

Increased Temperature: Due to the overall limited potential for Oregon spotted frogs in Wickiup Reservoir under the DBHCP, a change in temperature (positive or negative) would not make an appreciable difference in conditions or alter the likelihood for breeding, summer rearing or overwintering to occur there.

Deschutes River – Wickiup Dam to Bend

Amount and Timing of Precipitation: Efforts to improve habitat conditions for Oregon spotted frogs in the Upper Deschutes River are hampered by the limited availability of water. Increase in flow during the winter to improve habitat conditions during that time of year result in reduced flows during the summer that can have negative consequences to riparian wetland habitats. Conservation Measure WR-1 is a compromise between winter and summer flows to make optimal use of the available water. Any increase in annual flow would improve conditions for Oregon spotted frogs by enabling reservoir operators to provide higher flows downstream of the reservoir. Since the additional water could be stored in the reservoir or passed through directly, reservoir operators would have the option of releasing the water at the most beneficial time for frogs. The ability to store excess water also minimizes any impacts associated with a shift in the timing of precipitation and runoff. Wickiup Reservoir is not predicted to fill in most years under the DBHCP, and this means there will be storage capacity in the reservoir to capture higher winter flows (if they occur) and release the water at the most beneficial time.

A decrease in precipitation in the upper Deschutes Basin, if it occurred, could reduce inflow to Wickiup Reservoir, but the effects on Oregon spotted frogs downstream in the Deschutes River would be minimal. Conservation Measure WR-1 intentionally gives priority for the use of water to meet flow targets for Oregon spotted frogs. In years when reservoir inflow is reduced, the DBHCP flow targets are still met and the reduced availability of water becomes a shortage for NUID. Hydrologic modeling for the DBHCP (See Section 6.2.6.3 - *Effects of DBHCP Measures WR-1 on the Hydrology of the Upper Deschutes River*) indicates that winter flows of up to 400 cfs can consistently be met, even in dry years. A reduction of 3 percent in reservoir inflow would not substantially reduce the ability to meet these downstream flow targets.

Increased Temperature: Increased temperatures in the upper Deschutes Basin in the winter and spring could cause Oregon spotted frogs along the Upper Deschutes River to begin breeding earlier than they have in the past. Conservation Measure WR-1 requires a flow downstream of Wickiup Dam of at least 600 cfs beginning April 1 to support Oregon spotted frog breeding in riparian wetlands. If the onset of breeding shifts to a date earlier than April 1, the changed circumstances provisions of Chapter 9 would be triggered and the Districts and USFWS would determine the appropriate adjustment to the conservation measures.

Crescent Creek and Little Deschutes River

Amount and Timing of Precipitation: The maintenance and enhancement of Oregon spotted frog habitat in Crescent Creek and the Little Deschutes River is limited by the amount of water that is naturally available. Conservation Measure CC-1 is a balance between winter and summer use of the water, with the understanding that an increase in release from the reservoir to benefit Oregon spotted frogs at one time of year would reduce the availability of water at another time, regardless of the use of the water for irrigation once it is released. An increase in reservoir inflow caused by climate change would provide more options for increasing flows downstream of Crescent Lake Dam and would be beneficial to Oregon spotted frogs. A decrease of up to 3 percent, on the other hand, could further reduce downstream flows. Initially, summer flows would be reduced to avoid draining the reservoir and threatening winter releases. In an extreme case, the reservoir could be drained despite reducing summer flows, and winter flows in lower Crescent Creek and lower Little Deschutes River would also suffer. These conditions are a possibility even without climate change, but reduced flows could occur with greater frequency if overall precipitation declines in the basin. The effects of a shift in the timing of runoff would be minimal in the Little Deschutes subbasin because the storage capacity of Crescent Lake Reservoir is quite large compared to average annual runoff. Higher runoff in winter or early spring would simply mean more water could be stored for release during the summer.

Increased Temperature: As noted for other locations within the upper Deschutes Basin, an increase in average temperature during the winter and/or spring could result in earlier breeding by Oregon spotted frogs than has occurred in the past. This would have no negative consequences relative to the DBHCP in Crescent Creek and the Little Deschutes River, however, because there is no required change in flow or reservoir management that is keyed to the onset of breeding. The minimum release of 10-12 cfs from Crescent Lake Reservoir will be applicable from October through June to provide habitat for both overwintering and breeding. Oregon spotted frogs will find suitable conditions for breeding during this entire period, regardless of the timing of onset.

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FINAL

DESCHUTES BASIN
HABITAT CONSERVATION PLAN

Chapter 9 – Changed and Unforeseen Circumstances

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9 – CHANGED AND UNFORESEEN CIRCUMSTANCES

9.1 Introduction

The federal No-Surprises Rule (USFWS and NMFS 1989) defines *changed circumstances* as, "changes in circumstances affecting a species or geographic area covered by a (habitat) conservation plan that can reasonably be anticipated by plan developers and the Service and that can be planned for (e.g., the listing of new species, or a fire or other natural catastrophic event in areas prone to such events)." The No-Surprises Rule requires that HCPs identify changed circumstances pertinent to the covered lands and covered species, and include provisions for additional conservation and mitigation measures that will be necessary to respond to those changed circumstances if they occur during the term of the HCP. If additional conservation and mitigation measures are deemed necessary to respond to a changed circumstance that was not provided for in the HCP's operating conservation program, the Services will not require additional conservation or mitigation measures beyond those provided for in the HCP without the consent of the permittee, provided the HCP is being properly implemented.

The No-Surprises Rule also defines *unforeseen circumstances* as, "changes in circumstances affecting a species or geographic area covered by an HCP that could not reasonably have been anticipated by plan developers or the Services at the time of the HCP's negotiation and development, and that result in a substantial and adverse change in the status of a covered species." If unforeseen circumstances occur, the Services will not require the commitment of additional land, water or financial compensation or place additional restrictions on the use of land, water (including quantity and timing of delivery), or other natural resources beyond the level otherwise agreed upon for the species covered by the HCP, without the consent of the permittee.

The DBHCP Permittees and the Services have identified the changed circumstances pertinent to the covered lands and covered species, and developed measures that will be taken in response to those changed circumstances. This chapter contains all changed circumstances and all provisions that could be required of the Permittees to respond to changed circumstances during the term of the DBHCP. If conservation measures or costs beyond those provided for in the DBHCP become necessary in response to these or other changed or unforeseen circumstances, the Services will not require additional measures or expenditures without the prior consent of the Permittees. The incidental take permits supported by the DBHCP will remain in effect as long as the DBHCP is being properly implemented and the changed circumstances provisions of this chapter are implemented when needed.

9.2 Change in Habitat on the Covered Lands Due to Flooding

The covered lands are aquatic, wetland, and riparian habitats that have been shaped and will continue to be shaped by periodic natural disturbances. The primary natural disturbance processes affecting the covered lands are flooding and landslides. Flood flows can cause bank cutting, the movement of bedload, and in extreme cases channel migration. Heavy precipitation associated with floods can also trigger debris torrents (landslides) in steep tributary streams. All of these processes can have both positive and negative effects on habitats for the covered species. Bank cutting is a primary provider of gravel and coarse wood to streams, both of which contribute to properly functioning habitat for salmonid fishes. Bank sloughing has also been observed as a source of Oregon spotted frog breeding habitat on Crescent Creek. However, excessive bank cutting can over-widen streams and reduce water depths to unfavorable levels. Landslides can deliver gravel and coarse wood, but they often deliver large amounts of fine sediment as well. Fine sediment may be associated with properly functioning habitat for Oregon spotted frogs, but high levels of fine sediment can be detrimental to salmonid reproduction by impairing egg development. Bedload movement and channel migration can also alter wetland and riparian habitats. New wetlands are created when channel migration leads to the formation of backwaters and oxbows, but existing riparian wetlands can become hydrologically isolated when channels move. Riparian wetlands can be eliminated altogether when the main channel of a river migrates back into an oxbow.

The covered activities have historically altered the frequency and magnitude of floods and they will continue to exert influence on floods under the DBHCP. All four of the storage reservoirs covered by the DBHCP influence the frequency and magnitude of downstream floods. Some of this influence is incidental to the storage of irrigation water during seasons when floods typically occur, and some of the influence is the intentional result of reservoir management for flood control (i.e., Ochoco Reservoir). Nevertheless, flooding will still occur in the rivers and creeks covered by the DBHCP and habitats for the covered species will be affected. The influence of the covered activities on flooding has been accounted for in the development of the DBHCP conservation measures, and the measures will not be modified or expanded in the event of a flood. The Permittees will not be required to provide mitigation in addition to that already provided in the DBHCP in the event that habitats for covered species are impacted by flooding.

9.3 Non-emergency Maintenance, Repair and Modification of Covered Facilities

Routine maintenance and repair of the covered dams and diversions (including fish screens and ladders) as described in Chapter 3 are covered activities because they are predictable and their effects on the covered species are generally minor and well documented. However, over the term of the DBHCP it may become necessary to conduct more extensive maintenance, repair or modification of a covered facility that exceeds the limits described in Chapter 3. Non-emergency maintenance, repair and modification activities are those that are necessary for the safe and efficient operation of the covered facility, but do not need to be conducted immediately and can be delayed as needed to reduce impacts to covered species, avoid conflicts with the implementation of the DBHCP and otherwise accommodate the operational needs of the structure and the responsible Permittee. These are distinguished from emergency actions that are addressed in Section 9.4, and are often referred to collectively as extraordinary maintenance.

The need for maintenance, repair or modification beyond the limits described in Chapter 3 may be identified by a Permittee in the course of routine operations, or it may result from state or federal oversight or inspection of a facility. Maintenance, repair or modification of a covered facility that exceeds the description of maintenance in Chapter 3 or could impact a covered species beyond the level described in Chapter 8 will be considered a changed circumstance, unless the activity is required by Reclamation as part of its oversight of the operation and maintenance of federal transferred works (Crane Prairie and Wickiup dams) or its administration of the Dam Safety Act at Crane Prairie, Wickiup and Ochoco dams. Maintenance, repair and modifications at the covered facilities required by Reclamation and addressed through separate Section 7 consultations with the Services are neither covered activities nor changed circumstances under the DBHCP, and these will not be subject to additional requirements under the DBHCP.

When a Permittee finds the need to conduct non-emergency maintenance, repair or modification to a covered facility that exceeds the limits of maintenance described in Chapter 3 or has the potential for impacts to covered species beyond those assessed in Chapter 8, and the activity is not covered under a Section 7 consultation by Reclamation, the Permittee will, as expeditiously as possible:

1. Provide the Services with a written description of the activity;
2. Work with the Services to determine the potential impacts of the activity to the covered species;
3. Work with the Services to develop procedures and a schedule for the activity that minimizes impacts to the covered species while allowing the activity to occur in a safe, effective and economical manner within a reasonable timeframe; and
4. Work with the Services to identify any additional actions, including monitoring, that are necessary to minimize and mitigate unavoidable impacts to the covered species.

The responsible Permittee will conduct the non-emergency activity according to the schedule and procedures developed with the Services and take any additional minimization and mitigation actions required by and agreed to with the Services. The responsible Permittee will report on the results of the activity and any required monitoring during the next scheduled DBHCP reporting period, or sooner if required by the monitoring provisions developed with the Services.

9.4 Failure or Impairment of a Dam or Diversion Structure

Most of the conservation measures of this DBHCP require the Permittees to operate the covered dams and diversion structures in ways that will provide specified storage volumes and/or instream flows. All dams and diversion structures covered by the DBHCP are maintained and inspected at regular intervals to ensure they remain in safe and proper operating condition. However, unplanned events could occur during the term of the DBHCP to render dams or diversion structures inoperable for the short or long term. These events include, but are not limited to earthquakes, floods, landslides, acts of vandalism or sabotage, structural fires and mechanical failures. While the potential for these events is quite low, and the Permittees will continue to take appropriate steps to prevent them and minimize their impact if they occur, any one or more of these events could occur during the term of the DBHCP and require the Permittees to take emergency actions.

The Permittees’ first obligation in the event of failure or impairment of a dam or diversion will be to public safety. The Permittees (and Reclamation in the case of federal transferred works) will work as expeditiously as possible to remove threats to public safety and public resources (e.g., roads and infrastructure) following an event that prevents a dam or diversion from being operated properly. During that time, the Permittees will notify the Services of the failure or impairment and endeavor to simultaneously remain in compliance with the terms of the DBHCP and associated incidental take permits, but the Permittees will be under no obligation to remain in compliance where doing so would interfere with the need to first protect public safety and public resources.

Once the Permittees, Reclamation and other governmental agencies with jurisdiction over dam safety have determined there is no longer a threat to public safety and public infrastructure, the Permittees will consult with the Services to determine the appropriate actions for meeting the biological goals and objectives of the DBHCP. If the extent of damage to a dam or diversion is likely to prevent the Permittees from providing reservoir storage volumes, instream flows or other forms of protection to covered species required by the DBHCP for more than 1 month, the Permittees will provide a response plan to the Services that defines steps that have been or will be taken to minimize the impact to the covered species. The Permittees and Services will identify actions that could be taken to compensate for lost ecological function until the storage volumes, flows and other protection measures required by the DBHCP can again be provided. However, in the event of failure or impairment of a covered dam or diversion the Permittees will have no obligations to provide minimization or mitigation above the levels already required by the DBHCP, expend funds in excess of those already committed to DBHCP implementation or modify the covered activities in ways not already required by the DBHCP.

9.5 Change in the Biological Status of a Covered Species

The biological status of a covered species could change for a number of reasons including large-scale loss of habitat outside the covered lands; introduction of a competitor, predator or pathogen; or global climate change. If the Permittees and the Services determine the ability of a covered species to persist on the covered lands has been reduced due to factors unrelated to the covered activities and the conservation measures of the DBHCP, the Permittees and the Services will seek opportunities to modify the DBHCP in ways that increase the potential for the species to persist. The DBHCP will only be modified to increase the potential for a covered species to persist if the modification does not: a) decrease or degrade habitat for another covered species, b) decrease the potential for another covered species to persist, c) require the Permittees to commit additional land, water, or funding, or d) place additional restrictions on the covered activities.

9.6 Change in the Federal Status of a Species

During the term of the HCP, the Services could list additional species under the ESA as threatened or endangered, delist species that are currently listed, or declare a listed species extinct. In the event of a change in the federal status of one or more species, the following steps will be taken.

9.6.1 New Listings of Species Not Covered by the DBHCP

If a species that is present or potentially present on the covered lands but not covered by the DBHCP becomes a candidate for listing, is proposed for listing, or is the subject of an emergency listing under the ESA, the Permittees will survey potential habitat for the species on the covered lands or take other appropriate steps to determine whether the species and/or its habitat(s) are present. The survey results or other information will be reported to the Services. If the Services determine there is potential for incidental take of the species as a result of the covered activities and/or continued implementation of the DBHCP, they will provide the Permittees with take avoidance/minimization guidelines and the Permittees will follow those guidelines to the extent possible once the species becomes listed and until the Permittees secure incidental take coverage for the species. When providing the Permittees with take avoidance/minimization guidelines, the Services will consider the effects of take avoidance on species already covered by the DBHCP and on the effectiveness of the DBHCP conservation measures. If the Permittees find they are not physically or legally able to follow the guidelines, they will notify the Services in writing. The Services will revise the guidelines, as appropriate, to address the needs of the species in question in a manner that can be implemented.

If avoidance of take of a newly-listed species is not possible or the Permittees desire incidental take coverage for the species, the Permittees and the Services will enter into good-faith discussions to develop the necessary and appropriate conservation measures to support incidental take coverage. All parties will endeavor to secure incidental take coverage for the Permittees prior to final listing of the species. The Services will consider all conservation benefits resulting from the Permittees' past and ongoing actions on the covered lands when determining the need for additional conservation measures for the newly-listed species.

If avoidance of take of a newly-listed species interferes with the Permittees' ability to meet their obligations under the DBHCP, the Permittees and the Services will enter into good-faith discussions to develop necessary and appropriate conservation measures and secure incidental take coverage for the species as described above. While in such discussions, and until the Permittees can secure incidental take coverage for the newly-listed species, the Permittees will follow guidance provided by the Services in accordance with this subsection. The Permittees' existing incidental take coverage will continue while new conservation measures are being discussed and amendments to the DBHCP are being prepared.

9.6.2 Presence of a Listed Species not Covered by the DBHCP on the Covered Lands

The Permittees have conducted a thorough review of species present or potentially present on the covered lands and identified for coverage in the DBHCP those listed species thought to be impacted or potentially impacted by the covered activities. However, species that are currently listed but absent from the covered lands could be present on those lands in the future due to a range expansion or reintroduction effort. If a listed species not already covered by the DBHCP is found on the covered lands and the Services determine there is potential for incidental take of the species as a result of the covered activities and/or continued implementation of the DBHCP, the Permittees will avoid incidental take of the species as directed by the Services, to the extent possible, until they secure incidental take coverage for the species. If avoidance of take of the species is not possible, the Permittees and the Services will enter into good-faith discussions to develop the necessary and appropriate conservation measures to support incidental take coverage for the species. The Services will provide the Permittees with take avoidance/ minimization guidelines and the Permittees will follow those guidelines to the extent possible until the Permittees secure incidental take coverage for the species. The Services will consider all conservation benefits resulting from the Permittees' past and ongoing actions on the covered lands when determining the need for additional conservation measures for the species.

If avoidance of take of a listed, uncovered species interferes with the Permittees' ability to meet their obligations under the DBHCP, the Permittees and the Services will enter into good-faith discussions to develop necessary and appropriate conservation measures and secure incidental take coverage for the species as described above. While in such discussions, and until the Permittees can secure incidental take coverage for the species, the Permittees will continue to implement the guidance provided by the Services. The Permittees' existing incidental take coverage will continue while new conservation measures are being discussed and amendments to the DBHCP are being prepared.

9.6.3 Delisting of a Species Covered by the DBHCP

If a species covered by the DBHCP is delisted, the Permittees and the Services will review the conservation measure(s) being implemented for that species to determine whether they are still necessary to protect the species from being relisted or proposed for relisting. If continued conservation by the Permittees is necessary to avoid relisting the species, implementation of the necessary conservation measure(s) will continue as specified in the DBHCP. If cessation or modification of the conservation measure(s) for that species will not lead to the relisting or proposal to relist the species, the Permittees and the Services will revise the DBHCP to eliminate or otherwise modify the conservation measure(s) in question, but only to the extent that such elimination or modification will not materially reduce the conservation benefits of the DBHCP for another covered species.

9.6.4 Extinction of Species Covered by the DBHCP

In the event that a species, Distinct Population Segment or Evolutionarily Significant Unit covered by the DBHCP becomes extinct, the Permittees and the Services will review the conservation measure(s) being implemented for that species to determine whether they are still necessary for the remaining (extant) covered species. If the Permittees and the Services mutually agree that elimination or modification of conservation measure(s) initially implemented for the extinct species will not materially reduce the conservation benefits of the DBHCP for another covered species, the conservation measure(s) will be eliminated or modified.

9.6.5 Adoption or Modification of a Federal Recovery Plan for a Covered Species

Federal recovery plans have been prepared for bull trout and steelhead trout, but as of 2019 there are no federal recovery plans pertinent to the covered lands for the Oregon spotted frog or sockeye salmon. The conservation measures of the DBHCP have been designed to be consistent with federal recovery plans that have been adopted and with current best available science where federal recovery planning has not been completed. If an existing federal recovery plan for a covered species is updated during the term of the DBHCP, or if a new federal recovery plan for a covered species is adopted, the Permittees and the Services will review the DBHCP for consistency with the updated or new federal recovery plan. If modification to the DBHCP is required to make it consistent with an updated or new federal recovery plan, such modification will only be made with the approval of the Permittees, and the Permittees will be under no obligation to cease or alter the covered activities, modify conservation measures or expend additional funds to retain incidental take coverage for the full term of the incidental take permits.

9.7 Climate Change

Anthropogenic increases in atmospheric CO_2 and other greenhouse gases are predicted to alter the climate of Oregon over the term of the DBHCP. In particular, changes are anticipated in air and water temperature, precipitation, snowpack, hydrologic regimes, and frequency and duration of extreme weather events. Potential effects of climate change with relevance to the DBHCP are changes in the timing and magnitude of precipitation that reduce flows in the covered waters on a seasonal or year-round basis.

The DBHCP has been specifically designed to accommodate hydrologic changes, including those that may result from climate change, without the need to modify or adjust the conservation measures. Specifically, the conservation measures in Chapter 6 and the adaptive management provisions in Chapter 7 allow for modification to the timing and duration of instream flows consistent with the amounts committed to in the conservation measures. All conservation measures of the DBHCP regarding hydrology are stated in terms of minimum instream flows that will be provided with the assumptions that future shortfalls in precipitation, if they occur, will be borne by the Permittees. If total annual inflow to the four covered reservoirs (Crane Prairie, Wickiup, Crescent Lake and Ochoco) decreases over time due to climate change, the instream flows downstream of the reservoirs specified in the DBHCP will still be provided and the decreased inflow will result in reduced irrigation storage. Instream flows provided for in the DBHCP will always have priority for water, and there are no guarantees of minimum irrigation storage in the DBHCP. The same is true for Whychus Creek where there is no storage and the DBHCP deals entirely with live flow. Conservation Measure WC-1 specifies that the last 20 cfs of available flow will remain in Whychus Creek, even though TSID's state water right would allow it to continue diverting half of the available flow down to the last cfs.

9.8 Permittee(s) Seeking Amendment to or Exit from the DBHCP

The DBHCP relies on a collective conservation strategy, while recognizing that each Permittee is legally independent from all other Permittees. The DBHCP includes a set of independent Conservation Measures that, collectively, minimize and mitigate the impacts of take from the Covered Activities to the maximum extent practicable. At the same time, the DBHCP acknowledges that each Permittee has independent legal authorities and will be individually responsible for implementing specific Conservation Measures under the DBHCP.

The DBHCP is a voluntary agreement and, during the term of the DBHCP, one or more Permittees may seek to amend their individual obligations under the DBHCP (or otherwise amend the DBHCP) or terminate their individual incidental take coverage under the Permits. The Services and the Permittees recognize that such an action by one or more Permittees could affect the collective conservation benefits provided by the DBHCP or the Services' analyses of those conservation benefits. In that event, the Services may determine that it is necessary for the Permittees to modify their conservation approach or for the Services to modify the Permits or analyses supporting those Permits.

To address the possibility that one or more Permittees will seek to amend or exit the HCP, the Permittees will execute the Inter-District Coordination Agreement attached to the DBHCP in Appendix B, which becomes effective on the date that the Services issue the Permits. That Agreement requires any "Amending or Exiting Permittee" to provide notice to all other Permittees and the Services at least one year in advance of the proposed amendment or DBHCP exit date. A “changed circumstance” occurs under this subsection of the DBHCP when all other Permittees and the Services actually receive that notice.

The Agreement creates contractual obligations for any Amending or Exiting Permittee to ensure that its proposed amendment or exit does not disrupt the conservation benefits provided under the DBHCP or the other Permittees’ abilities to maintain the Permits. The Amending or Exiting Permittee must fully cooperate with the Services and all other Permittees to conduct any additional analyses to maintain the Permits. The Amending or Exiting Permittee must also bear all resulting financial costs incurred by the other Permittees to maintain incidental take coverage under the Permits.

9.9 Inability of NUID to Secure Alternate Sources of Irrigation Water

The flow requirements for the Upper Deschutes River at Hydromet Station WICO specified in Conservation Measure WR-1 of this DBHCP will reduce average annual storage in Wickiup Reservoir and subsequently reduce the average amount of storage available to NUID. Similarly, the upper limits on irrigation season flows at WICO specified in Conservation Measure WR-1 will reduce NUID’s access to otherwise available storage. The practicability of these flow requirements is based in large part on NUID’s ability to secure replacement irrigation water, particularly when it will be needed most during years of average and below average precipitation in the Upper Deschutes River when Wickiup Reservoir does not fill during the storage season (thereby reducing storage) and/or stream flows are low during the irrigation season (thereby reducing live flow). NUID intends to secure replacement water from COID, which has recently embarked on a program of piping its canals to reduce seepage losses and encourage similar piping of patron-owned canals. COID has committed to making Deschutes River live flow that it conserves available to NUID to divert during the irrigation season. COID intends to make such water available pursuant to Oregon’s allocation of conserved water program. This will replace the water NUID will forego to support minimum flows during the storage season and maximum flows during the irrigation season at WICO under Conservation Measure WR-1. In turn, consistent with Oregon’s allocation of conserved water program, NUID will transfer or lease equal volumes of water to instream use (or flow augmentation) to support the storage season flows at WICO. The water NUID expects to acquire from COID will not, however, replace lesser amounts of water that will be lost to other flow requirements of Conservation Measure WR-1 (e.g., early ramp up and delayed ramp down).It is anticipated these other flow requirements will result in shortages for NUID’s patrons during the term of the DBHCP regardless of the amount of replacement water COID makes available to NUID.

COID has done considerable analysis of its piping program and is justifiably optimistic it will be able to provide the water needed by NUID, but two factors COID cannot fully control have bearing on the timing of the completion of the piping program, and thus on the practicability of Conservation Measure WR-1 for NUID: the availability of funding for the COID piping program, and the potential for legal challenges to the piping program. As of 2020, COID has secured much, but not all, of the funding needed to support the piping necessary to replace the water NUID will lose to the minimum storage season flows at WICO. Grants have been secured for a good portion of the COID piping, but required matching funds are still being sought.

In addition, COID and other DBBC Districts have also been faced with multiple legal challenges to their piping programs over the past decade by parties that oppose the replacement of open man-made irrigation canals with piped conveyances. These challenges have frequently resulted in delays to the piping projects. The potential for future legal challenges to COID's piping program, and associated delays, will likely continue until all piping is completed.

No changed circumstance shall exist with respect to Conservation Measure WR-1 of this DBHCP for Years 1 through 7 of implementation,[1] regardless of (i) the status of COID's piping program, (ii) the volume of replacement water that COID has made available to NUID, or (iii) the corresponding amount of water NUID has transferred or leased to instream use (or flow augmentation) to support storage season flows. Similarly, no changed circumstance shall exist with respect to Conservation Measure WR-1 in Years 8 through 12 of DBHCP implementation when COID has made at least 60,000 acre-feet of replacement water available to NUID, and NUID has transferred or leased an equal volume of water to instream use (or flow augmentation) to support the required 300 cfs storage season flow at WICO. Likewise, no changed circumstance shall exist with respect to Conservation Measure WR-1 in Years 13 through 30 of DBHCP implementation when COID has made at least 90,000 acre-feet of replacement water available to NUID, and NUID has transferred or leased an equal volume of water to instream use (or flow augmentation) to support the required 400 cfs storage season flow at WICO.

A changed circumstance shall exist at Year 8 of DBHCP implementation when a funding shortfall or legal challenge prevents COID from making at least 60,000 acre-feet of replacement water available to NUID. Similarly, a changed circumstance shall exist at Year 13 when a funding shortfall or legal challenge prevents COID from making at least 90,000 acre-feet of replacement water available to NUID. However, no changed circumstance shall exist during either phase of DBHCP implementation, regardless of the amount of water made available by COID, until NUID has exhausted the options described below for securing the respective replacement water amounts from other sources.

These thresholds of 60,000 and 90,000 acre-feet are not the full amounts of water needed by NUID to offset anticipated DBHCP losses of storage at Wickiup Reservoir in all years, but they are the amounts NUID has expectations of receiving from COID. A dry year during the first 7 years of DBHCP implementation could result in a shortage of as much as 35,200 acre-feet for NUID (Reclamation 2020). Much of this potential for shortage is attributable to the recent increase in minimum winter flow to 100 cfs (from the historical 20.8 cfs). In Years 8 through 12 of DBHCP implementation, NUID's annual shortage in dry years could reach as high as 92,800 acre-feet (47% of total demand), and in Years 13 to 30 the shortage could be as high as 126,000 acre-feet (64% of demand) (Reclamation 2020). The acquisition of 60,000 acre-feet of live flow by Year 8 will offset only the incremental increase of 57,600 acre-feet (from 35,200 acre feet in Years 1 through 7 to 92,800 in Years 8 through 12); it will not address the original 35,200 acre-feet of potential shortage. Similarly, the acquisition of 90,000 acre-feet by Year 13 will only represent the estimated 90,800 acre-foot increase relative to Years 1 through 7.

No later than July 1, 2028, COID and NUID shall determine the total amount of water COID will be making available to NUID beginning in April of 2029. If the total is less than 60,000 acre-feet, the Permittee Districts shall secure additional water for NUID on a temporary or permanent basis from willing parties at market rates, up to the amount needed to reach 60,000 acre-feet total. To support the acquisition of this additional water, the Permittee Districts will notify their patrons annually of the opportunity to sell water to NUID. If the amount of water made

[1] Year 1 of DBHCP implementation shall begin on January 1, 2021.

available by COID plus the water acquired on a temporary or permanent basis for use beginning April 1, 2029 totals 60,000 acre-feet or more, no changed circumstance shall exist. If the total is less than 60,000 acre-feet, however, a changed circumstance shall exist effective September 16, 2028. A changed circumstance of this nature shall remain in effect unless COID makes the full 60,000 acre-feet available or NUID is able to secure full replacement water from other sources, but under no circumstances shall a changed circumstance of this nature continue past September 16, 2030. Beginning September 16, 2030, the minimum flow at WICO from September 16 through March 31 shall be 300 cfs regardless of the amount of water NUID has secured from COID or other sources.

A similar changed circumstance shall exist effective September 16, 2033 if COID and NUID determine the amount of water made available by COID plus the water acquired on a temporary or permanent basis (as described above) for use beginning on April 1, 2034 totals less than 90,000 acre-feet. A changed circumstance beginning September 16, 2033 shall remain in effect unless COID makes the full 90,000 acre-feet available or NUID is able to secure full replacement water from other sources, but under no circumstances shall a changed circumstance continue past September 16, 2035. Beginning September 16, 2035, the minimum flow at WICO from September 16 through March 31 shall be 400 cfs regardless of the amount of water NUID has secured from COID or other sources.

When a changed circumstance of this nature occurs, the minimum storage season flow at WICO will be the flow that can be maintained without preventing Wickiup Reservoir from reaching “target storage volume” by April 1 in the calendar year following the start of the changed circumstance, or the minimum flow that was required in the previous phase of DBHCP implementation, whichever is greater. For purposes of a changed circumstance of this nature, “target storage volume” is 200,000 acre-feet minus: (i) the volume of water that NUID has transferred or leased to instream use (or flow augmentation) as a result of the conserved water generated from COID’s piping efforts and made available to NUID, pursuant to Oregon’s allocation of conserved water program, and (ii) the water NUID has acquired on a temporary or permanent basis for use beginning April 1. For purposes of a changed circumstance of this nature, forecasting of Wickiup Reservoir storage volume shall be done from November through March of each year by Reclamation, USFWS and NUID, with input and assistance from OWRD. During a changed circumstance of this nature, the minimum storage season flow at WICO shall be reviewed monthly from November through March and adjusted as necessary to reflect current forecasts for reservoir fill.

During a changed circumstance of this nature, COID and the other Permittee Districts shall also make a good-faith effort to identify other sources of water they can legally and logistically make available to NUID during the subsequent irrigation season, thereby enabling storage season flow at WICO to be increased toward the otherwise required minimum. This could include the release of additional storage from Crane Prairie Reservoir in accordance with Item H of Conservation Measure CP-1, if approved by USFWS. Also during a changed circumstance of this nature, the irrigation season caps on flow at WICO specified in Conservation Measure WR-1 will be lifted for up to 15 days per year, to the extent needed by NUID to meet irrigation demand.

9.10 Change in the Status of Whychus Creek

Incidental take coverage for steelhead trout on Whychus Creek is based on the presumption that peak summer water temperatures in the creek will continue to decrease over time as a result of increases in instream flows as well as ongoing and future habitat enhancement activities funded by TSID and others (including but not limited to riparian habitat restoration, channel restoration and floodplain restoration). In the event this presumption proves to be incorrect, the Services and TSID acknowledge the possible need to revisit the DBHCP conservation measures for Whychus Creek and modify those measures to further reduce peak summer water temperatures, or increase stream productivity through habitat enhancement projects.

For the term of the DBHCP, water temperature in Whychus Creek will be monitored on an hourly basis for at least the months of April through October at RM 6.0, as specified in DBHCP Chapter 7. Water temperature data collected at this location will be used to calculate the 7-day average of the daily maximum water temperature (7-DADM). Monitoring results will be reviewed annually by the Services and TSID beginning in Year 1 of DBHCP implementation to track overall subbasin progress toward reducing the 7-DADM at RM 6.0. If monitoring results do not indicate incremental reduction in peak summer temperatures or there has been limited progress in implementation of projects to ultimately reduce peak summer temperatures or otherwise offset the effects of high temperatures on steelhead, the Services will identify voluntary measures TSID can implement to advance toward meeting the 10-year target identified in the following paragraph.

No later than November 30 of Year 10 of DBHCP implementation, and every 2 years thereafter for the term of the DBHCP, TSID and the Services will review the water temperature data collected at RM 6.0 on Whychus Creek. If the maximum 7-DADM has not exceeded 20°C for more than one week (7 consecutive days) in the two summers (June 1-September 15) preceding a review (e.g., the summers of Years 9 and 10 for the review in Year 10), the presumption of decreasing peak water temperatures in Whychus Creek shall be considered correct and TSID shall retain incidental take coverage for steelhead trout. If the maximum 7-DADM exceeds 20°C for more than one week in either of the two summers preceding a review, TSID and the Services will consider the following additional factors:

1. If 7-DADM values in excess of 20°C at RM 6.0 are the result of instream and/or riparian habitat conditions, as determined by the Services, at and immediately upstream of RM 6.0, and the maximum 7-DADM between the TSID diversion and this reach does not exceed 20°C for more than one week per year, the presumption of decreasing peak water temperatures in Whychus Creek shall be considered correct and TSID shall retain incidental take coverage for steelhead trout.
2. If 7-DADM values in excess of 20°C at RM 6.0 are solely the result of natural conditions in Whychus Creek (e.g., extremely low flows) that persist even after TSID has ceased diverting water, TSID shall be considered in compliance with the DBHCP and shall retain incidental take coverage for steelhead trout.
3. If overall conditions between the TSID diversion and RM 6.0 are considered by the Services to be suitable for steelhead trout rearing due to low overall temperatures, sufficient diel temperature fluctuations and/or the presence of adequate cold-water refugia, the presumption of decreasing peak water temperatures in Whychus Creek shall be considered correct and TSID shall retain incidental take coverage for steelhead trout.
4. If monitoring in Whychus Creek indicates juvenile rearing is sufficient to support a sustainable population of steelhead in the creek, or if the steelhead population in the creek overall is found to be stable and sustainable, as determined by the Services, the

presumption of decreasing peak water temperatures in Whychus Creek shall be considered correct and TSID shall retain incidental take coverage for steelhead trout.

5. If none of Items 1 through 4 above is met, the presumption of decreasing peak water temperatures in Whychus Creek shall be considered incorrect and TSID and the Services shall review the Whychus Creek conservation measures to identify additional measures TSID can implement to reduce or mitigate for high peak water temperatures. TSID and the Services shall also identify metrics that can be used to verify the success of those additional measures and monitoring that can be done to track those metrics. If the Services, after conferring with TSID, identify measures that can be taken and monitoring that can be conducted by TSID with a reasonable likelihood of reducing peak water temperatures, TSID shall implement those measures and conduct that monitoring and TSID shall retain incidental take coverage for steelhead trout. TSID and the Services shall then review water temperature monitoring results, along with other available pertinent information, every two years beginning in Year 12 of implementation to verify the effectiveness of the additional measures. If the conditions specified in any of Items 1 through 4 above are met by Year 12 of implementation and continue to be met thereafter, TSID shall retain incidental take coverage for steelhead trout. If none of the conditions in Items 1 through 4 above are met by Year 12, NMFS may take action under its statutory and regulatory authorities, including 50 CFR 222.306, to modify, amend, suspend or revoke TSID's incidental take coverage for steelhead trout.

9.11 Unforeseen Circumstances

Unforeseen circumstances are distinguished from changed circumstances, which have been defined and for which appropriate responses have been determined. For purposes of the DBHCP, any change in circumstances affecting the covered species or the covered lands not identified as a changed circumstance in Sections 9.2 through 9.10 shall, at the determination of the Services, be considered an unforeseen circumstance.

The Services will be responsible for demonstrating when an unforeseen circumstance affecting the covered species exists, using the best available scientific and commercial data. The Services shall consider, but not be limited to:

1. The size of the current range of the affected species;
2. The percentage of the range adversely affected by the covered activities;
3. The percentage of the range that has been conserved by the DBHCP;
4. The ecological significance of that portion of the range affected by the DBHCP;
5. The level of knowledge about the affected species and the degree of specificity of the conservation program for that species under the DBHCP; and
6. Whether failure to adopt additional conservation measures would appreciably reduce the likelihood of survival and recovery of the species in the wild.

In the event of an unforeseen circumstance, the Services will not require the commitment of additional land, water or financial compensation from the Permittees or place additional restrictions on the use of land, water or other natural resources, beyond the levels already required by the DBHCP, without the prior consent of the Permittees. If additional conservation and mitigation measures are deemed necessary to respond to an unforeseen circumstance, the Services may require additional measures of the Permittees where the DBHCP is being properly implemented only if such measures are limited to modifications within conserved habitat areas or to the DBHCP's operating conservation program for the affected species, and maintain the original terms of the DBHCP to the maximum extent possible. If an unforeseen circumstance is found, the Permittees will not be required to provide additional resources or funds to remedy the unforeseen circumstance, but the Services and the Permittees will work together to determine an appropriate response within the original resource commitments of the DBHCP. However, the Permittees will not be constrained from voluntarily taking additional actions at their own expense and with the approval of the Services to protect or conserve the covered species in the event of an unforeseen circumstance or at any other time during implementation of the DBHCP.

If during the term of the DBHCP the Services identify an unforeseen circumstance, they will notify the Permittees in writing of the unforeseen circumstance. Upon being notified, the Permittees will assist the Services in determining the impacts of the unforeseen circumstance to the covered species and covered lands, and in developing actions that could be taken to avoid or minimize the impacts consistent with continued performance of the covered activities and implementation of the DBHCP. The Permittees may voluntarily provide funding for data collection, environmental studies, engineering, report preparation or other activities associated with responding to unforeseen circumstances, but they will not be required to do so.

9.12 References Cited

Reclamation (US Bureau of Reclamation). 2020. Technical memorandum – hydrologic evaluation of alternatives for the Deschutes Basin Habitat Conservation Plan, Deschutes Project, Oregon. Bureau of Reclamation Columbia Pacific Northwest Region, Boise, ID. September 2020.

USFWS and NMFS (US Fish and Wildlife Service and National Marine Fisheries Service). 1998. Habitat Conservation Plan Assurances ("No Surprises") Rule, Final Rule. Federal Register Vol 63, No 35:8859-8873. February 23, 1998.

FINAL

DESCHUTES BASIN HABITAT CONSERVATION PLAN

Chapter 10 – Costs and Funding of the Proposed Conservation Measures

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10 – COSTS AND FUNDING OF THE PROPOSED CONSERVATION MEASURES

10.1 Introduction

The DBHCP will be implemented by the nine Permittees (eight irrigation districts and the City of Prineville). Each Permittee will have separate and distinct responsibilities for DBHCP implementation, as specified in Chapter 3, Table 3-9. Consequently, the costs and funding for implementing the DBHCP are determined separately for each Permittee. The nine Permittees are separate legal entities with fiduciary responsibilities to their patrons or citizens. Each Permittee will be responsible for ensuring adequate funding for its respective requirements under the DBHCP, and each Permittee is precluded by Oregon law from assuming financial responsibility for the requirements of other Permittees.

The costs of implementing the DBHCP have been divided into six categories:

- **Capital Costs:** These are one-time capital improvements costs that are required for DBHCP implementation. These do not include canal piping by Permittees during DBHCP implementation because piping is not required to ensure the effective implementation of the DBHCP. The conservation measures of the DBHCP will be implemented as required regardless of whether additional canal piping occurs.
- **Habitat Conservation Funds:** Conservation Measures UD-1, WC-2, WC-6 and CR-4 require contributions by the Districts to habitat conservation funds annually for the term of the DBHCP.
- **Operations Staff Labor:** Most of the Permittees will experience increased labor costs under the DBHCP due to modified operations of dams and diversions and requirements for monitoring of reservoir volumes and stream flows. These costs will occur every year.
- **Administrative Staff Labor:** All of the Permittees will experience increased labor costs for administrative staff involved in compliance monitoring and annual reporting. These costs will occur every year.
- **Contract Services for Monitoring:** The Permittees will fund implementation and biological effectiveness monitoring as required by the DBHCP (see Chapter 7, *Monitoring, Reporting and Adaptive Management*). Monitoring requirements, which are linked to specific Conservation Measures, vary by Permittee. Consequently, the costs for effectiveness monitoring will also vary by Permittee. Monitoring activities will vary from year to year, so average annual costs for the term of the DBHCP are reported here. Most requirements for implementation and effectiveness monitoring in DBHCP Chapter 7 that require the services of qualified biologists are stated in terms of the numbers of hours of biologists' time the Permittees will fund each year. The costs for that monitoring summarized here in Chapter 10 are therefore estimates based on anticipated labor rates for contract biologists. These estimated costs are not commitments on the part of the Permittees and are not to be viewed as requirements of the DBHCP. The requirements for monitoring are the commitments to secure the services of qualified biologists for the numbers of hours specified in Chapter 7.

- **Contract Services for Annual Reporting:** The Permittees will contract for the annual compilation of information from all nine Permittees and preparation of the annual compliance and effectiveness monitoring report to the Services. The costs for annual reporting are allocated among the nine Permittees.

All DBHCP implementation costs are summarized in Table 10-1. The costs for each of the nine Permittees, along with the respective funding sources, are described in the following sections.

Table 10-1. Estimated direct costs for implementing the Deschutes Basin HCP, in 2020 dollars.

Permittee	One-time Capital Costs	Average Annual Expenditures					
		Conservation Funds	Operations Staff Labor	Admin Staff Labor	Contract Services (monitoring)	Contract Services (reporting)	Total Annual Expenditures
AID	$0	$6,243	$14,256	$1,129	$14,796	$178	**$36,602**
COID	$0	$63,770	$24,288	$4,200	$25,208	$1,762	**$119,228**
LPID	$0	$3,373	$14,256	$640	$14,796	$119	**$33,184**
NUID	$0	$83,882	$3,900	$1,200	$25,000	$2,284	**$116,266**
OID	$46,500	$4,000	$18,000	$720	$1,500	$766	**$24,986**
SID	$0	$6,207	$4,126	$825	$0	$178	**$11,336**
TSID	$50,000	$16,000	$11,250	$2,520	$0	$290	**$30,060**
TID	$0	$11,525	$20,000	$5,000	$15,333	$290	**$52,148**
City	$0	$4,000	$0	$734	$0	$733	**$5,467**

10.2 Arnold Irrigation District

AID will experience average annual implementation costs of $36,602 for the term of the DBHCP (Table 10-1). The largest portions of AID's annual costs will be associated with operation and monitoring of Crane Prairie Reservoir. The reservoir is operated by COID primarily on behalf of itself, AID and LPID. A small portion of the storage in the reservoir is allocated to NUID as a result of recent conserved water projects, but NUID does not share in operational costs for the reservoir. Crane Prairie Reservoir is an unmanned facility that lies about 72 miles from COID's offices in Redmond. The reservoir volume and flow targets specified in Conservation Measure CR-1 will require frequent trips to the dam to adjust outflow in all months of the year. The additional cost for operating Crane Prairie Reservoir under the DBHCP is estimated to be $52,800 annually. All costs for operation and maintenance of Crane Prairie Reservoir are allocated among the three Districts in proportion to their full storage rights (46% COID, 27% AID and 27% LPID). Based on this method of allocation, AID's share of the increased annual costs for operation and maintenance will be $14,256.

Biological effectiveness monitoring of Crane Prairie Reservoir will vary in intensity from year to year because various elements of the monitoring will not occur every year. The average annual cost for effectiveness monitoring will be $54,800. Based on AID's responsibility for 27 percent of the costs for operation and maintenance, its share of the costs for effectiveness monitoring will be $14,796.

The cost of the Upper Deschutes Basin Habitat Conservation Fund will be allocated among the six Permittees that divert water from the Deschutes River (AID, COID, LPID, NUID, SID and TID) based on their relative size (irrigated acres). AID's share of the fund will be $5,351 per year. AID will also pay another $892 per year to support implementation monitoring associated with the fund, for a total cost to AID of $6,243 associated with the fund.

AID will also have internal costs of $1,129 annually for administrative staff time involved in tracking the District's compliance with the DBHCP. Lastly, AID's share of the costs for preparation of the annual DBHCP monitoring and compliance report to the Services will be $178. AID will not need to make any capital improvements to fulfill its requirements under the DBHCP.

AID will fund its DBHCP implementation costs by increasing patron assessments or incurred charges as necessary, as authorized by Oregon law [*See* ORS 545.381, 545.482]. As of 2020, AID's annual operating revenue from patrons was $898,021. The DBHCP implementation cost of $36,602 will require a 4.1 percent increase in annual revenue. The District has 650 patrons who irrigate 4,384 acres. An annual cost of $36,602 represents $56.31 per patron or $8.35 per irrigated acre.

The reduced access to storage in Crane Prairie Reservoir under the DBHCP will reduce AID's ability to meet irrigation demand, particularly in dry years. This will not prevent AID from fulfilling its requirements under the DBHCP, but it will impact the economic interests of its patrons. To compensate for the reduced availability of water, AID plans to pipe its main canals and reduce the associated seepage losses. The current estimated costs for piping to eliminate AID's need for Crane Prairie Reservoir storage altogether is $40,000,000. This is in addition to approximately $700,000 AID spent on canal piping and lining to reduce seepage losses between 2010 and 2020. The District will seek government grants to support a portion of its canal piping costs during the term of the DBHCP. Under the assumption of a 30-year loan, the full cost of piping at 1.59 percent interest results in a maximum annual debt service of $1,686,894, which would equate to an additional annual cost of $2,595.22 per patron or $384.78 per acre.

10.3 Central Oregon Irrigation District

COID will experience average annual implementation costs of $119,228 for the term of the DBHCP (Table 10-1). The Upper Deschutes Basin Conservation Fund will account for nearly half of COID's annual implementation costs; operation and monitoring of Crane Prairie Reservoir will account for most of the remainder. With a responsibility for 46 percent of the costs for operation and maintenance of the reservoir, COID's share of increased costs under the DBHCP will be $24,288 and its share of effectiveness monitoring will be $25,208.

COID will have internal costs of $4,200 each year for administrative staff time involved in tracking the District's compliance with the DBHCP. COID's share of the costs for preparation of the annual DBHCP monitoring and compliance report to the Services will be $1,762. COID will not need to make any capital improvements to fulfill its requirements under the DBHCP.

COID will fund its DBHCP implementation costs by increasing patron assessments or incurred charges as necessary, as authorized by Oregon law [*See* ORS 545.381, 545.482]. As of 2020, COID's annual patron irrigation revenue was $1,951,115. The DBHCP implementation cost of $119,228 will require a 6.1 percent increase in annual irrigation revenue. The District has 3,590 patrons who irrigate 45,000 acres. An annual cost of $119,228 represents $33.21 per patron or $2.65 per irrigated acre.

The reduced access to storage in Crane Prairie Reservoir under the DBHCP will reduce COID's ability to meet irrigation demand in most years. This will not prevent COID from fulfilling its requirements under the DBHCP, but it will impact the economic interests of its patrons. To compensate for the reduced availability of water, COID plans to pipe its main canals and reduce the associated seepage losses. The current estimated costs for piping to eliminate COID's need for Crane Prairie Reservoir storage altogether is $115,000,000. This is in addition to approximately $5,415,000 COID spent on canal piping to reduce seepage losses between 2010 and 2020. The District will seek government grants to support a portion of its canal piping costs during the term of the DBHCP. Maximum annual debt service of $4,849,822 on loans of $115,000,000 would equate to an additional annual cost of $1,350.93 per patron or $107.77 per acre. Additionally, due to decreased diversions COID expects a decrease of $300,000 in hydroelectric revenue each year. To offset this revenue loss COID would need to assess an additional $83.57 per patron or $6.67 per acre.

10.4 Lone Pine Irrigation District

LPID is the third District with storage rights in Crane Prairie Reservoir. It will experience average annual implementation costs of $33,184 for the term of the DBHCP, largely associated with the increased costs for operating and monitoring the reservoir (Table 10-1). LPID is responsible for 27 percent of the annual costs at Crane Prairie Reservoir. This will amount to an additional $14,256 for operation and maintenance and $14,796 for effectiveness monitoring under the DBHCP. Due to its small size compared to other Deschutes River districts, LPID's annual contribution to the Upper Deschutes Basin Conservation Fund, including monitoring costs, will be $3,373.

LPID will have internal costs of $640 each year for administrative staff time involved in tracking the District's compliance with the DBHCP. Its share of the costs for preparation of the annual DBHCP monitoring and compliance report to the Services will be $119. LPID will not need to make any capital improvements to fulfill its requirements under the DBHCP.

LPID will fund its DBHCP implementation costs by increasing patron assessments or incurred charges as necessary, as authorized by Oregon law [*See* ORS 545.381, 545.482]. As of 2020, LPID's annual operating revenue was $153,985. The DBHCP implementation cost of $33,184 will require a 21.6 percent increase in annual revenue. The District has 19 patrons who irrigate 2,369 acres. An annual cost of $33,184 represents $1,746.53 per patron or $14.01 per irrigated acre.

The reduced access to storage in Crane Prairie Reservoir under the DBHCP will reduce LPID's ability to meet irrigation demand in all years. This will not prevent LPID from fulfilling its requirements under the DBHCP, but it will impact the economic viability of its patrons. To compensate for the reduced availability of water, LPID plans to pipe its main canal and reduce the associated seepage losses at an estimated cost of $10,254,245. Piping of the canal will not eliminate LPID's need for Crane Prairie Storage altogether, but it will reduce demand to the volume of water that will be available under the DBHCP. The District has secured federal funding for $7,690,000 of this and is seeking state funding for another $600,000. LPID estimates it will be able to secure grants for all but $1,964,245 of the amount needed to pipe its main canal. This is in addition to approximately $98,162 LPID spent on canal piping to reduce seepage losses between 2010 and 2020. Maximum annual debt service of $82,837 on loans of $1,964,245 would equate to an additional annual cost of $4,359.83 per patron or $34.97 per acre.

10.5 North Unit Irrigation District

NUID will spend an average of $116,266 annually on direct implementation costs and another $250,000 to offset a portion of the storage it will lose each year in Wickiup Reservoir with water from the Crooked River. In addition, NUID will lose as much as $500,000 annually in revenue due to reduced water sales under the DBHCP.

The majority (72%) of NUID's annual implementation costs for the DBHCP will be the $83,882 it will contribute to the Upper Deschutes Basin Conservation Fund and associated monitoring (Table 10-1). The District will also spend an estimated $25,000 on implementation monitoring for Conservation Measure WR-1. Annual implementation costs will also include $3,900 in labor to operate the Crooked River Pumps in compliance with Conservation Measure CR-7, $1,200 in administrative time to track and report DBHCP compliance at Wickiup Dam and the Crooked River pumps and $2,284 to cover NUID's share of the joint report to the Services. NUID will also contribute to the Crooked River Conservation Fund required by Measure CR-4. The Districts contribution to the fund will be phased in over time based on increases in the Consumer Price Index, and is not expected to exceed $4,000 per year. Since NUID will not contribute to the Crooked River Conservation Fund in Year 1, the amount is not shown in Table 10-1. NUID will not need to make any capital improvements to fulfill its requirements under the DBHCP.

NUID will replace a portion of the storage that will not be available from Wickiup Reservoir by purchasing stored water in Prineville Reservoir. Each year Reclamation makes up to 10,000 acre-feet of water in Prineville Reservoir available for purchase by NUID at $5.00 per acre-foot. The exact amount made available depends on the extent to which Prineville Reservoir fills each year, and it could be less than 10,000 acre-feet. Historically, NUID has needed this storage only occasionally. Under the DBHCP, however, NUID anticipates needing to purchase the full available amount every year. Once released from Prineville Reservoir, the water moves down the Crooked River where it is diverted at the NUID pumps. The current cost to pump the water out of the river and into NUID's main canal is approximately $20.00 per acre-foot, mostly for electricity. The total cost is thus $25.00 per acre-foot, or $250,000 annually for the full 10,000 acre-feet that NUID will need to pump. It is anticipated that the pumping costs will increase during the term of the DBHCP, as the cost of electricity is anticipated to increase over time.

NUID will also experience revenue losses under the DBHCP due to the loss of storage in Wickiup Reservoir. NUID typically delivers about 2 acre-feet per acre to its patrons each year. This is less than half the full water right (duty) assigned to the lands within the district, but it is an amount NUID can reliably deliver in most years. Patrons are assessed a charge or fee to meet the financial needs of operating the District. The assessed amount typically increases 2 to 3 percent annually as a result of inflation. In years of high runoff when Wickiup Reservoir fills and NUID has access to more water than it needs to meet the initial deliveries, it makes the "excess" water available to patrons at an additional charge. Unlike initial deliveries that are covered by the annual fee, excess water is billed by the amount delivered. This approach enables NUID to provide reliable deliveries based on the amount of water available in Wickiup Reservoir in most years, and offer patrons additional opportunities for crop production in wet years. This water is not excess relative to the duty for NUID lands because the full duty is never met. The water is excess only relative to the normal delivery rate for NUID, which is less than half the duty.

From 2004 through 2018 NUID generated an average of $306,178 in revenue from the sale of excess water (Table 10-2). Under the DBHCP, Wickiup Reservoir will fill less often and sales of excess water will be reduced. The shortage of water and associated reduction in excess water deliveries will increase over time under the DBHCP as the required minimum flow below Wickiup Dam in the winter increases from 100 cfs in Year 1 to 400 cfs in Year 13. Based on RiverWare hydrologic model projections of NUID shortage under the DBHCP (Reclamation 2020) and actual sales of excess water from 2004 through 2018, NUID's average annual loss will range from an estimated $71,347 in Years 1-7 to $285,068 in Years 13 and later. In some years after Year 13 the annual loss in revenue could exceed $500,000.

NUID will fund direct DBHCP implementation costs and additional water purchase costs, and replace lost revenue, by increasing patron assessments or incurred charges as necessary, as authorized by Oregon law [*See* ORS 545.381, 545.482]. As of 2020, NUID's annual operating revenue was $4,491,238. The direct DBHCP implementation cost of $116,266, water purchase cost of $250,000, and average revenue loss of $71,347 to $285,068 will require a 9.7 to 14.5 percent increase in annual revenue. Years with costs in excess of these averages will require larger increases in annual revenue. The District has 980 patrons who irrigate 59,000 acres. An annual cost of $437,613 to $651,334 represents $446.54 to $664.63 per patron or $7.42 to $11.04 per irrigated acre.

The reduced access to storage in Wickiup Reservoir under the DBHCP will reduce NUID's ability to meet irrigation demand in most years. This will not prevent NUID from fulfilling its requirements under the DBHCP, but it will impact the economic viability of agriculture within the District. To compensate for the reduced availability of water, NUID plans to acquire water from COID by cost-sharing in the piping of COID canals to reduce seepage losses. The current estimated cost for the amount of piping needed to replace NUID's lost storage is $115,000,000.

This is in addition to approximately $2,306,129 NUID spent on canal piping to reduce seepage losses within its own district and COID between 2010 and 2020. NUID will seek government grants to support a portion of the canal piping costs it will incur during the term of the DBHCP. Maximum annual debt service of $4,849,822 on loans for $115,000,000 would equate to an additional cost of $4,948.80 per patron or $82.20 per acre.

Table 10-2. Historical sales of excess water by NUID, and corresponding reductions in sale revenues that would have occurred during those years under the Deschutes Basin HCP.

Year	Historical Sales		Estimated Reductions in Excess Water Sales during DBHCP Phases (acre-feet)			Estimated Revenue Losses during DBHCP Phases		
	Volume Delivered (acre-feet)	Revenue Generated	100 cfs Minimum Flow (Years 1-7)	300 cfs Minimum Flow (Years 8-12)	400 cfs Minimum Flow (Years 13-30)	100 cfs Minimum Flow (Years 1-7)	300 cfs Minimum Flow (Years 8-12)	400 cfs Minimum Flow (Years 13-30)
2004	9,565	$177,760	2,057	9,565	9,565	$29,482	$177,760	$177,760
2005	2,301	$43,791	2,301	2,301	2,301	$43,791	$43,791	$43,791
2006	13,204	$262,728	247	13,204	13,204	$224,798	$484,364	$484,364
2007	19,659	$400,088	0	7,778	19,659	$280	$145,835	$400,088
2008	23,896	$517,211	0	8,274	23,896	$214	$182,896	$517,211
2009	16,501	$363,518	0	1,921	11,362	$31,994	$51,511	$253,544
2010	7,449	$173,535	0	4,341	7,449	$24,598	$107,035	$173,535
2011	12,156	$311,173	0	8,574	12,156	$67,712	$234,522	$311,173
2012	15,221	$399,003	0	0	5,563	$93,789	$71,472	$192,335
2013	15,353	$404,182	0	4,799	15,353	$96,595	$178,314	$404,182
2014	12,460	$335,139	0	1,594	12,460	$85,909	$102,604	$335,139
2015	8,136	$224,207	0	2,717	8,136	$61,871	$108,241	$224,207
2016	5,979	$171,681	0	5,979	5,979	$52,364	$171,681	$171,681
2017	9,775	$330,866	0	9,775	9,775	$135,489	$330,866	$330,866
2018	7,206	$256,146	379	6,957	7,206	$121,318	$250,822	$256,146
Average	**11,924**	**$306,178**	**332**	**5,852**	**10,938**	**$71,347**	**$176,114**	**$285,068**

10.6 Ochoco Irrigation District

OID will have a one-time capital cost of $46,500 during the first 5 years of DBHCP implementation and annual costs of $24,986 for all years of the DBHCP, including Year 1 (Table 10-1). The majority of OID's annual implementation costs ($18,000) will be associated with operation and monitoring of its reservoirs and diversions to ensure the instream flow commitments of Conservation Measures CR-1, CR-2 and CR-3 are met. OID will also have internal costs of $720 per year for administrative tracking of the District's compliance with the DBHCP. OID's share of the costs for preparing the annual DBHCP monitoring and compliance report will be $766. OID will incur capital costs of $21,500 for the installation of stream gages in Year 1 to satisfy the monitoring requirements of Chapter 7. OID will also incur capital costs of $5,000 each year for the first five years of implementation to support screening of patron pumps as required by Conservation Measure CR-5.

OID will fund its DBHCP annual implementation costs by increasing patron assessments or incurred charges as necessary, as authorized by Oregon law [*See* ORS 545.381, 545.482]. As of 2020, OID's annual operating revenue was $1,514,953. The DBHCP implementation cost of $24,986 will require a 1.7 percent increase in annual revenue. OID has 898 patrons who irrigate 20,062 acres. An annual cost of $24,986 represents $27.82 per patron or $1.25 per irrigated acre.

The capital cost of $26,500 ($21,500 + $5,000) in Year 1 will be covered by patrons at the additional cost of $29.51 per patron or $1.32 per acre. The capital costs of $5,000 per year in Years 2 through 5 will be covered by patrons at the additional cost of $5.57 per patron or $0.25 per acre.

10.7 Swalley Irrigation District

SID will have average annual implementation costs of $11,336 for the term of the DBHCP (Table 10-1). The largest portion of SID's annual implementation costs will be its annual contribution of $6,207 to the Upper Deschutes Basin Habitat Conservation Fund and associated implementation monitoring. SID will also spend an estimated $4,126 each year for additional staff time to operate and monitor its diversions during winter stock runs in compliance with Conservation Measure DR-1. SID will have internal costs of $825 each year for administrative tracking of the District's compliance with the DBHCP. Its share of the costs for preparation of the annual DBHCP monitoring and compliance report will be $178. SID will not need to make any capital improvements to fulfill its requirements under the DBHCP.

SID will fund its DBHCP implementation costs by increasing patron assessments or incurred charges as necessary, as authorized by Oregon law [*See* ORS 545.381, 545.482]. As of 2020, SID's annual operating revenue was $569,335. The DBHCP implementation cost of $11,336 will require a 2.0 percent increase in annual revenue. The District has 662 patrons who irrigate 4,467 acres. An annual cost of $11,336 represents $17.12 per patron or $2.54 per irrigated acre.

SID generates electricity at its Ponderosa Hydroelectric Project, which utilizes water diverted for irrigation and livestock. If the DBHCP reduces SID's diversions of water it will also reduce revenues from the sale of electricity. SID's diversions during the irrigation season are not expected to be impacted by the DBHCP, but diversion of stock water during the winter could be reduced by Conservation Measure DR-1 when the flow in the Deschutes River upstream of Bend is low. SID generates about $6,800 in hydropower revenue annually from stock water diversions. All or part of this $6,800 could be lost in a winter of low flows.

10.8 Three Sisters Irrigation District

TSID will have a one-time cost of an estimated $50,000 of in-kind services for the implementation of Conservation Measure WC-7, *Plainview Dam removal*, and annual costs of $30,060 for all years of the DBHCP, including Year 1 (Table 10-1). The largest portion of TSID's annual implementation costs will be its combined contributions of cash and in-kind services to two conservation funds totaling $16,000 per year. The District will also spend an estimated $11,250 for additional staff time to operate and monitor its diversion in compliance with Conservation Measures WC-1 and WC-5. TSID will also have internal costs of $2,520 each year for administrative tracking of the District's compliance with the DBHCP. Its share of the costs for preparation of the annual DBHCP monitoring and compliance report will be $290.

TSID will fund its DBHCP implementation costs by increasing patron assessments or incurred charges as necessary, as authorized by Oregon law [*See* ORS 545.381, 545.482]. As of 2020, TSID's annual operating revenue was $297,900. Annual implementation costs of $30,060 (excluding capital costs) will require a 10.1 percent increase in annual revenue. TSID has 194 patrons who irrigate 7,572 acres. An annual cost of $30,060 represents $154.95 per patron or $3.97 per irrigated acre.

In 2019 and 2020 TSID completed the piping of its main canal and transferred the final 3 cfs of conserved water to instream use to achieve the 31.18 cfs of permanent instream water right identified in Conservation Measure WC-1. This final phase of piping cost TSID approximately $100,000. During the same period, TSID automated its intake structure to enable it to meet the flow requirements of Conservation Measures WC-1 and WC-5, at a cost of about $20,000. However, these costs are not included in the TSID totals shown in Table 10-1 because they were incurred prior to completion of the DBHCP and issuance of the incidental take permits.

10.9 Tumalo Irrigation District

TID will experience average annual implementation costs of $52,148 for the term of the DBHCP (Table 10-1). The largest portion of this ($20,000) will be additional labor needed to operate and monitor Crescent Lake Dam in compliance with Conservation Measure CC-1. Like Crane Prairie Dam, Crescent Lake Dam is a remote, unmanned facility located more than 50 miles from TID's office in Bend. Operation of the dam under the DBHCP will require more frequent visits by TID personnel than would otherwise occur. TID also recently installed a new stream gage on Crescent Creek in anticipation of the DBHCP. Operation and maintenance of that gage for DBHCP compliance will require regular visits by District personnel to download data and service the equipment. TID's contribution to the Upper Deschutes Basin Habitat Conservation Fund and associated implementation monitoring will be $11,525. The District will spend an estimated $15,333 each year on compliance and implementation monitoring. The District will also have internal administrative costs of $2,400 each year for tracking compliance with the DBHCP, and TID's share of the costs for preparation of the annual DBHCP monitoring and compliance report will be $290.

TID will fund its DBHCP annual implementation costs by increasing patron assessments or incurred charges as necessary, as authorized by Oregon law [*See* ORS 545.381, 545.482]. As of

2020, TID's annual operating revenue was $1,296,266. The annual DBHCP implementation cost of $52,148 will require a 4.0 percent increase in annual revenue. The District has 660 patrons who irrigate 8,110 acres. An annual cost of $52,148 represents $79.01 per patron or $6.43 per irrigated acre.

The reduced access to storage in Crescent Lake Reservoir under the DBHCP will reduce TID's ability to meet irrigation demand in most years. This will not prevent TID from fulfilling its requirements under the DBHCP, but it will impact the economic interests of its patrons. To compensate for the reduced availability of water, TID plans to pipe its canals and reduce the associated seepage losses. The current estimated costs for piping the entire District to compensate for the loss of Crescent Lake Reservoir storage is $44,000,000. TID anticipates receiving federal grants for $29,500,000 of this cost, leaving $14,500,000 to be funded by the District. TID spent approximately $18,331,150 on canal piping to reduce seepage losses between 2010 and 2020. The annual debt service on $14,500,000 will be $611,921, which equates to $927.15 per patron or $75.45 per acre.

10.10 City of Prineville

The City will incur annual costs of $5,467 during implementation of the DBHCP. The largest portion of this ($4,000) will be the City's contribution to the Crooked River Conservation Fund. Internal labor costs for annual compliance monitoring will be $734, and the City's share of costs for preparation of the annual DBHCP monitoring and compliance report to the Services will be $733. The City will fund DBHCP implementation within its existing annual budget, consistent with the City's powers under its general charter (*See* City of Prineville Charter, Section 4).

10.11 References Cited

Reclamation (US Bureau of Reclamation). 2020. Technical memorandum – hydrologic evaluation of alternatives for the Deschutes Basin Habitat Conservation Plan, Deschutes Project, Oregon. Bureau of Reclamation Columbia Pacific Northwest Region, Boise, ID. September 2020.

FINAL

DESCHUTES BASIN
HABITAT CONSERVATION PLAN

Chapter 11 – Alternatives to the Proposed Incidental Take

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11 – ALTERNATIVES TO THE PROPOSED INCIDENTAL TAKE

11.1 Introduction

The ESA requires applicants for incidental take permits to identify what alternative actions to the take of covered species were considered and the reasons why those alternatives were not selected. During the preparation of the DBHCP, the Services, the Permittees and other members of the Working Group identified and considered a number of alternatives to the proposed incidental take. These alternatives involved variations in the authorized level of incidental take (including take avoidance) and variations in the type and magnitude of minimization and mitigation. Many of the alternatives were subtle changes to the proposed conservation measures that were identified during measure development; these were evaluated for their potential effectiveness, and dismissed in favor of the conservation measures described in Chapter 6. Other alternatives, however, represent meaningful differences in the overall approach of the DBHCP that were favored by one or more participant in the process, but were dismissed because the Permittees and/or the Services found they were less likely than the proposed DBHCP to meet the objectives of the Permittees and/or satisfy the incidental take permit issuance criteria of ESA Section 10(a)(2)(B). These alternatives are presented below, along with the reasons they are not being utilized in the DBHCP.

The DBHCP covers a large and diverse geographic area. The grouping of conservation measures by subbasin in Chapter 6, *Habitat Conservation*, is a reflection of this diversity. Each subbasin is unique, each was evaluated individually during DBHCP development, and each will be managed according to a specific set of conservation measures that is not applicable to the other subbasins. The same is true for alternatives. No single alternative could simultaneously address the different approaches to habitat conservation that were identified for the individual subbasins. Consequently, alternatives are presented below according to the individual subbasins used to describe the conservation measures. For some subbasins, there was clear consensus on the conservation approach throughout DBHCP development and take avoidance was the only identified alternative. For other subbasins multiple alternatives were developed, and these are described below.

A primary consideration by the Permittees when evaluating alternatives to the proposed incidental take was the practicability of those alternatives. Simply stated, practicability addresses the ability of a Permittee to implement a habitat conservation strategy in a manner that is technologically feasible, legally permissible and economically viable. The determination of practicability is variable from Permittee to Permittee because each Permittee has a unique set of physical, legal and financial constraints under which it operates. The process by which practicability was determined for each individual DBHCP Permittee is described in detail in Section 11.8 of this chapter.

11.2 Take Avoidance

If the Permittees chose not to pursue incidental take coverage for the covered activities they would remain subject to the take prohibitions of ESA Section 9(a)(1)(B) and would therefore need to avoid all take of listed species during the performance of their activities. This is generally referred to as *take avoidance*. The Permittees considered take avoidance, but they did not pursue it for the covered activities because it would be either economically impracticable or technically impossible.

Practicability becomes a constraint when take avoidance requires the complete or near complete cessation of a covered activity. For example, changes in the flow of the Upper Deschutes River resulting from the storage and release of water at Wickiup Reservoir have been identified as potentially causing incidental take of Oregon spotted frogs inhabiting the Deschutes River downstream of the reservoir. Complete avoidance of the potential for take would likely require significant reduction in storage, if not complete cessation of storage altogether. On average, NUID has historically met over half of its irrigation demand with storage from Wickiup Reservoir. A reduction in storage of the amount that would be required for take avoidance would make irrigated agriculture impossible throughout much of the area served by NUID. Under the DBHCP, NUID will reduce the amount of water it stores in Wickiup Reservoir over time to reduce the potential for incidental take, but the transition will not be immediate and it will not be complete. The transition to reduced storage will occur over multiple years to enable NUID to secure alternate sources of water, and the transition will stop short of eliminating all storage because NUID's irrigation demands cannot be fully met from other sources. Without the issuance of incidental take permits at the beginning of the transition process, NUID would need to immediately reduce storage at Wickiup Reservoir to levels that would have severe consequences to its patrons. Analogous conditions exist at Crane Prairie Reservoir (operated by COID), Crescent Lake Reservoir (operated by TID) and Ochoco Reservoir (operated by OID). None of the Districts that rely on these reservoirs could accommodate an immediate cessation of storage to avoid the potential for incidental take without severely impacting the agricultural activities of patrons.

Potential incidental take associated with the diversion of irrigation water and resulting reductions in instream flow would also be impracticable to avoid. The relationships between irrigation diversions and instream habitats for fish and wildlife are extremely complex in aquatic systems that also experience natural variations in flow. Habitat suitability in aquatic systems fluctuates seasonally and annually under natural conditions, and mortality of fish and wildlife is often a consequence of those natural fluctuations. Changes in flow resulting from irrigation diversions alter natural hydrology and can decrease overall habitat quality to the extent that aquatic organisms are harmed. Since it is impossible to fully distinguish natural mortality from anthropogenic mortality in highly altered aquatic systems, the only option for avoiding potential take with certainty would be to significantly reduce or eliminate the human activity. In the case of the covered activities, this would mean substantially reducing or eliminating irrigation diversions altogether. The Permittees do not consider this a practicable alternative because it would be inconsistent with the legal mandates of the Permittees to deliver irrigation water to their patrons.

In addition to the matter of practicability, it would be extremely difficult if not impossible to eliminate all sources of incidental take associated with the covered activities. This is particularly true for Wickiup Reservoir. The historical storage and release of water at Wickiup Reservoir have increased spring and summer flows in the Deschutes River far above natural levels (see Section 6.2.6, *Rationale for Conservation Measure WR-1*). Wetlands downstream of Wickiup Dam that currently support Oregon spotted frogs are at least partially dependent on those artificially elevated summer flows. If winter storage of water were ceased or substantially reduced to eliminate the negative effects on Oregon spotted frog overwintering habitat in the Upper Deschutes River, spring and summer flows could decrease to the extent that Oregon spotted frog habitat in the occupied wetlands would diminish and deteriorate. It is possible that new wetlands could develop lower in the Deschutes River floodplain (i.e., closer to the main channel of the river) over time with reduced summer flows, but a sudden transition to reduced flows could have a substantial negative impact on Oregon spotted frogs that currently inhabit these areas. The only viable approach for addressing the long-term conservation of Oregon spotted frogs in the Upper Deschutes River is a gradual transition from historical reservoir operation to one that balances beneficial winter and summer habitat conditions. This would not be possible without some incidental take of Oregon spotted frogs.

Take avoidance would be equally difficult on Crescent Creek and the Little Deschutes River. Water is typically stored in Crescent Lake Reservoir from October through June and released for irrigation use from July through September. Natural flows downstream of Crescent Dam are quite variable from month to month and year to year. Operation of the reservoir has reduced the natural fluctuations and improved riparian wetland habitat conditions for Oregon spotted frogs in the spring and summer. The average reduction in flow associated with winter storage over 9 months each year (a potential negative impact) is very small compared to the average increase in flow when that same volume of water is released over three months from July through September. The summer release comes at a time when natural flows in Crescent Creek and the Little Deschutes River are at their annual low. Consequently, the releases maintain wetland habitats for Oregon spotted frogs that would otherwise go dry. The reservoir also buffers natural spikes in flow during the Oregon spotted frog breeding season that could otherwise lead to stranding or flushing of eggs and tadpoles. At the end of each irrigation season in late September, the release of storage from Crescent Lake Reservoir ceases and the flows in lower Crescent Creek return to natural levels. This transition has been identified as potentially resulting in incidental take of Oregon spotted frogs, but if the transition were not made there could be no storage of water during the winter and no beneficial release of that water the subsequent summer.

The conservation measures described in Chapter 6, *Habitat Conservation*, are designed to reduce the potential for incidental take associated with the covered activities as much as is technically and economically feasible. For the reasons stated above, complete avoidance of take is not considered a viable alternative by the Permittees.

11.3 Alternatives to the 30-year Term of the DBHCP

The term of the DBHCP and associated incidental take permits will be 30 years. Terms of less and more than 30 years were considered, but dismissed. Terms of less than 30 years would provide less regulatory certainty for the Permittees and less time to realize the fish and wildlife benefits of the increased instream flows the DBHCP will provide. The Districts will need to make substantial capital improvements to their canal systems to replace the water being left instream under the DBHCP. These improvements will take several years to complete, and the rate at which instream flows will increase is based in part on the rate at which the Districts can fund and complete the improvements. A term of less than 30 years would give the Districts less time to make system improvements, and the amount of water that could practicably be left instream would be less. In addition, the Services and the parties supported by the Upper Deschutes Basin Habitat Conservation Fund (Conservation Measure UD-1) will need time to make physical habitat improvements to the river and floodplain concurrent with scheduled increases in instream flow. A shorter term for the DBHCP would allow less time to make these habitat improvements. A term of more than 30 years would provide the Permittees greater regulatory certainty, and potentially more time to make system improvements, but it would also extend the time before the Services could seek modifications to the conservation strategies for the covered species, if needed.

11.4 Alternatives for the Upper and Middle Deschutes River

11.4.1 Crane Prairie Reservoir

No alternatives to the DBHCP have been identified for Crane Prairie Reservoir that would result in less incidental take than the conservation measures described in Chapter 6. The proposed management of Crane Prairie under the DBHCP will emphasize the protection and enhancement of Oregon spotted frog habitat above all else, and it will allow for modifications over time to achieve that objective (see Chapter 7, *Monitoring, Reporting and Adaptive Management*). The Permittees and the Services were in agreement on the importance of wetland habitats in Crane Prairie throughout DBHCP development, and no fundamentally different approaches to reservoir management were identified.

Continued operation of Crane Prairie Reservoir according to historical practices was not considered a viable alternative. Although it might allow Oregon spotted frogs to persist in the reservoir, it would also limit the number of frogs the reservoir could sustain. Historical fluctuations of 4 feet or more in water surface elevation between spring and fall, and drawdown of the reservoir in early summer, likely resulted in years when there was little or no survival of tadpoles. Oregon spotted frogs likely persisted in the reservoir only because of the high reproductive capacity of adult females in years of favorable water levels. Under the DBHCP, conditions for breeding, summer rearing and overwintering will be much improved from historical operations by the reduction in seasonal fluctuation during most years, and this is anticipated to increase the number of Oregon spotted frogs that are supported. On a periodic basis, the reservoir may be fluctuated an additional 5,000 acre-feet to maintain favorable vegetation conditions for Oregon spotted frogs over the long term and discourage invasive plants and animals that are harmful to the frogs.

11.4.2 Wickiup Reservoir

Three alternatives to the DBHCP were identified for the management of Wickiup Reservoir. All three alternatives involved changes in the timing and magnitude of minimum flows in the Deschutes River below Wickiup Dam during the winter (Table 11-1). Historically the minimum flow below Wickiup Dam was 20.8 cfs. In 2016 the minimum was increased to 100 cfs. Conservation Measure WR-1 of the DBHCP (see Section 6.2.5, *Conservation Measure for Wickiup Reservoir and the Upper Deschutes River*) requires increases in the minimum flow to 400 cfs (with provisions for up to 500 cfs) in two phases over the first 12 years of implementation. Wickiup Alternative 1 would accelerate the scheduled flow increases from those in Conservation Measure WR-1 in three phases, for a minimum of 200 cfs in Year 1, 300 cfs in Year 6, and a variable minimum of 400 to 500 cfs starting in Year 11. Wickiup Alternative 2 would accelerate the increases even further and require a variable minimum of 400 to 600 cfs starting in Year 6. Alternative 3, which was the proposal for Conservation Measure WR-1 in the 2019 Draft DBHCP, would increase winter minimum flows in three phases and it would stop at a 400 cfs in Year 21.

Variations on these alternatives could involve minor changes to the timing of the flow increases, but the variations are not presented as separate alternatives because they would not alter the fundamental reason the alternatives were not selected.

Table 11-1. Alternatives to the DBHCP for the operation of Wickiup Reservoir.

<table>
<tr><th rowspan="2">Period</th><th colspan="3">Minimum Winter (Sep 16 – Mar 31) Flow (cfs) Below Wickiup Dam</th></tr>
<tr><th>Wickiup Alternative 1</th><th>Wickiup Alternative 2</th><th>Wickiup Alternative 3 (2019 Draft DBHCP Proposal)</th></tr>
<tr><td>Years 1 – 5</td><td>200</td><td>300</td><td>100</td></tr>
<tr><td>Years 6 – 10</td><td>300</td><td rowspan="3">400-600</td><td>200</td></tr>
<tr><td>Years 11 – 20</td><td rowspan="2">400-500</td><td>300</td></tr>
<tr><td>Years 21 – 30</td><td>400</td></tr>
</table>

Alternative Wickiup 3 was not selected because USFWS did not consider the timing for the proposed increases in winter minimum flow to be quick enough to meet conservation and recovery goals for the Oregon spotted frog in the Upper Deschutes River. The second phase of increase in flow (200-cfs winter minimum) was also dropped from the final DBHCP because USFWS saw no benefit to Oregon spotted frogs from this intermediate step. Conversely, Alternatives Wickiup 1 and Wickiup 2 are not being utilized for the DBHCP because the Permittees are currently unable to identify a practicable means of ensuring the required minimum winter flows earlier in the permit term than proposed in Measure WR-1. Increasing the winter minimum flow from 100 cfs to 300 cfs will increase NUID's average annual shortage of water by 18,482 acre-feet (Figure 11-1). A similar increase to 400 cfs will increase average annual shortage another 17,947 acre-feet, for a total average annual shortage of over 40,000 acre-feet. More importantly, the 20 percent exceedance levels for shortage (i.e., shortages that could occur in 2 years out of 10) will increase by 42,083 acre-feet when the minimum flow increases to 300 cfs, and another 24,196 acre-feet when the minimum flow is 400 cfs. These 20 percent exceedance flows can occur for multiple consecutive years, during which NUID would experience severe shortages of water. When the minimum flow is 400 cfs, NUID will experience 20 percent exceedance shortages of over 72,000 acre-feet. These shortages can represent more than one-third of NUID's average annual demand. This would not be economically viable for NUID and its patrons without a replacement for the lost water, which will take many years to accomplish.

To replace this water, other DBHCP Permittees (primarily COID) plan to pipe canals within their Districts and provide saved water (conserved live flow) to NUID. Engineering feasibility studies conducted by COID and others have identified an estimated 90,000 acre-feet that can be conserved through canal piping over the next 12 years, at a cost of roughly $425,000,000. The conserved water cannot be guaranteed, however, given the myriad legal, economic and technical obstacles to canal piping that COID and others have encountered in recent years. Since the minimum instream flow targets in Conservation Measure WR-1 must be met regardless of whether canal piping occurs, NUID risks multiple successive years with less than half the water it needs to meet its demand. Studies by others in the Deschutes Basin (Reclamation and OWRD 2019) have suggested there is sufficient water potentially available through conservation to offset the loss of Wickiup Reservoir storage, but none of this water is guaranteed. Much of the conservation water identified by Reclamation and OWRD (2019) would require substantial funding from as-of-yet unidentified sources, and at least some of it would require changes to Oregon water law and/or construction of new storage facilities that have their own social and environmental impacts and would require multiple governmental approvals. In accordance with ESA Section 10(a)(2)(B)(iii), implementation of the conservation measures of the DBHCP cannot be contingent upon future governmental actions and/or unidentified sources of funding.

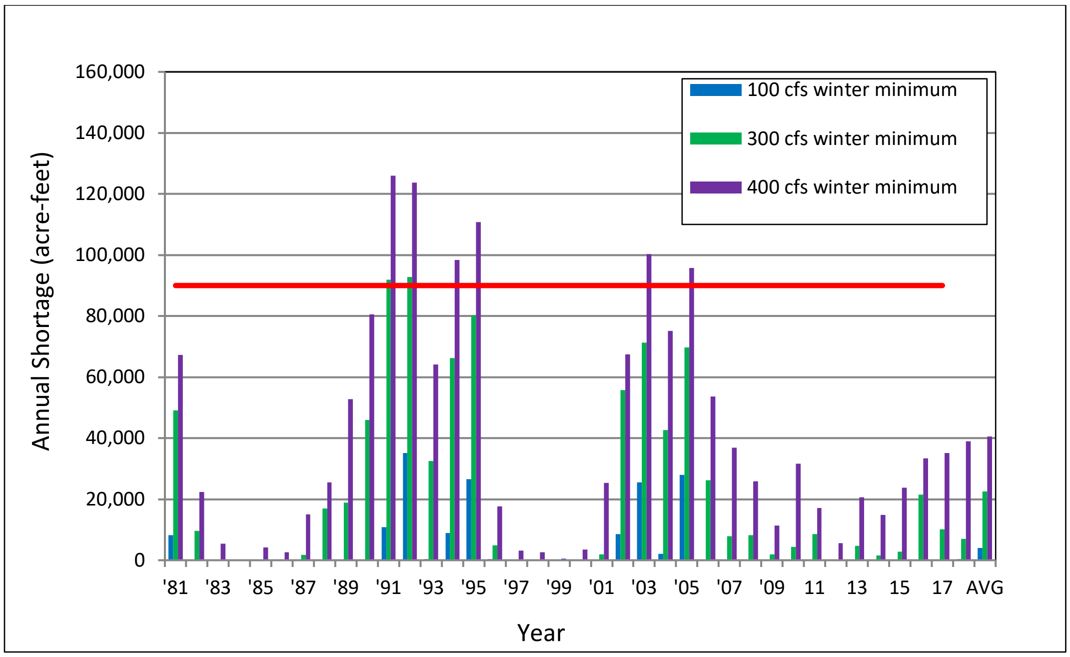

Figure 11-1. **Projected shortages of water for North Unit Irrigation District under the DBHCP.** Source: Reclamation 2020.

The guarantee that Measure WR-1 will be implemented is NUID's ability to reduce irrigation deliveries even if canal piping does not occur as planned, but NUID cannot afford to guarantee meeting the flow targets sooner or meeting a total flow target of more than 400 cfs that would reduce its supply of water by more than one-third. The patrons of NUID are already highly efficient and they use less water per acre than any other District in the basin. Additional reductions in water supply could not be accommodated by increased efficiency within NUID; they would instead result in an overall reduction in cultivated acres throughout the District and threaten the economic viability of the District as a whole. It has been suggested that patrons of other Districts be required to conserve water for transfer to NUID, but Oregon water law does not allow Districts to require patrons to conserve water on-farm or require patrons to transfer conserved water to other Districts. Similarly, Oregon water law does not allow Districts to burden their patrons with the costs of system improvements, such as canal piping, where the benefits of those improvements would simply be transferred to other Districts. The estimated cost of $425,000,000 to make available the first 90,000 acre-feet of COID conserved water for NUID is well beyond the financial capabilities of NUID, and alternate sources of funding will need to be identified. Meanwhile, in the absence of any means to ensure water will be conserved and provided to the District, NUID is unable to ensure minimum winter flows in the Upper Deschutes River beyond those specified in Measure WR-1.

Storage and release of water at Crane Prairie Reservoir also affects winter flows below Wickiup Dam, but there are limited opportunities to modify Crane Prairie operations to provide additional winter flows. As specified in Conservation Measure CP-1, Crane Prairie will be operated to optimize habitat conditions for Oregon spotted frogs. This will require reductions in seasonal reservoir fluctuation and higher storage volume in the reservoir throughout the year compared to historical levels. The net effect of Measure CP-1 will be a small increase in storage in Wickiup Reservoir that will partially offset the reduction in storage associated with increased winter flows, and this increase in storage has been accounted for in the estimate of economic impact to NUID. Further reduction or elimination of seasonal reservoir fluctuation altogether at Crane Prairie could increase storage in Wickiup Reservoir, but the increase would be very small. At most, eliminating the storage and release of 10,000 acre-feet each year at Crane Prairie (see Measure CP-1) would increase storage in Wickiup Reservoir by something less than 10,000 acre-feet because a portion would be lost to groundwater before reaching Wickiup due to the fact that seepage from Crane Prairie increases substantially as reservoir elevation increases (see Chapter 6, Figure 6-4). An increase of 10,000 acre-feet of storage in Wickiup Reservoir would be sufficient to increase winter flows below Wickiup Dam by only 34 cfs, but the associated elimination of seasonal fluctuations at Crane Prairie could also have negative consequences to Oregon spotted frog habitat within that reservoir (see Section 8.4.1, *Crane Prairie Reservoir and Upper Deschutes River between Crane Prairie Dam and Wickiup Reservoir*).

11.4.3 Middle Deschutes River

Early in the development of the DBHCP the Permittees and the Services explored options for increasing summer flows in the Middle Deschutes River (Bend to Lake Billy Chinook). The general approach was to conserve water through the piping of canals, and protect the conserved water instream during the irrigation season to increase flows downstream of Bend. A draft conservation measure prepared in 2015 called for permanently increasing instream rights in the Middle Deschutes River by 60 cfs (from 109 cfs to 169 cfs) over a period of 15 years (Table 11-2). This measure was subsequently removed from the DBHCP to provide additional flow in the Deschutes River during the winter for Oregon spotted frogs.

Under the DBHCP, water conserved through the piping of canals and other District improvements will be used to replace Wickiup and Crane Prairie storage, thereby enabling the Permittees to increase winter flows in the Upper Deschutes River (Measure WR-1) and reduce seasonal fluctuations in Crane Prairie Reservoir (Measure CP-1). Both of these actions will improve habitat conditions for the Oregon spotted frog. Some of the water conserved under the DBHCP may be protected in the Middle Deschutes River during the summer if required by Oregon water law, but most of the water will be provided to other Districts (primarily NUID) to offset the reductions in storage. Any conserved water that is used to increase flows in the Middle Deschutes River during the summer would be unavailable as a replacement for storage, and the result would be a decrease in winter flows and an increase in summer flows in the Upper Deschutes River (Wickiup Dam to Bend) compared to the DBHCP.

Table 11-2. Irrigation season (Apr 1 – Oct 31) flow targets for the Deschutes River at River Mile 159 under the Middle Deschutes River alternative to Conservation Measure WR-1.

Deadline	Target Flow (cfs)	
	Minimum 1-Day Average	Minimum 7-Day Average
Beginning no later than the date of issuance of the Incidental Take Permits	82	109
Beginning no later than 5 years after the date of issuance of the Incidental Take Permits	104	139
Beginning no later than 15 years after the date of issuance of the Incidental Take Permits	127	169

11.5 Alternatives for Crescent Creek and Little Deschutes River

11.5.1 Crescent Lake Reservoir

Two alternatives to the Final DBHCP were identified for the management of Crescent Lake Reservoir. One alternative was continued operation of the reservoir according to the terms of the 2016 settlement agreement between the Center for Biological Diversity, WaterWatch of Oregon, the US Bureau of Reclamation, and five Districts (AID, COID, LPID, NUID and TID). The alternative would be similar to the Final DBHCP, with one major difference. Under this alternative, the minimum flow in Crescent Creek below Crescent Lake Dam would be 30 cfs from March 15 to November 30 and 20 cfs from December 1 to March 14. This contrasts with Conservation Measure CC-1 of the Final DBHCP that has a base minimum flow of 10 to 12 cfs during the winter and the option for additional flow, as needed, through adaptive management. The second alternative, which was proposed in the 2019 Draft DBHCP, included a minimum flow of 20 cfs the entire winter during all years of DBHCP implementation.

Neither alternative was selected for the final DBHCP because neither offered the opportunity for adaptive use of Crescent Lake Reservoir storage for Oregon spotted frog habitat management that the Final DBHCP provides. The slightly higher winter flows that the alternatives would have provided would have had little or no benefit to Oregon spotted frogs, but the lack of adaptive flow management under the alternatives would prevent adjustments to the operation of Crescent Lake Reservoir during the term of the DBHCP and reduce the overall biological effectiveness of the DBHCP.

11.6 Alternatives for Whychus Creek

No alternatives to the DBHCP have been identified for Whychus Creek. The entire TSID canal system has been piped to reduce seepage over the past 15 years and the conserved water has been protected instream with priority dates equal to those of TSID's irrigation rights. It is anticipated this piping of the TSID canals and delivery of pressurized water to TSID patrons will now stimulate piping of patron canals as well, which will lead to additional reductions in demand and higher instream flows during the irrigation season. No additional opportunities exist for permanently increasing instream flows in Whychus Creek, short of reducing water deliveries to all TSID patrons and/or reducing the irrigated acres within the District. None of these options were considered as viable alternatives for the DBHCP because continued diversions of water and deliveries to patrons at current levels are needed to repay loans that funded piping to provide the current instream flows.

11.7 Alternatives for the Crooked River, Ochoco Creek and McKay Creek

Two alternatives to the DBHCP conservation measures for the Crooked River subbasin were considered during DBHCP development. The first was a modification to Conservation Measure CR-1 to have a target minimum flow of 80 cfs in the Crooked River year round. This alternative was dismissed because a flow of 80 cfs in the Crooked River during the summer would have limited benefit to covered fish species, but it would reduce the amount of water available to maintain habitat conditions during the winter, particularly in the high-quality reach of the Crooked River between Bowman Dam and the Crooked River Diversion.

The second alternative would be a modification to Conservation Measure CR-1 or a new conservation measure requiring NUID to use a portion of the 10,000 acre-feet of Prineville Reservoir storage it can purchase each year to increase flows in the Crooked River rather than for irrigation. This alternative was dismissed because NUID will be heavily reliant on the 10,000 acre-feet to meet its irrigation demands under the DBHCP (see Section 11.8.3.4, *North Unit Irrigation District*). Any reduction in NUID's access to the 10,000 acre-feet, or modification in the timing of the release of the water from Prineville Reservoir, could have severe consequences to the District's patrons.

11.8 Determination of Practicability

11.8.1 General Considerations

In addition to requiring the consideration of alternatives, the ESA requires applicants for incidental take permits to minimize and mitigate the impacts of the taking to the maximum extent practicable. The consideration of alternatives and the requirement to mitigate to the limit of practicability are interrelated because impracticability is often the reason an alternative is not selected. The following discussion of practicability is provided as background to the consideration of alternatives in Sections 11.2 through 11.7.

Practicability is determined for each HCP based on the specific circumstances of the Permittees and their respective covered activities. The HCP Handbook (USFWS and NMFS 2016) provides general guidelines for determining the limits of practicability, but for each HCP the determination is based on the physical, legal and economic constraints of the Permittees. In the case of the DBHCP, the determination of practicability is made separately for each of the nine Permittees (eight irrigation districts and the City). As described in Section 3.6, *DBHCP Implementation*, each Permittee owns and/or operates covered irrigation facilities that are separate from the covered facilities of the other eight Permittees. Likewise, the effects of each Permittee's activities on the covered species are separate from the effects of the other eight Permittees' activities, and the conservation measures that will be implemented to minimize and mitigate the impacts of each Permittee are the sole responsibility of that Permittee. Each Permittee also has a unique set of physical, legal and economic constraints that determine its limit of practicability. While there are similarities between the Permittees, the determination of practicability for one Permittee is not necessarily pertinent to another.

The nine Permittees have collaborated on the preparation of the DBHCP because of the following: they all influence the surface hydrology of the Deschutes Basin; they conduct similar activities that have similar effects on the covered activities; and they have been able to realize cost savings during DBHCP development by conducting a single set of discussions with the Services and sharing the costs of conducting studies and preparing documents. This approach has also enabled the Services to consolidate their efforts and conduct a comprehensive analysis of effects on the covered species. However, it was never the intention of the Permittees to minimize or mitigate for the impacts of each other's activities or assume responsibility for each other's authorized incidental take. As individual legal entities organized under Oregon law, each of the eight irrigation districts has fiduciary responsibilities to its patrons that preclude it from expending funds to mitigate the impacts of another district, absent appropriate compensation or other consideration. This extends to the distribution and use of water as well. Thus, one irrigation district cannot, under Oregon law, transfer water to another district or another entity outside an organized district without the requisite approval by the entity, appropriate consideration, and protections to avoid reductions in the availability of water to the district's patrons.

Irrigation districts can make system improvements, such as canal piping to reduce seepage losses, and transfer the saved water to another district without reducing the delivery of water to their own patrons. This type of activity has occurred in the past and is expected to occur in the future during DBHCP implementation. However, the district conducting the system improvement cannot transfer water to another district without being appropriately compensated for the costs of the improvements. The patrons of one district cannot be required to finance improvements for the transfer of water to the patrons of another district.

There are also potential legal hurdles to the transfer of water between irrigation districts for the DBHCP or any other purpose. The transfer of water between districts requires approval by the Oregon Water Resources Department (OWRD) to ensure it is consistent with Oregon water law and established water rights. The OWRD must ensure that no other water right holder is injured by the transfer and that the transfer results in no enlargement of the transferred right.

Within individual districts, patrons also have restrictions on the use and transfer of water rights appurtenant to their lands to avoid impacts to other patrons. For example, districts cannot allow individual patrons to transfer appurtenant water rights outside the district if doing so would harm other patrons within the district or otherwise impair the district's ability to deliver water to the other patrons. The existing systems of open canals that remain in most districts require "carry water" to facilitate deliveries to all patrons. A portion of each patron's water allocation is also carry water for other patrons on the same canal. If a patron were to transfers his or her appurtenant water right to a new place of use outside the district, the loss of the associated carry water could impair the ability of the district to deliver water to the other patrons. For this and other reasons most districts have policies requiring district approval of all water right transfers.

Conversely, individual patrons cannot be required to surrender any part of the water rights appurtenant to their lands so long as they are complying with Oregon law for the use of that water (i.e., putting the water to “beneficial use”). In times of shortage, districts must reduce water deliveries to patrons in as uniform of a manner as the distribution system allows, consistent with that district’s water rights. Irrigation districts cannot preferentially reduce deliveries to a subset of patrons based on the geographic location, economic status, or use of the water for a particular crop, as long as the use conforms to Oregon law.

The eight DBHCP Districts belong to the Deschutes Basin Board of Control (DBBC). This is an entity formed by intergovernmental agreement for the purpose of enabling the eight members to cooperate on and share the cost of developing the DBHCP. Participation in the DBBC does not obligate or enable any member district to assume responsibility, provide financial support, commit water, modify the operation of other districts, or place requirements on it patrons for the benefit of another member district. In a similar manner, the City cannot legally assume responsibility for the impacts of one of the irrigation districts or expend City funds to mitigate the impacts of an irrigation district without the requisite approval, appropriate consideration, and compliance with the laws governing City actions and activities.

The nine Permittees shared in the cost of DBHCP development based on their respective size (irrigated acres), but the allocation of costs for implementation of the DBHCP must, by law, be allocated according to each individual Permittee’s impacts on the covered species. The clear delineation and segregation of covered activities, associated impacts and required mitigation actions (conservation measures) in Section 3.6 were specifically designed to support implementation of the DBHCP in a manner that is consistent with Oregon law. The following review of practicability is therefore based on the assumption that each Permittee is fully responsible for the effects of its activities on the covered species and each Permittee is solely responsible for the costs of implementing the conservation measure(s) associated with its activities, as indicated in Chapter 3, Table 3-9.

11.8.2 Criteria for Determining Practicability

The Permittees have identified the following three criteria for determining the practicability of DBHCP implementation.

Criterion 1: The cost of DBHCP implementation versus the cost of take avoidance.

The DBHCP is being implemented to support the issuance of incidental take permits for the effects of certain activities on four covered species. The ESA does not require landowners and other non-federal parties to obtain incidental take permits; the permit is an option available to non-federal parties who find it impossible, economically infeasible or otherwise undesirable to avoid take. If a party can continue to conduct its activities and avoid take to standards established by the Services, it need not seek incidental take coverage or develop an HCP.

The cost of avoiding incidental take is one of the first considerations a non-federal party undertakes, often with the assistance of the Services, when it discovers its activities have the potential to impact a listed species. When take avoidance is simple and straightforward for a given party, the incidental take permit option is typically not pursued. When take avoidance appears cost-prohibitive or technically infeasible for a given activity, preparation of an HCP is the logical option. However, when take avoidance is expensive but still technically feasible, the cost-benefit analysis continues throughout the development of the conservation strategy. If the conservation strategy necessary to support the issuance of an incidental take permit exceeds the cost of take avoidance, a prospective applicant may simply revert to take avoidance and forego incidental take coverage. When the prospective applicant is a governmental agency or publicly-traded company with fiduciary obligations to citizens or shareholders, respectively, it may have no choice other than to pursue the more cost-effective option of avoiding incidental take.

In the case of the DBHCP Permittees, this cost-benefit analysis amounts to a comparison of the costs of implementation to the costs of either a) making structural improvements to compensate for or replace the irrigation water that would be lost to take avoidance, or b) proceeding with less water and reducing deliveries to patrons.

Criterion 2: The cost of DBHCP implementation compared to the economic benefit of the covered activities.

When take avoidance is physically or technologically impossible for a given activity, the party conducting that activity must seek incidental take coverage to remain in compliance with the ESA. However, if the cost of mitigation required to support the issuance of an incidental take permit exceeds the financial resources of the party or the economic benefits of the covered activity, the party may have no choice other than to cease the activity altogether. The DBHCP Permittees have obligations under Oregon law to continue providing irrigation water to their patrons; they cannot simply choose to cease storing, releasing and diverting water. They can, however, predict with reasonable certainty when a given conservation strategy would increase operational costs and/or reduce water deliveries to the point that the economic viability of their patrons, and of the district as a whole, would eventually be jeopardized.

The amount of water needed to produce agricultural crops in the Deschutes Basin has been well documented and it forms the basis for existing water rights. The volume and rate of water that can be delivered to each patron are specified in the water rights, and these are based on the amount of water required to grow traditional crops in the basin. As the amount of water available to a district on a regular basis diminishes and deliveries to patrons are reduced, the viability of agriculture in that district also diminishes.

Water availability varies naturally from year to year due to fluctuations in weather. In a similar manner, the impacts to the Permittees (reductions in the amount of water) resulting from the DBHCP will vary from year to year. To provide a consistent basis for the determination of practicability, the Permittees considered the *median annual* reduction in irrigation water that will result from implementation of the DBHCP. This is the magnitude of reduction in water from historical levels (shortage) that can be expected to occur in up to half the years during implementation. Water shortages will come in cycles, with multiple consecutive years of high shortage followed by multiple years of less shortage or no shortage. So although a median shortage is only expected to occur in half the years of DBHCP implementation, those could be in sequences of 3 to 5 consecutive years.

The predicted water shortages under the DBHCP will vary by Permittee. The Permittees that will experience substantial water shortages are seeking options for replacing the water by increasing the efficiencies of their infrastructure and/or purchasing water from other Permittees. These actions have financial costs, and the magnitudes of these costs relative to the financial resources of the Permittees and their patrons form the basis for determining practicability. If the cost of replacing the water exceeds the financial resources of an irrigation district, it is considered impracticable.

As they identify irrigation system improvements to accommodate shortages or replace the lost water, the Permittees are also seeking government assistance in the form of state and federal grants to fund the improvements. The determination of practicability for each Permittee accounts for any grants that have already been secured or committed, but it does not include future grants that may or may not be available. The Permittees cannot base the practicability analysis on speculative or uncertain financial options.

Criterion 3: The legal, technological and physical feasibility of the conservation action.

Implementation of the DBHCP must comply with all pertinent local, state and federal laws, regulations and policies. Any conservation action that would not be in full compliance with existing legal requirements would be impracticable. A conservation option that is currently prohibited by law or regulation could be considered practicable if there is a clear and viable process for seeking legal exemption, such as a variance or waiver under established regulations. Conservation actions that would be prohibited by current law and for which there is no clear and feasible exemption process are not considered practicable. Examples of conservation actions that would not be considered practicable are inter-district transfers of water that cannot be approved by OWRD, and uses of the covered irrigation reservoirs for purposes other than those authorized by Congress.

All conservation measures in the DBHCP must be based on proven technology and have a reasonable likelihood of success. Actions that are speculative or would require untested methodologies are not considered practicable because there would be no certainty of the benefits of the actions for the covered species. An example of a technologically infeasible conservation action would be the simultaneous increase in flow below a storage reservoir during the winter and the summer. If water is not stored in the winter (with associated reduction in downstream flow) it cannot be released during the summer to increase instream flow. The balance between winter and summer flows can and will be adjusted for the covered irrigation reservoirs under the DBHCP, but the simultaneous increase in both winter and summer flows is not physically achievable.

11.8.3 Practicability for Individual Permittees

11.8.3.1 Arnold Irrigation District

AID is seeking incidental take coverage for the storage of water by COID in Crane Prairie Reservoir on AID's behalf, and the diversion of water (live flow and storage) by AID from the Deschutes River in Bend. The activities being covered for AID have the potential to impact all four covered species (Oregon spotted frog, bull trout, steelhead and sockeye salmon) to varying degrees. The storage of water in Crane Prairie Reservoir affects Oregon spotted frogs residing within and downstream of the reservoir, but AID's diversions of water at Bend have no known effect on Oregon spotted frogs. The storage of water and the diversion of live flow (summer and winter) in Bend reduce flows in the Deschutes River downstream of Bend, including the reach of the river below Big Falls that is occupied or potentially occupied by bull trout, steelhead and sockeye salmon.

The determination of practicability for minimizing and mitigating effects on the Oregon spotted frog is based on Criterion 1 (the cost of avoiding incidental take). As a quasi-municipal governmental entity in the State of Oregon, AID could not expend more on securing incidental take coverage than it would cost the District to avoid incidental take, unless incidental take coverage would provide the District with significantly more regulatory certainty or otherwise have tangible benefits to its patrons. The determination of practicability for minimizing and mitigating AID's effects on covered fish species is based on a combination of all three criteria.

Oregon Spotted Frog

The liability for incidental take of the Oregon spotted frog associated with the storage of AID's water could be avoided by forgoing all storage and release of water on its behalf in Crane Prairie Reservoir. This could cost the District less than implementing the DBHCP.

AID holds rights to store up to 13,500 acre-feet of water in Crane Prairie Reservoir for irrigation use. Under Conservation Measure CP-1, total annual release of irrigation storage from Crane Prairie Reservoir will be reduced to 4,900 acre-feet (less than 10 percent of the reservoir's authorized storage capacity of 50,000 acre-feet). Half of this storage will be available to AID (the remainder will be used by LPID and COID). AID only uses Crane Prairie storage in dry years when its live flow water right in the Deschutes River cannot be fully met. Historically up to 8,304 acre-feet of storage have been released from Crane Prairie for AID in a single year, but the average release from 2002 through 2015 was only 867 acre-feet (Figure 11-2) because of system improvements the District made early in the 21st Century to increase water conveyance efficiency.

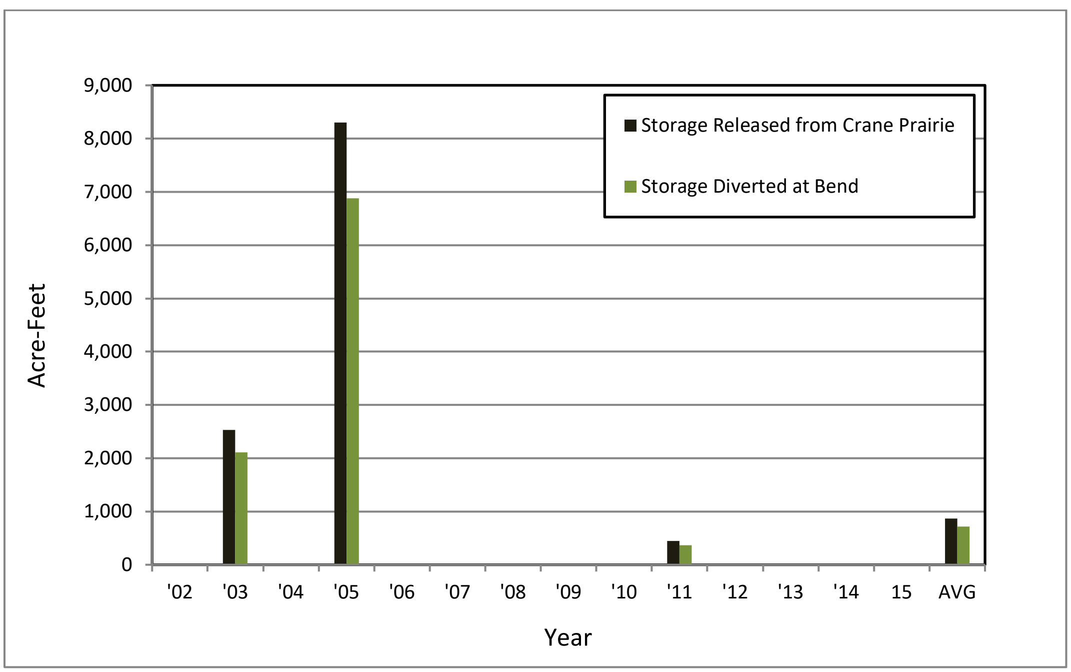

Figure 11-2. Use of irrigation storage by Arnold Irrigation District from 2002 through 2015. Source: OWRD 2016.

AID will not be impacted by the reduced availability of Crane Prairie storage in moderate and wet years under the DBHCP because live flow water rights will meet District demand. In dry years, when live flow is not sufficient, the District will accommodate the reduction in storage by reducing deliveries to its patrons. During the term of the DBHCP the District will continue to make improvements to its infrastructure (i.e., canal piping) to reduce its need for storage. Eventually, the need for storage, and the associated need for incidental take coverage of the Oregon spotted frog, will be eliminated altogether. The total estimated cost for these system improvements is approximately $40,000,000, some of which may be secured through government grants.

If AID found it necessary to forego the use of Crane Prairie Reservoir storage altogether to avoid incidental take of Oregon spotted frogs, the District would respond much the same as it will under the DBHCP. Deliveries to patrons would be reduced in dry years and system improvements would continue as funding becomes available to increase efficiency within the District. Other than running the risk of having less water in occasional dry years while the system improvements are made, the cost to AID of avoiding take of Oregon spotted frogs would be no higher than the cost of the DBHCP. In fact, the cost of the DBHCP will be higher than the cost of avoiding take because the District will also incur over $36,000 in annual costs for DBHCP implementation (Table 11-3). These are all costs that AID would not incur for take avoidance. The District considers these additional implementation costs reasonable for the certainty of having irrigation storage during dry years under the DBHCP, but any significant increase in implementation costs would reduce the availability of District capital for system improvements and diminish the benefits of securing incidental take coverage for the short period of time during which it will be needed.

Table 11.3. Estimated costs associated with implementation of the Deschutes Basin HCP.

Permittee	Capital Costs (infrastructure improvements)	Annual Costs						
		Lost Revenue	Conservation Funds	Operations Staff Time	Administrative Staff Time	Contract Services (monitoring)	Contract Services (annual reporting)	Total Annual Costs and Lost Revenue
Arnold	$40,000,000	$0	$6,243	$14,256	$1,129	$14,796	$178	**$36,602**
Central Oregon	$115,000,000	$300,000	$63,770	$24,288	$4,200	$25,208	$1,762	**$419,228**
Lone Pine	$1,962,245	$0	$3,373	$14,256	$640	$14,796	$119	**$33,184**
North Unit	$115,000,000	variable [1]	$83,882	$3,900	$1,200	$25,000	$2,284	**$116,266**
Ochoco	$46,500	$0	$4,000	$18,000	$720	$1,500	$766	**$24,986**
Swalley	$0	$0	$6,207	$4,126	$825	$0	$178	**$11,336**
Three Sisters	$120,000	$0	$16,000	$11,250	$2,520	$0	$290	**$30,060**
Tumalo	$14,510,000	$0	$11,525	$20,000	$5,000	$15,333	$290	**$52,148**
City	$0	$0	$4,000	$0	$734	$0	$733	**$5,467**
TOTAL	**$286,638,745**	**variable [1]**	**$199,000**	**$110,076**	**$16,234**	**$96,633**	**$6,600**	**$183,444**

Note:
[1] NUID will experience lost revenue due to reduced sales of "excess" water (see Section 10.5, *North Unit Irrigation District*). Estimated average lost revenue will vary by DBHCP implementation year. NUID lost revenues are not included in this table.

Covered Fish Species

AID's activities have the potential to affect covered fish species by reducing instream flows in the Deschutes River. The limits of practicability for addressing impacts to fish are a combination of the cost of avoiding take (Criterion 1), the economic impact of providing additional mitigation (Criterion 2) and the physical limitations to improving habitat conditions (Criterion 3). The storage of water in the winter, the diversion of live flow for stock water in the winter, and the diversion of live flow in the summer all reduce flows downstream of Bend and have the potential to influence habitat for covered fish species.

Winter Storage of Water: The hydrological effects of winter storage for AID on covered fish species are extremely low due to the small volume of water involved. Winter storage of water in Crane Prairie Reservoir for all three Districts (AID, COID and LPID) under the DBHCP will result in a total average reduction in flow of less than 35 cfs downstream in the Deschutes River. Based on the rating curve for the OWRD gage in the Deschutes River below Bend, a change in flow of 35 cfs would produce a change in water depth of less than 1.5 inches. A flow reduction of this magnitude is nearly indiscernible in the reach of the river accessible to covered species (below Big Falls), where the average winter flow is several hundred cfs. AID has few options to mitigate this minor effect on flow other than to reduce storage even more or avoid winter storage altogether. As noted above, AID could cease storage at Crane Prairie Reservoir to avoid incidental take of Oregon spotted frogs and the effects of storage on winter flows for fish would be avoided as well. It would not be practicable for AID to take additional steps or expend additional funds to mitigate for this small effect on winter flows when the impact could be avoided altogether at less cost than the DBHCP.

Stock Water Diversions: The diversion of water for livestock by AID and other districts will reduce flows in the Deschutes River below Bend to as low as 250 cfs about once a month during the winter. This is a reduced rate of diversion (higher instream flow) than occurred historically. The required minimum flow of 250 cfs is based on ODFW's application for instream water right to support salmonid migration, spawning, egg incubation, fry emergence and juvenile rearing in the Deschutes River from Bend to Lake Billy Chinook. AID could provide additional mitigation by making further reductions in winter diversions, but these diversions provide an essential source of water to the District's livestock producers. Reductions in diversion beyond those required by Conservation Measure DR-1 could make livestock production infeasible for some AID patrons.

Summer Diversions of Live Flow: AID's diversions of live flow at Bend during the summer reduce downstream flow in the Deschutes River. These diversions are essential to meeting the District's obligations for the delivery of water to irrigators. AID could increase instream flow by reducing diversions, but the District is already one of the smaller diverters on the river and the amount of water it could return to instream flow would also be small. As noted in Chapter 8, small and moderate increases in flow during the summer would likely have negative effects on covered fish species by increasing water temperatures between Big Falls and Lake Billy Chinook. AID considers its current rate of diversion during the summer to be an appropriate rate for both the District and the covered species.

11.8.3.2 Central Oregon Irrigation District

COID is seeking incidental take coverage for the storage of water in Crane Prairie Reservoir on behalf of itself, AID and LPID, and for the diversion of live flow and storage from the Deschutes River in Bend. COID's covered activities have the potential to impact all four covered species.

The storage of water in Crane Prairie Reservoir affects Oregon spotted frogs residing within and downstream of the reservoir, but COID's diversions of water at Bend have no known effect on Oregon spotted frogs. The storage of water and the diversions of live flow (summer and winter) in Bend reduce flows in the Deschutes River downstream of Bend, including the reach of the river below Big Falls that is occupied or potentially occupied by bull trout, steelhead and sockeye salmon.

The determination of practicability for minimizing and mitigating COID's effects on the Oregon spotted frog is based on Criterion 1 (the cost of avoiding incidental take). As a quasi-municipal governmental entity in the State of Oregon, COID could not expend more on securing incidental take coverage than it would cost the District to avoid incidental take, unless incidental take coverage would provide the District with significantly more regulatory certainty or otherwise have tangible benefits to its patrons. The determination of practicability for minimizing and mitigating COID's effects on covered fish species is based on a combination of all three criteria.

Oregon Spotted Frog

COID's liability for incidental take of the Oregon spotted frog could be avoided by forgoing all storage and release of water on its own behalf in Crane Prairie Reservoir and transferring operation of the reservoir to AID and/or LPID. This could cost the District less than implementing the DBHCP.

COID holds rights to store up to 26,000 acre-feet of water in Crane Prairie Reservoir for irrigation use. Under Conservation Measure CP-1, total annual release of irrigation storage from the reservoir will be reduced to 4,900 acre-feet (less than 10 percent of the reservoir's authorized 50,000 acre-feet). COID will have access to less than half of this available storage; the remainder will be used by AID and LPID. COID uses Crane Prairie storage in dry years when its live flow rights are not fully available, and for short periods at the beginning and end of each irrigation season (shoulder seasons) when the District's live flow rights are limited. Historically up to 10,399 acre-feet of storage have been released from Crane Prairie for COID in a single year. The average annual release from 2002 through 2015 was 3,779 acre-feet (Figure 11-3).

COID will accommodate the reduction of Crane Prairie storage under the DBHCP by piping canals to reduce seepage losses. The District has been piping canals to conserve water for the past decade and it will continue to do so during DBHCP implementation. A portion of the water saved through piping will be used to replace the loss of storage at Crane Prairie Reservoir and address other District needs. The remaining water will be available for transfer to other Districts like NUID to replace water they will lose under the DBHCP (see Section 11.8.3.5, *North Unit Irrigation District*). COID estimates it will spend $7,000,000 over the first 4 years of the DBHCP to complete the portion of piping needed to replace Crane Prairie storage. After that, COID will no longer need to store water at Crane Prairie Reservoir, and it will no longer need incidental take coverage for the Oregon spotted frog.

If COID were to avoid the incidental take of Oregon spotted frogs immediately, rather than pursuing incidental take coverage, it would devote all saved water to its own needs and delay transfers to NUID. COID estimates it would take 10 years to eliminate its need for Crane Prairie storage if it devoted all water saved through piping to its own needs. During that time, deliveries of water to patrons would be reduced during shoulder seasons and in dry years. By eliminating the need for incidental take coverage, COID would also save an estimated $119,228 in annual implementation costs associated with the DBHCP (Table 11-3). The economic impacts of take avoidance to COID would be minor, and potentially positive. However, the economic impact to

NUID could be substantial because of the lack of water to replace its loss of Wickiup Reservoir storage under the DBHCP.

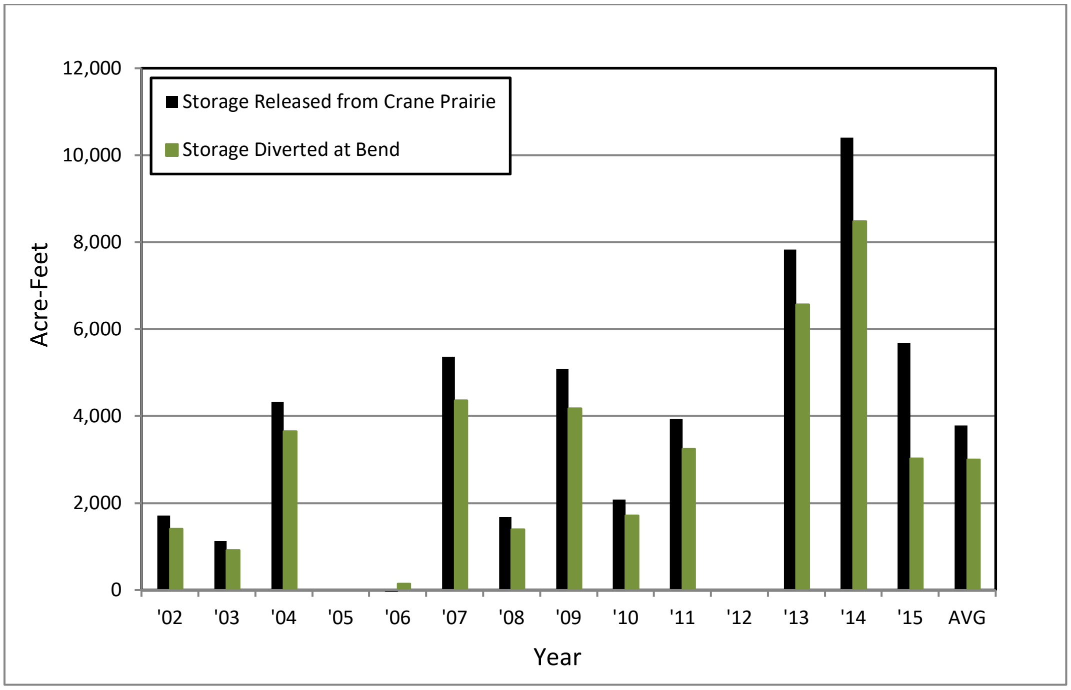

Figure 11-3. Use of irrigation storage by Central Oregon Irrigation District from 2002 through 2015. Source: OWRD 2016.

Covered Fish Species

COID's activities have the potential to affect covered fish species by reducing instream flows in the Deschutes River. The limits of practicability for addressing impacts to fish are a combination of the cost of avoiding take (Criterion 1), the economic impact of providing additional mitigation (Criterion 2) and the physical limitations to improving habitat conditions (Criterion 3). The storage of water in the winter, the diversion of live flow for stock water in the winter, and the diversion of live flow in the summer all reduce flows downstream of Bend and have the potential to influence habitat for covered fish species.

Winter Storage of Water: The hydrological effects of COID's winter storage are similar to those of AID. The potential for impacting covered fish species is extremely low due to the small volume of water involved. Winter storage of water in Crane Prairie Reservoir for all three Districts (AID, COID and LPID) under the DBHCP will result in a total average reduction in flow of less than 35 cfs downstream in the Deschutes River. A flow reduction of this magnitude, which would result in a change in water depth of less than 1.5 inches, is nearly indiscernible in the reach of the river accessible to covered species (below Big Falls), where the average winter flow is several hundred cfs. COID has few options to mitigate this minor effect other than to reduce storage even more or avoid winter storage altogether. COID could cease storage at Crane Prairie Reservoir to avoid incidental take of Oregon spotted frogs and the effects of storage on winter flows for fish would be avoided as well. It would not be practicable for COID to take additional steps or expend additional funds to mitigate for this small effect on winter flows when the impact could be avoided altogether at less cost than the DBHCP.

Stock Water Diversions: The diversion of water for livestock by COID and other Districts will reduce flows in the Deschutes River below Bend to as low as 250 cfs about once a month during the winter. This is a reduced rate of diversion (higher instream flow) than occurred historically. The required minimum flow of 250 cfs is based on ODFW's application for instream water right to support salmonid migration, spawning, egg incubation, fry emergence and juvenile rearing in the Deschutes River from Bend to Lake Billy Chinook. COID could provide additional mitigation by making further reductions in winter diversions, but as noted for AID these diversions provide an essential source of water to the District's livestock producers. Reductions in diversion beyond those required by Conservation Measure DR-1 could make livestock production infeasible for some COID patrons.

Summer Diversions of Live Flow: COID's diversions of live flow at Bend during the summer reduce downstream flow in the Deschutes River. These diversions are essential to meeting the District's obligations for the delivery of water to irrigators. COID could increase instream flow in the summer by transferring water it saves through canal piping to instream use, but this would reduce the amount of water it would have available to transfer to NUID to offset the loss of Wickiup Reservoir storage. This would have a substantial economic impact to NUID.

The benefits to covered fish species of increasing summer flows in the Deschutes River are also questionable. As noted in Chapter 8, moderate increases in flow during the summer would likely have negative effects on anadromous salmonids by increasing water temperatures between Big Falls and Lake Billy Chinook. COID considers its current rate of diversion during the summer to be an appropriate rate for both the District and the covered species.

11.8.3.3 Lone Pine Irrigation District

LPID is seeking coverage for the storage of water by COID in Crane Prairie Reservoir on LPID's behalf, and the diversion of water (live flow and storage) by COID from the Deschutes River in Bend on LPID's behalf during the irrigation season. These activities have the potential to impact all four covered species. The storage of water in Crane Prairie Reservoir affects Oregon spotted frogs residing within and downstream of the reservoir, but the diversion of LPID's water at North Canal Dam in Bend have no known effect on Oregon spotted frogs. The storage of water and the diversion of live flow during the summer in Bend reduce flows in the Deschutes River downstream of Bend, including the reach of the river below Big Falls that is occupied or potentially occupied by bull trout, steelhead and sockeye salmon.

The determination of practicability for minimizing and mitigating LPID's effects on the Oregon spotted frog is based on the overall cost of the DBHCP to the District (Criterion 2) and the physical limitations of the District's water distribution system (Criterion 3). The determination of practicability for minimizing and mitigating LPID's effects on covered fish species is based on a combination of all three criteria.

Oregon Spotted Frog

LPID relies heavily on the use of Crane Prairie storage in all years. The District holds rights to store up to 10,500 acre-feet of water in the reservoir for irrigation use. Historically as much as 4,349 acre-feet of storage have been released for LPID in a single year. The average annual release for LPID from 2002 through 2015 was 3,067 acre-feet (Figure 11-4). During those years, storage made up 12 to 25 percent (average 18%) of total irrigation water diverted for LPID at Bend.

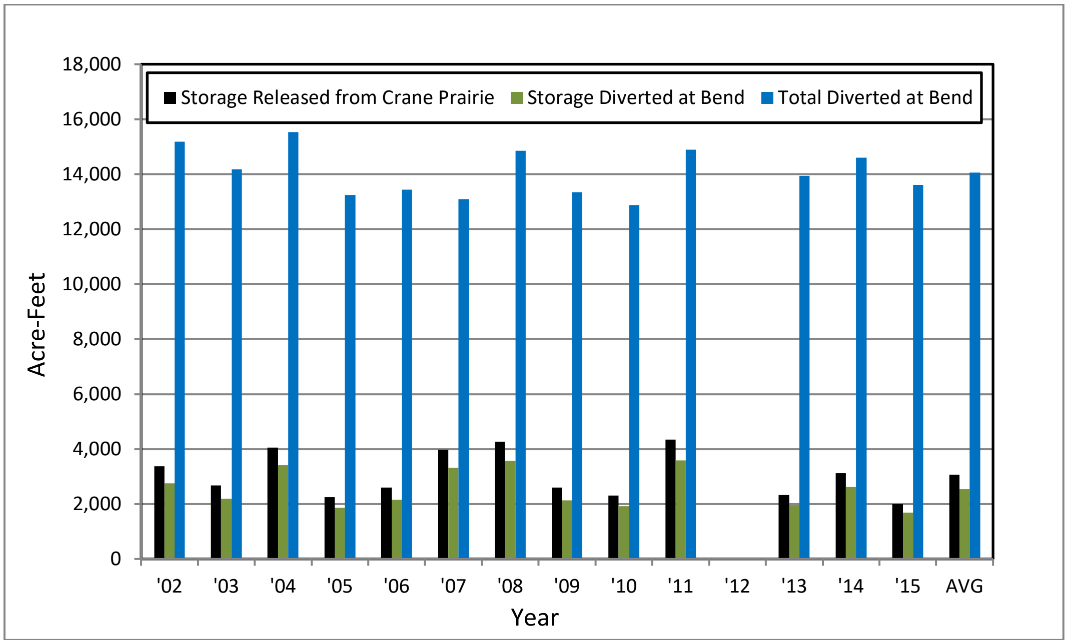

Figure 11-4. Use of irrigation water by Lone Pine Irrigation District from 2002 through 2015. Source: OWRD 2016.

The cessation of storage to avoid incidental take of the Oregon spotted frog is not feasible for LPID in the short term. Under the DBHCP, total annual release of irrigation storage from Crane Prairie Reservoir will be up to about 4,900 acre-feet, of which as much as half could be available to LPID. This could be sufficient storage to meet its demand in normal and wet years, but LPID may experience shortages in dry years under the DBHCP if it does not take steps to replace the lost storage.

LPID is currently in the process of securing funding to pipe its entire main canal and utilize a portion of the saved water to offset the DBHCP reduction of Crane Prairie storage. The District anticipates securing government grants to cover all but about $2,000,000 of the piping costs; the District will fund the $2,000,000 itself. A portion of the conserved water will be transferred instream as required by the State grants. LPID anticipates the portion of the conserved water it retains for its own use will offset most, but not all of the lost storage at Crane Prairie Reservoir. LPID will continue to require about 1,000 acre-feet of storage at Crane Prairie Reservoir each year for the term of the DBHCP.

The operation of Crane Prairie Reservoir under the DBHCP (Measure CP-1) includes annual fluctuation of the reservoir (partial draining and refilling) to maintain desirable vegetation conditions for Oregon spotted frogs. The magnitude and timing of the fluctuation may change as a result of adaptive management, but some amount of fluctuation will still be desirable for ecological reasons. LPID anticipates its annual storage needs will be met with the minimum amount of annual fluctuation likely to occur at Crane Prairie. The intent of the DBHCP is to operate the reservoir with Oregon spotted frog habitat as the primary objective and irrigation storage as an incidental benefit. Once that is achieved through adaptive management, the potential for incidental take will be as low as it can possibly be, and there will be no need for any of the Districts with storage rights in Crane Prairie (AID, COID and LPID) to provide additional mitigation.

Covered Fish Species

The storage of water for LPID and the diversion of live flow for LPID have the potential to affect covered fish species by reducing instream flows in the Deschutes River. The limits of practicability for addressing impacts to fish are a combination of the cost of avoiding take (Criterion 1), the economic impact of providing additional mitigation (Criterion 2) and the physical limitations to improving habitat conditions (Criterion 3). The storage of water in the winter and the diversion of live flow in the summer both reduce flows downstream of Bend and have the potential to influence habitat for covered fish species. LPID does not conduct winter stock water runs.

Winter Storage of Water: The hydrological effects of LPID's winter storage on covered fish species are identical to those of AID, and are extremely low due to the small volume of water involved. Winter storage of water in Crane Prairie Reservoir for all three Districts (AID, COID and LPID) under the DBHCP will result in a total average reduction in flow of less than 35 cfs and average reduction in water depth of less than 1.5 inches downstream in the Deschutes River. A flow reduction of this magnitude is nearly indiscernible in the reach of the river accessible to covered species (below Big Falls), where the average winter flow is several hundred cfs. LPID has few options to mitigate this effect other than to reduce storage even more or avoid winter storage altogether. As noted above, LPID will undertake piping of its main canal to eventually reduce its need for storage to a level that will have no effect on Oregon spotted frogs in the reservoir. In the interim, LPID could not reduce its use of storage below the levels allowed in the DBHCP without jeopardizing the economic viability of its patrons.

Summer Diversions of Live Flow: LPID's diversions of live flow at Bend during the summer reduce downstream flow in the Deschutes River by a very small amount. These are the smallest diversions of the eight irrigation districts covered by the DBHCP, but they are essential to meeting the LPID's obligations for the delivery of water to irrigators. LPID could increase instream flow by reducing diversions (and impacting its patrons), but because the District is already the smallest diverter on the river the amount of water it could return to instream flow would also be small. As noted in Chapter 8, small increases in flow during the summer would likely have negative effects on covered fish species by increasing water temperatures between Big Falls and Lake Billy Chinook. LPID considers its current rate of diversion during the summer to be an appropriate rate for both the District and the covered species.

11.8.3.4 North Unit Irrigation District

NUID is seeking incidental take coverage for the storage of water in Wickiup Reservoir, the diversion of water from the Deschutes River at Bend, the diversion of water from the Crooked River near Smith Rock, and the return of water to the Deschutes River and Crooked River at multiple locations. NUID's covered activities have the potential to impact all four covered species. The storage of water in Wickiup Reservoir affects Oregon spotted frogs residing within and downstream of the reservoir, but NUID's diversions of water at Bend have no known effect on Oregon spotted frogs. The storage of water and the diversion of live flow from the Deschutes River during the summer reduce flows downstream of Bend, including the reach of the river below Big Falls that is occupied or potentially occupied by bull trout, steelhead and sockeye salmon. The diversion of water from the Crooked River reduces flows downstream of Smith Rock and affects habitat or potential habitat for all three covered fish species.

The determination of practicability for NUID is based on the economic costs of the DBHCP to the District (Criterion 2) and on the physical limitations of NUID's current infrastructure (Criterion 3). The practicability of mitigating impacts in the Deschutes River and the practicability of mitigating impacts in the Crooked River are evaluated together because these two sets of impacts are entirely interrelated. Some of the lands within NUID can only be irrigated by one source of water or the other (i.e., Deschutes River or Crooked River), but much of the farmland is irrigated with water from both sources. When NUID experiences a shortage of water from one source it is often able to make up the shortage from the other. This means that a reduction in the availability of water from one source under the DBHCP gives increased importance to water from the other and impacts NUID's flexibility to use the other source for mitigation. Specifically, the anticipated shortages of storage in Wickiup Reservoir under the DBHCP will increase NUID's need for live flow and storage from the Crooked River and reduce the District's ability to modify its Crooked River activities for the DBHCP.

NUID will experience significant reductions in the availability of water due to modified operation of Wickiup Reservoir under the DBHCP. The District will rely more heavily than it did in the past on storage available in Prineville Reservoir, but this will make up only a small percentage of the shortage. NUID has very limited options for replacing this lost water within its own District, either through the piping of canals or increased efficiency on farms. Instead, NUID plans to replace the lost Wickiup Reservoir storage with live flow from COID through a cooperative arrangement between the two Districts. The amount of water potentially available from COID is limited, and the costs for obtaining it will be high. NUID will continue to experience shortages of water under the DBHCP even with the water it acquires from COID, and its patrons will experience significant increases in the cost of water for that reduced amount. Any additional loss of water or commitment of financial resources to the DBHCP would exceed the financial capabilities of NUID and could jeopardize the viability of irrigated agriculture for the majority of NUID patrons. This is explained in greater detail below.

Oregon Spotted Frog

NUID is limited in its ability to provide mitigation for the Oregon spotted frog by its need to replace the Wickiup Reservoir storage it will lose under the DBHCP. The storage of water in Wickiup Reservoir will be reduced under the DBHCP to increase winter flows in the Upper Deschutes River for the Oregon spotted frog. This loss of storage will have a significant impact on NUID. From 2010 through 2017 the District diverted an annual average of 196,759 acre-feet of water from the Deschutes and Crooked rivers combined. Wickiup Reservoir storage regularly made up more than 40 percent of this total diversion, and in some years storage provided as much as 80 percent. Reclamation (2020) has estimated that during the first 7 years of DBHCP implementation, when the minimum flow in the Upper Deschutes River is 100 cfs, NUID could experience an average annual shortage of over 4,000 acre-feet (2 percent of its average demand) (Figure 11-1). NUID's shortage will increase over time as the requirement to increase winter flow increases, and when the minimum winter flow is 400 cfs in Year 13 of DBHCP implementation the average annual shortage could exceed 40,000 acre-feet (21 percent of NUID's average demand). Shortages of water will be even greater during dry years when there is less live flow and NUID's reliance on storage is increased. In dry years the District could fall short of meeting demand by over 120,000 acre-feet (61 percent of total demand). The magnitude of shortage in any given year will be a function of weather, which has historically been cyclical and resulted in alternating periods of successive wet years and successive dry years. During dry periods under the DBHCP, shortages of 100,000 acre-feet or more could occur in back-to-back years (Figure 11-1).

NUID has a junior water right on the Deschutes River and its historical diversions do not fully reflect agricultural demand on the District. Most NUID patrons consistently receive less than their full water right allocation, and rotational fallowing of fields due to lack of water is a regular occurrence. Annual deliveries to NUID patrons typically average about 2.0 acre-feet per acre, which is less than half of the amount (duty) provided for under the state water rights for these lands. The average amount delivered per acre is among the lowest in the Deschutes Basin. Reduction in water availability by up to 21 percent during DBHCP implementation would reduce average deliveries to 1.58 acre-feet per acre. By comparison, the average annual crop water demand for NUID farmers is 2.8 acre-feet per acre. Farmers currently remain viable by emphasizing crops that demand less than the average amount of water and by fallowing portions of their farms each year. Additional reductions in delivery below the historical 2.0 acre-feet per acre on a regular basis could make irrigated agriculture infeasible in portions of the District.

NUID plans to replace lost water by helping to fund irrigation system improvements (piping) in COID and having COID deliver the saved water to NUID. The two Districts estimate that 90,000 acre-feet of water can be made available to NUID in this manner. The Districts are jointly pursuing funding for the piping, but NUID will still need to pay a significant portion of the total costs. The piping will cost NUID as much as $115,000,000 and the District will still be left with a shortage of as much as 30,000 acre-feet in dry years under the DBHCP (Figure 11-1).

Any increase in winter flows in the Upper Deschutes River above the levels required in the DBHCP would further increase NUID's shortages. The costs for replacing additional lost storage, if it could be purchased, would increase NUID's operating costs. Either situation would threaten the economic viability of the District. Implementation of the DBHCP as specified and acquisitions of water from COID, if accomplished, will increase annual operating costs for patrons by up to $5,613 per year and leave them with as little as 1.58 acre-feet per acre for irrigation in some years. This means that NUID patrons will have the double burden of substantially higher water costs (to pay for implementation of the DBHCP and acquisition of water from COID) and continuing shortages. It is likely that many farms within the District could not remain viable if NUID were required to increase winter flows in the Upper Deschutes River beyond the levels already required by the DBHCP.

Covered Fish Species

NUID's activities have the potential to affect covered fish species by reducing instream flows in the Deschutes River and the Crooked River. The storage of water in Wickiup Reservoir during the winter and the diversion of live flow at Bend in the summer reduce flows downstream of Bend and have the potential to influence habitat for covered fish species. The diversion of live flow from the Crooked River in the summer also has the potential to affect fish habitat downstream of the NUID pumps near Smith Rock. The limits of practicability for addressing impacts to fish are a combination of the economic impact of providing additional mitigation (Criterion 2) and the physical limitations to improving habitat conditions (Criterion 3). The primary determinant of NUID's ability to address these effects is the same as for the Oregon spotted frog; the loss of storage in Wickiup Reservoir due to increased winter flows in the Upper Deschutes River.

Winter Storage of Water: The increases in winter flow below Wickiup Dam required by Conservation Measure WR-1 for the Oregon spotted frog will have downstream benefits to covered fish species as well. Historically, NUID's storage of water reduced winter flows in the Deschutes River from Wickiup Dam to the mouth. Under the DBHCP, NUID's effects on winter flow will be reduced dramatically from historical levels, and by Year 13 of implementation the minimum flow during the winter below Wickiup Dam will be 400 cfs. The entire Deschutes River downstream of the dam will benefit from these increases.

As noted previously, the increased winter flows will result in substantial shortages of water for NUID. A portion of the lost water can be replaced at a cost that will require the District to substantially increase its operating budget, but shortages of as much as 30,000 acre-feet will still occur. Any requirement to increase minimum winter flow above 400 cfs for Oregon spotted frogs or covered fish species will leave NUID with predictable shortages of more than 30,000 acre-feet per year. Any requirement to reach the 400-cfs minimum sooner than Year 13 will increase shortages in the interim years until NUID is able to acquire water from COID.

Summer Diversions of Live Flow in the Deschutes River: NUID's diversions of water at Bend during the summer reduce downstream flow in the Deschutes River, but this effect is relatively small because most of the water being diverted in mid-summer is storage that was released from Wickiup Reservoir specifically for the purpose of being diverted at Bend. The flow downstream of Bend is only reduced by the diversion of live flow, which makes up a small percentage of NUID's summer diversions. However, these live flow diversions will be critical to NUID because of the anticipated reductions in storage under the DBHCP. The District will be heavily dependent on whatever live flow it has in the Deschutes River, and will be unable to reduce the small effect it has on downstream flow.

Summer Diversions of Live Flow in the Crooked River: NUID will continue to divert water from the Crooked River during the summer under the DBHCP. As noted previously, Crooked River water will have increased importance to NUID due to the loss of storage in the Deschutes River. Any reduction in the availability of irrigation water from the Crooked River or restriction on the timing of use of Crooked River water would have the same effect on NUID's ability to deliver water as an equal reduction from the Deschutes River. The two rivers represent a single, combined source of water for NUID, and the District has no greater flexibility for its use of Crooked River water than it has for the Deschutes River.

11.8.3.5 Ochoco Irrigation District

OID is seeking incidental take coverage for the storage of water in Ochoco Reservoir, the diversion of water from the Crooked River, Ochoco Creek, McKay Creek and Lytle Creek, and the return of water at multiple locations. OID's covered activities have the potential to impact the three covered fish species. The determination of practicability for OID is based on the economic costs of the DBHCP to the District (Criterion 2) and the physical limitations of OID's current infrastructure (Criterion 3).

Covered Fish Species

OID's effects on covered species are related to the storage and diversion of water. The District diverts a combination of live flow and storage, but the majority of its diversions are of water that is seasonally stored in Ochoco Reservoir and Prineville Reservoir (the latter a federal facility under the jurisdiction of Reclamation). Live flows in the Crooked River and Ochoco Creek are very low in the summer, and irrigated agriculture within OID would not be possible without the storage of water.

OID's largest source of water is Prineville Reservoir, where the District manages rights for the storage of up to 57,899 acre-feet. OID operates Bowman Dam/Prineville Reservoir under contract with Reclamation and is in the process of paying the Federal Government for the original cost of construction. The reservoir currently has a total storage capacity of 148,633 acre-feet, but 80,360 acre-feet of the available storage were never contracted for irrigation use. This "uncontracted" storage capacity, while it could not be directly used for irrigation, benefited OID and the other Prineville Reservoir contract holders by acting as a buffer in dry years. Inflow to Prineville Reservoir is highly variable from year to year and the reservoir does not completely fill in many years. When the reservoir filled, OID and the other contract holders had access to their full contracted amount of 68,273 acre-feet and the remaining uncontracted water remained in the reservoir until the next year. If the reservoir did not fill in a given year, OID and the other contract holders often still had access to their full contracted amount of water because of the uncontracted water that remained from the year before. As a further margin of safety, OID typically delivered less than the full water right (duty) to its patrons each year (Figure 11-5) so it could leave a portion of its contracted water in the reservoir at the end of wet and average years along with any remaining uncontracted water. In this way OID was able to provide a reliable quantity of water to its patrons in most dry years as well.

This historical operation of Prineville Reservoir has changed, however, due to the efforts of OID and others. Early in the development of the DBHCP, OID and the City identified an opportunity to provide additional instream flow in the Crooked River by asking Congress to authorize use of the uncontracted water for fish and wildlife. OID recognized this would reduce the buffering effect of the uncontracted water and in turn reduce the amount of water OID could reliably deliver to its patrons, but the District and the City supported the request as means of reducing the effects of their activities on the covered fish species. With the support of OID, the City, the Services and others, Congress passed and President Obama signed the Crooked River Collaborative Water Security and Jobs Act of 2014 (Crooked River Act). This Act now allows Reclamation to use up to 62,520 acre-feet of storage in Prineville Reservoir (42 percent of the total storage capacity) to support flows in the Crooked River for fish and wildlife. Reclamation, with input from the Services, continues to refine the use of the water for optimal benefit to fish and wildlife, and the full effect of the Crooked River Act on OID is not yet known. Nevertheless, it is clear that releases of the uncontracted water will have substantial benefit to the covered fish species while simultaneously reducing the amount of storage available to OID, particularly during successive dry years.

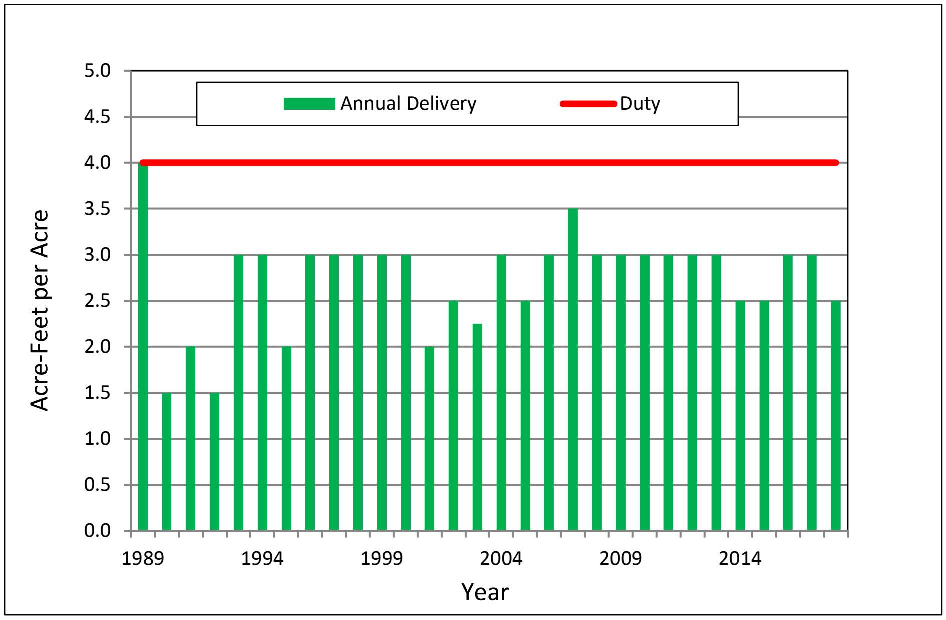

Figure 11-5. Ochoco Irrigation District deliveries of water to patrons from 1989 through 2018.
Source: OID 2019.

Although the Crooked River Act was pursued proactively by OID and the City during DBHCP development, it cannot be considered part of the DBHCP conservation strategy. However, this does not reduce the benefits of the Act on the covered species or the impacts of the Act to OID. Any water OID might have been able to dedicate to the DBHCP prior to the Crooked River Act is no longer available. The potential for shortage within the District has increased as a result of the Act, but the magnitude and frequency of the shortages are unknown because the use of the uncontracted water is still evolving and is under the control of Reclamation. As a consequence, OID is unable to commit additional water to instream flow beyond that already required by Conservation Measure CR-1.

OID's ability to commit more water to the DBHCP is also constrained by the way in which storage is allocated under the Crooked River Act. The irrigation contract holders in Prineville Reservoir have first-fill priority, and water is available for uncontracted fish and wildlife use only when the total reservoir volume exceeds 86,113 acre-feet. If OID were to use more of its available storage for fish and wildlife (beyond the requirements of Conservation Measure CR-1), this would reduce the amount the District leaves in the reservoir in the fall and indirectly decrease the amount available for fish and wildlife use the following year. The use of OID's water described in the DBHCP represents an intentional effort to achieve balance between annual storage, irrigation use and fish and wildlife use that can be sustained over the long-term.

11.8.3.6 Swalley Irrigation District

SID is seeking coverage for the diversion of live flow from the Deschutes River during the summer for irrigation and during the winter for livestock. SID has no storage reservoir or storage water rights. The District's activities have no effect on the Oregon spotted frog, but the diversion of water at North Canal Dam in Bend reduces flows in the Deschutes River downstream of Bend, including the reach of the river below Big Falls that is occupied or potentially occupied by bull trout, steelhead and sockeye salmon. The determination of practicability for SID is based on the cost of mitigation to the District (Criterion 2) and the physical ability of the District to provide mitigation for the covered species (Criterion 3).

SID is a leader in water conservation within the Deschutes Basin. The District has proactively returned about 43 cfs to the Deschutes River as of 2019. During DBHCP development alone, SID transferred 39 cfs (31 percent) of its original 125 cfs Deschutes River diversion right to instream flow. This is a higher percentage of total irrigation water right transferred instream than any other irrigation district has even attempted in Oregon. It was accomplished through the piping of 5.1 miles of SID's main canal to reduce seepage losses, followed by the unprecedented instream transfer of more water than SID actually saved by piping (thereby resulting in a net loss of water by Swalley). The canal piping was opposed in federal court by over 600 landowners; a process that consumed several years and increased the overall cost to SID. When it was eventually completed, the piping was financed in part with emergency loans that are now being repaid with revenues from SID's Ponderosa Hydroelectric Project. The hydroelectric project generates electricity from water passing through the District's pipeline on its way to farms (the timing and magnitude of diversions are not altered by the operation of the project).

SID may conduct additional piping during the term of the DBHCP to improve the efficiency of its conveyance system. The un-piped portions of its canals continue to have seepage losses of about 21 percent. However, funding for the piping is tenable at best, and not all water potentially available to be conserved through that piping can be transferred instream, for the following two reasons.

First, a result of SID's past piping and instream water right transfers is that the District has insufficient water to meet patron demands during the shoulder seasons of April 1 through May 14 and September 15 through October 31. During the peak irrigation season (May 15 through September 14), when its major farm producers come online, the District operates with tight restrictions on the number of individual instream leases it can allow without further impairing deliveries to its remaining patrons; a function of the inefficiencies of the remaining segments of earthen canal in the District. In some years, as evidenced by the 2018 irrigation season, the District was unable to fulfill patron demands throughout the entire peak season despite many fields lying fallow and out of production. If a higher percentage of the fallowed fields came into production at once and the District experienced full demand, it would not be able to fulfill peak season deliveries. Future conserved water from piping projects will therefore be needed to compensate for the major instream transfers SID has already made. Said another way, the water right transfers made prior to 2019 exceeded the canal seepage reductions SID was able to realize and resulted in reduced deliveries to SID patrons, but the transfers were required to secure emergency loans that were necessary to cover major cost overruns caused by local opposition to piping. Over the term of the DBHCP SID will attempt to continue piping its canal system as grant funding becomes available, with the goal of once again being able to fully meet patron irrigation demand.

Second, the continued diversion of SID's remaining water right is necessary for generating hydroelectric revenues, which in turn are used to repay the loans for the completed piping projects that enabled SID to transfer 43 cfs of its irrigation rights to instream use for fish. The financial model for piping was based on the assumption that hydropower revenues would be available to repay construction loans. Since hydropower generation is directly tied to irrigation diversions, additional reductions in SID diversions during the term of the DBHCP would reduce hydropower revenues and impair SID's ability to repay existing loans. Furthermore, SID's power sale agreement with PacifiCorp contains contractual minimum production clauses, scheduled rate decreases of over 50 percent by 2028, and an expiration date of 2030 that will leave the District with no guarantee of a revenue stream to repay or secure future loans.

SID's effects on flow in the Middle Deschutes River are very small compared to other irrigation districts because of its small size (current peak diversions of 82 cfs) and relatively low seepage losses. Already being in a deficit water supply situation, SID could not remain viable as an irrigation district nor repay its current debt if it had to further reduce its diversions from the Middle Deschutes River during the summer.

11.8.3.7 Three Sisters Irrigation District

TSID is seeking coverage for the diversion of live flow from Whychus Creek upstream of Sisters, Oregon during the summer for irrigation and during the fall and spring for livestock. The District has no instream irrigation storage or storage water rights. TSID's diversions of live flow reduce the flow in Whychus Creek, which can affect steelhead and bull trout. The determination of practicability for TSID is based on the physical limitations of the District's water distribution system (Criterion 3).

TSID has transferred 31.18 cfs (20 percent) of its original diversion right to instream flow by piping its entire water conveyance and distribution system. The canal piping was financed in part with loans that are being repaid with revenues from two hydroelectric projects that were built in conjunction with the piping. The hydroelectric projects generate electricity from water diverted through the District's pipe. TSID has no additional opportunities to conserve water within its system.

Additional flow in Whychus Creek could only be provided through voluntary instream transfers by individual TSID patrons. The DBHCP includes two provisions for TSID to facilitate such transfers. Conservation Measure WC-2 requires TSID to provide financial support for temporary instream leasing by patrons, and Conservation Measure WC-4 commits TSID to assisting patrons with the piping of their private ditches that will enable them to make permanent instream transfers. TSID has no other means of providing additional instream flow.

11.8.3.8 Tumalo Irrigation District

TID is seeking coverage for the operation of Crescent Lake Reservoir on Crescent Creek, the diversion of water from the Deschutes River in Bend, and the diversion of water from Tumalo Creek. The operation of Crescent Lake Reservoir affects Oregon spotted frogs residing downstream of the reservoir in Crescent Creek, the Little Deschutes River and the Deschutes River. The diversions on the Deschutes River and Tumalo Creek have no identified effects on Oregon spotted frogs, but they can affect covered fish species in the Deschutes River downstream of Big Falls. The storage of water in Crescent Lake Reservoir also causes a small reduction in Deschutes River flow during the winter. The determination of practicability for TID is based on the physical limitations of the District's infrastructure (Criterion 3).

Oregon Spotted Frog

TID's operation of Crescent Lake Reservoir under the DBHCP represents a substantial reduction in the potential for incidental take of Oregon spotted frogs from historical conditions. Opportunities to provide additional mitigation are limited by the physical constraints of the reservoir and the hydrology of Crescent Creek.

The seasonal storage and release of water in Crescent Lake Reservoir decreases flows in lower Crescent Creek and lower Little Deschutes River for much of the storage season (October through June) and increases flows during the latter half of the irrigation season (July through September). Historically, the increased late-summer flows benefited Oregon spotted frogs by counteracting naturally low flows in Crescent Creek and Little Deschutes River and sustaining summer rearing habitat. Historical flows were extremely low during the storage season, however, and this reduced the availability of overwintering and breeding habitat for Oregon spotted frogs. Under the DBHCP, storage season flows below Crescent Lake Dam will be increased from historical levels to protect over-wintering and breeding habitat for Oregon spotted frogs. Storage season flows below the dam will be held constant (within operational limits) at the new level during the fall and winter to reduce the potential for extremely low flows that would otherwise occur under natural conditions and buffer natural fluctuations that are known to be harmful to Oregon spotted frog eggs and larvae. A minimum flow will also be maintained below Crescent Lake Dam in July through August to help sustain summer rearing habitat into the early fall regardless of irrigation demand during this period. If any of the initial DBHCP minimum flows prove to be too low to maintain and enhance Oregon spotted frog habitat, they can be increased through adaptive use of Crescent Lake Reservoir storage dedicated for this purpose (OSF storage) according to Conservation Measure CC-1.

The net effect of increasing winter flows and dedicating a portion of Crescent Lake Reservoir storage to Oregon spotted frog habitat management under the DBHCP will be an overall reduction in annual storage of as much as 5,600 acre-feet (28 percent of the long-term average annual storage) (Reclamation 2020). This will reduce the amount of water that is released for irrigation during the summer, which could result in potential degradation of summer wetland habitat conditions along lower Crescent Creek and lower Little Deschutes River. The potential for habitat degradation will be minimized, however, through strategic release of the OSF storage in collaboration with USFWS. The Permittees and USFWS believe this to be the optimal use of Crescent lake Reservoir storage. The portion of storage that continues to be released for irrigation will maintain the summer flows in lower Crescent Creek and lower Little Deschutes River that are known to be beneficial to Oregon spotted frogs, and the OSF storage will be used to fine-tune releases at times of the year when the irrigation releases result in less than optimal conditions. Any additional commitment of water to OSF storage above the amounts specified in Conservation Measure CC-1 would simultaneously reduce irrigation releases, which would negatively impact summer flows (and associated habitat conditions), and require that the additional OSF storage simply be released to make up the difference. Consequently, there would be no net improvement in habitat for Oregon spotted frogs.

By design, the DBHCP proposal strives for optimal use of the reservoir for Oregon spotted frogs. As noted above, winter flows cannot be higher without negatively impacting summer flows, and summer flows cannot be higher without negatively impacting winter flows. The ramp-down of flows at the end of the irrigation season, which has been suggested as a source of incidental take, will be gradual to reduce the associated impacts to frogs. The rate and timing of the ramp-down can be modified, as needed, with use of the OSF storage, but the ramp-down cannot be eliminated altogether without disrupting the desired hydrology of the creek and negatively impacting Oregon spotted frogs.

The OSF storage may also be used to make real-time (e.g., daily) adjustments to Crescent Creek outflow to counteract natural fluctuations in flow from unregulated tributaries (Big Marsh Creek and Upper Little Deschutes River) for the benefit of Oregon spotted frogs. However, the opportunities to do this will be limited by the remote location of the dam, the imprecise nature of the flow control structure, the unpredictable nature of the unregulated tributaries, and the lag in response time between the dam and occupied Oregon spotted frog habitat several miles downstream. Attempts to modify reservoir outflow to counteract short-term rises or falls in unregulated tributary flow will likely have just the opposite of the desired effect and increase, rather than decrease, the amplitude of the fluctuations.

Covered Fish Species

The DBHCP does not require TID to implement conservation measures for the Deschutes River, but the District's management response to the DBHCP is likely to have measurable incidental benefits to covered fish species. TID will accommodate the loss of storage in Crescent Lake Reservoir by piping its canal system to reduce seepage losses. The District estimates that complete piping of its canal system will reduce overall seepage losses by about 17,000 acre-feet per year and enable it to meet patron demand in most years. TID intends to secure public funding for the piping and transfer 100 percent of the former seepage loss to instream flow. Under Oregon's Allocation of Conserved Water law, the water saved through piping will be transferred instream to Tumalo Creek and Crescent Creek in proportion to TID's reliance on each. A portion of the water will be converted to an instream right in Tumalo Creek and downstream reaches of the Deschutes River during the summer where it will reduce the District's effects on habitat for covered fish species. The remainder of the conserved water will be used to create a permanent instream right in Crescent Creek for the storage season flow commitment of the DBHCP. This effort will not increase the amount of water released from Crescent Lake Reservoir in the winter, but it will result in an instream water right for the releases in perpetuity to protect them from downstream diversion.

Based on TID's current use of water, the portion placed instream in Tumalo Creek would be 60 percent, which would amount to about 10,200 acre-feet from complete piping of the canals. This proportion may change over time as TID's reliance on Tumalo Creek and Crescent Creek changes, but the need to split the saved water between the two creeks will continue throughout the piping program and it will determine the total amount of water TID can place instream in the Deschutes River during the summer. The benefit to fish of TID's conserved water projects will be that the Tumalo Creek water is considerably cooler than Deschutes River water at Bend. Any additional flow at the mouth of Tumalo Creek during the summer will improve habitat conditions for covered fish species downstream of Big Falls by reducing rather than increasing water temperature simultaneous with increasing flow.

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FINAL

DESCHUTES BASIN
HABITAT CONSERVATION PLAN

Chapter 12 – Acronyms, Abbreviations and Definitions

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12 – ACRONYMS, ABBREVIATIONS AND DEFINITIONS

12.1 Acronyms and Abbreviations

7-DADM	7-day average of the daily maximum temperature
AID	Arnold Irrigation District
AIP	Aquatic Inventories Project
BENO	Hydromet stream gage in the Deschutes River at Benham Falls
BLM	USDI Bureau of Land Management
BSWG	Basin Study Work Group
CAPO	Hydromet stream gage in the Crooked River near Prineville
CEST	Cascade Eastern Slope Tributaries
CFR	Code of Federal Regulations
cfs	cubic feet per second
City	City of Prineville, Oregon
COID	Central Oregon Irrigation District
CPI-U	Consumer Price Index for all urban consumers
CRA	Hydromet volume and stage gage in Crane Prairie Reservoir
CRAO	Hydromet stream gage in the Deschutes River below Crane Prairie Dam
CRE	Hydromet volume and stage gage in Crescent Lake Reservoir
CREO	Hydromet stream gage in Crescent Creek below Crescent Dam
CTWSRO	Confederated Tribes of the Warm Springs Reservation of Oregon
DBBC	Deschutes Basin Board of Control
DBHCP	Deschutes Basin Habitat Conservation Plan
DEBO	Hydromet stream gage in the Deschutes River below Bend
DO	dissolved oxygen
DPS	distinct population segment
DRC	Deschutes River Conservancy
EPA	US Environmental Protection Agency
ESA	Endangered Species Act
ESU	evolutionarily significant unit

FERC	Federal Energy Regulatory Commission
fps	feet per second
FR	Federal Register
gpm	gallons per minute
HCP	Habitat Conservation Plan
ICTRT	Interior Columbia Basin Technical Recovery Team
LAPO	Hydromet stream gage in the Little Deschutes River near La Pine
LPID	Lone Pine Irrigation District
MCR	Middle Columbia River
mgd	million gallons per day
mg/L	milligram per liter
MOU	memorandum of understanding
MPG	major population group
MWAT	Maximum weekly average temperature (annual maximum of the rolling 7-day average of daily average temperature)
NASS	National Agricultural Statistics Service
NFCP	Native Fish Conservation Policy
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPCC	Northwest Power and Conservation Council
NPDES	National Pollutant Discharge Elimination System
NUID	North Unit Irrigation District
NWI	National Wetland Inventory
OAR	Oregon Administrative Rule
OCH	Hydromet volume and stage gage in Ochoco Reservoir
OCHO	Hydromet stream gage in Ochoco Creek below Ochoco Dam
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
OID	Ochoco Irrigation District
ORS	Oregon Revised Statute
OWRD	Oregon Water Resources Department
PCE	primary constituent element of designated critical habitat

PGE	Portland General Electric
PRV	Hydromet volume and stage gage in Prineville Reservoir
PRVO	Hydromet stream gage in the Crooked River below Bowman Dam
Reclamation	USDI Bureau of Reclamation
RM	river mile
RU	recovery unit
Services	US Fish and Wildlife Service and National Marine Fisheries Service, collectively
SID	Swalley Irrigation District
TDG	total dissolved gas
TID	Tumalo Irrigation District
TMDL	total maximum daily load
TSID	Three Sisters Irrigation District
UCM	Unit Characteristic Method
UDLAC	Upper Deschutes Local Advisory Committee
UDWC	Upper Deschutes Watershed Council
USACE	US Army Corps of Engineers
USDA	US Department of Agriculture
USDI	US Department of Interior
USFS	US Forest Service
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
VSP	viable salmonid population
WRCC	Western Regional Climate Center

12.2 Definitions

adfluvial	Term to describe the life history strategy of fish that migrate between flowing waters (rivers and streams) and freshwater lakes.
alevin	A newly-hatched trout or salmon that is still attached to the yolk sac.
anadromous	Term to describe the life history strategy of fish that rear in freshwater rivers and streams, migrate to the ocean prior to maturity, and return to freshwater as adults to spawn.
duty	The maximum volume of water that can be delivered under a water right over the irrigation season, stated in acre-feet per acre of irrigated land.
emergent	Term to describe wetland vegetation that tolerates inundation during the growing season but has parts (typically stems, leaves and flowers) extending above the water surface.
fluvial	Term to describe the life history strategy of fish that migrate between small flowing waters and larger flowing waters.
headworks	Physical structure at the point of diversion from a surface water, to control the timing and rate of diversion.
lacustrine	Term to describe wetlands associated with lakes.
larvae	Life stage of an animal immediately after emergence from an egg; synonymous with alevin in salmon and trout and tadpole in amphibians.
lateral	A secondary canal used to convey irrigation water from a main canal to a point of delivery to a patron.
live flow	That portion of water flowing in a river or creek that is entirely caused by natural flow and is not reduced by the upstream storage of water or increased by the upstream release of water that was previously stored.
livestock water	Water that is diverted from a river or creek outside the normal irrigation season for use by livestock; also known as stock water.
natal	Term to describe the location of birth (or hatching) and early development of an animal
parr	Life stage of a salmon or trout between fry and smolt.
patron	Person or entity receiving the delivery of irrigation water from an irrigation district.

Permittee	One of the nine entities (eight irrigation districts and the City of Prineville, Oregon) receiving incidental take coverage through implementation of the Deschutes Basin Habitat Conservation Plan.
ranid	Term to describe frogs of the family Ranidae
redd	A depression in streambed gravel or sand excavated by an adult female salmon or trout for egg deposition.
regulated conditions	Conditions (flow and stage) in a river or creek as affected by the storage, release, diversion and return of irrigation water and other human activities.
reserved works	Federally-owned irrigation facility such as a reservoir, diversion dam or canal for which Reclamation maintains responsibility for operation and maintenance. Reclamation may conduct operation or maintenance itself or contract with an irrigation district to operate and maintain the facility.
return flow	Water diverted for irrigation that has subsequently been allowed to flow back into a natural river or creek.
riparian	Term to describe areas adjacent to fresh waters that ecologically influence and/or are influenced by the adjacent surface water.
spill	Diverted irrigation water that returns as surface water to a river or creek without ever being applied to irrigated lands.
stage	The depth of a water body at a point of measurement.
tailwater	Water that has been applied to irrigated lands and subsequently returned to a river or creek through surface flow.
transferred works	Federally-owned irrigation facility such as a reservoir, diversion dam or canal for which the responsibility for operation and maintenance has been permanently transferred to an irrigation district.
unregulated conditions	Conditions (flow and stage) in a river or creek that would occur under current land use, but without the effects of the storage, release, diversion or return of water for irrigation.