Harney Basin Placed Based Planning
DRAFT Rivers and Streams Step 2 Report
July 20, 2023 (Updated November 25, 2023)

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Step 2 Report for Harney Basin Rivers and Streams

Introduction

This report summarizes available information to describe the hydrology and ecology of the river systems of the Harney Basin. It includes information on the hydrology, water quality, historic and current presence of species, fish passage barriers, and the riparian areas associated with the river systems.

In the Harney Basin, the streams and rivers and their associated riparian areas provide crucial habitat for a diverse group of native species such as the Great Basin Spadefoot Toad, long-toed salamander, willow flycatcher, and redband trout. The basin's streams and rivers also provide the water that supports the ecosystems and species on the Malheur National Wildlife Refuge.

The data and information described in this report have been retrieved from state and federal agencies, non-governmental organizations or peer reviewed publications, with references provided. The report provides citations to additional information and identifies data gaps.

Overview of Harney Basin rivers and streams

Rivers, streams and their associated riparian areas in the Harney Basin support a diversity of fish, freshwater mussels, wildlife and plants. The Harney Basin represents the surface-water drainage area of three adjacent terminal lakes, Malheur Lake, Harney Lake, and Mud Lake (Garcia et al., 2022). It is composed of four sub-basins containing rivers and streams that flow towards these lakes: Silvies River, Silver Creek, Donner und Blitzen River, and a fourth, the Harney-Malheur Lakes sub-basin, that includes several smaller streams that flow towards the lakes from the north (Poison Creek, Prater Creek, Rattlesnake Creek, Coffeepot Creek and Cow Creek)) and from the south (Smyth Creek and Riddle Creek). (Figure 1).

Figure 1. Harney Sub-Basins (Silver Creek, Silvies River, Harney-Malheur Lakes and Blitzen). (From Esquivel 2018).

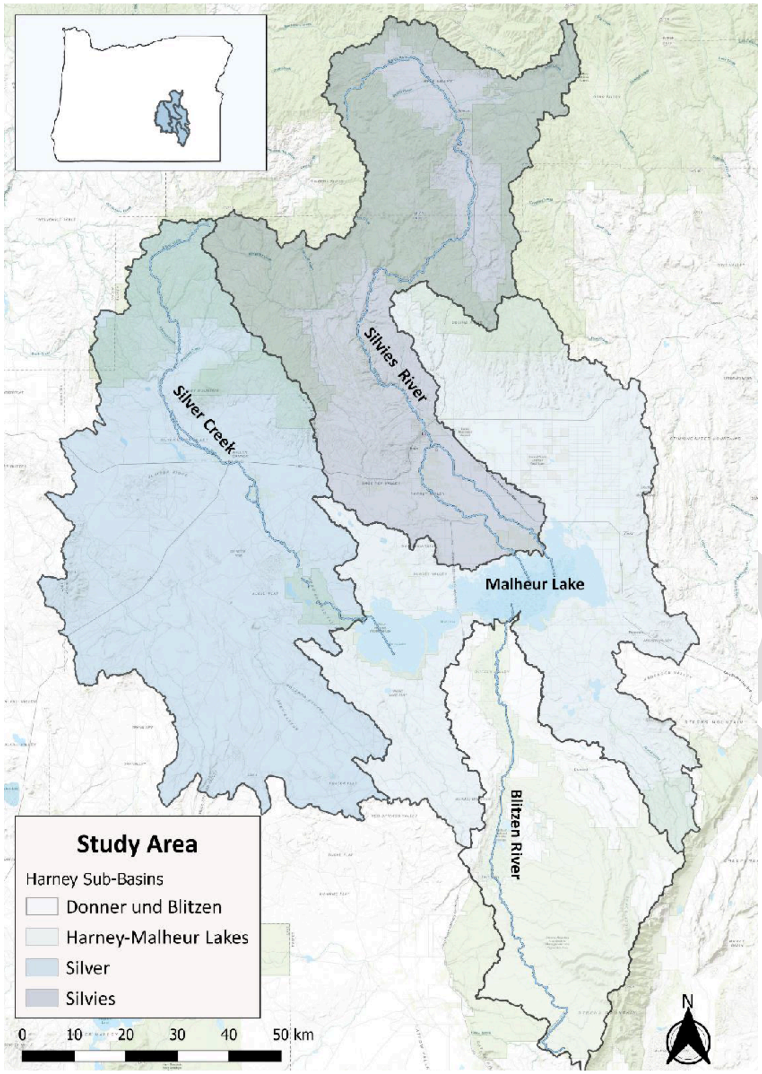

Figure 2. Location of the Harney Basin, southeastern Oregon, and its major geographic and cultural features. Northern, southern, and western regions are included for discussion and analysis purposes. (From Garcia et al., 2022).

4 Hydrologic Budget of the Harney Basin Groundwater System, Southeastern Oregon

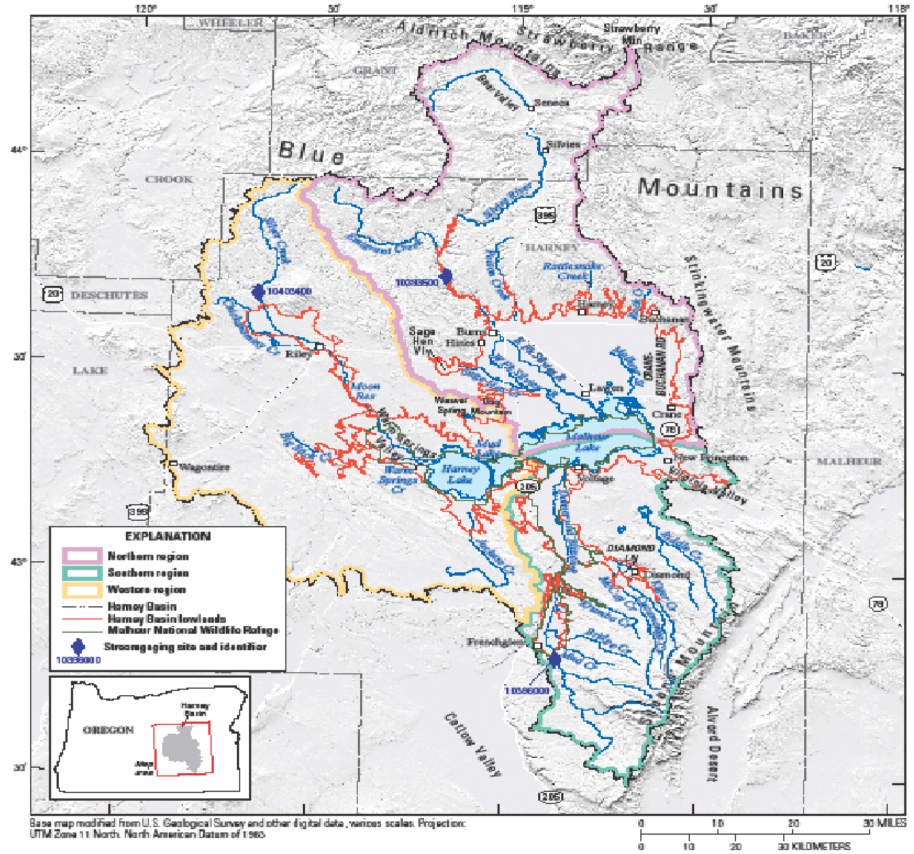

Figure 1. Location of the Harney Basin, southeastern Oregon, and its major geographic and cultural features. Northern, southern, and western regions are included for discussion and analysis purposes.

Figure 3. Table 1: Area and stream kilometers of Harney Basin sub-basins. Stream length calculations only incorporate perennial or intermittent streams. Source for areas: https://water.usgs.gov/GIS/huc_name.txt (visited 7-14-2023); source for stream miles: U.S. Geological Survey (2019). National hydrography dataset (ver. High resolution plus).

HUC 8	Sub-Basin Name	Acres	Square Miles	Stream kilometers (miles)
17120001	Harney-Malheur Lakes	908,800	1,420	1,737 (1,079)
17120002	Silvies	838,400	1,310	2,281 (1,417)
17120003	Donner und Blitzen	489,600	765	1,612 (1,002)
17120004	Silver	1,068,800	1,670	2,877 (1,788)

A 2018 report prepared by the Harney Basin High Desert Partnership for the Oregon Watershed Enhancement Board provides this overview:

> "The Harney Basin is a hydrographically closed watershed located in southeastern Oregon and is comprised of four major sub-basins (8-digit HUC) – Silvies, Silver, Malheur-Harney Lakes, and Donner und Blitzen (Figure 1). The basin receives drainage from the Silvies River and Silver Creek located to the north and northwest, respectively, and the Donner und Blitzen River (hereinafter referred to as the Blitzen River) located to the south. Water originates primarily from snowmelt and runoff from higher elevations; however, springs contribute some of the flow. The smaller tributaries into the basin are intermittent and disappear into the alluvial fans of the surrounding uplands. Since the late 1800's, numerous dikes, canals, drains, and water control structures have been installed across the basin to facilitate the diversion of water for the benefit of grazing and farming. With diversions, flows are intercepted and channels are dewatered often leaving no flow to reach Malheur and Harney Lakes."

(Esquivel, 2018).

Regarding streams in the lowlands, USGS explains that "[t]he areal extent of surface-water irrigated agricultural fields in the northern and western region lowlands today likely exceeds the area that naturally flooded prior to development and the current volume of surface water consumed through ET from flood-irrigated agriculture likely exceeds the annual volume naturally consumed before development" (Garcia et al., 2022). Therefore, there is likely more demand on lowland streamflow than natural, pre-development conditions.

Summary of Harney Basin river and stream hydrology

Many existing reports and papers assess and document the watersheds and hydrology of the Harney Basin, including but certainly not limited to the three sub-basin watershed assessments (for Silver Creek, Harney-Malheur Lakes, and Silvies River) prepared by the Harney County Watershed Council, funded in part by Oregon Watershed Enhancement Board (OWEB); the Malheur National Wildlife Refuge Comprehensive Conservation Plan (2013) and related papers; the Aquatic Health Basin-Wide Baseline Monitoring Report (2016-2018), funded by OWEB and prepared on behalf of the High Desert Partnership; and the Public Draft of the Malheur Lakes Redband Trout Conservation Plan (2018), prepared by the Oregon Department of Fish and Wildlife. This report does not attempt to summarize all of that work, but rather to provide an overview as a piece of the place based planning process.

Overview of the four sub-basins: Silvies River, Donner und Blitzen, Silver Creek, Harney-Malheur Lakes

Silvies River Sub-basin

The Silvies River sub-basin area is 838,400 acres (1,310 square miles). It ranges in elevation from 4,085 to 9,038 feet above sea level. At higher elevations, it is mainly forest lands which comprise about 40 percent of the total acreage in the Silvies watershed. Principal tree species are ponderosa pine and associated fir and larch. Sagebrush steppe range lands make up about 48 percent of the area in the Silvies watershed. Big sagebrush, rabbit-brush, and greasewood are dominant shrubs with desert salt grass, giant wild rye and other species of grasses interspersed.

In the 1925 adjudication of water rights of the Silvies River, the Oregon Supreme Court described the stream system as follows:

> "There are three valleys of considerable extent, through which Silvies River flows. These valleys have but little fall. Spring floods consequently overflow considerable of the land creating meadows, marshes and swamps, the peak of the flood occurring sometime in April. The run-off, prior to April 1st, is of but little benefit to the irrigators, as the ground is generally frozen or under snow until this time. Commencing at the north the first of these valleys is Bear Valley, which is situated near the headwaters of the river. It has an elevation of about 5,000 feet. The river flows through this valley from east to west and enters a deep winding canyon, which it follows southward for about 8 miles to where it enters Silvies Valley, which is the second valley of importance on this stream system. This valley has an elevation of 4,500 to 4,800 feet. The river flows through this valley in a well-defined but shallow channel and again enters a deep canyon which it follows in a general southward direction for about 35 miles to Harney Valley, which is the largest of the three valleys. The river flows in a southeasterly direction across Harney Valley to Malheur Lake. In this valley the river has no well-defined channel, but follows numerous sloughs and depressions for nearly 30 miles and empties into the lake in several different places."

(Re Rights to Waters of Silvies River, 237 P. 322, Or. 1925).

This description from La Marche (2011) provides additional detail:

> "The Silvies River naturally bifurcates as it enters Harney Valley. Numerous sloughs carry water to individual or groups of irrigators, the largest being Foley Slough. Legally, stream flow is to be divided between the main stem Silvies and Foley Slough at a ratio of approximately 10 to 1, based on the water rights on each system (This ratio actually varies somewhat based on the priority date and acreage of the rights being fulfilled from each channel, which in turn depends on the available flow above the bifurcation point).
>
> Historically, this division in flow occurred somewhat naturally due to the channel configuration and associated hydraulic properties in each channel. This is no longer true due to either natural or anthropogenic changes in the Silvies channel and some controversy exists on how to remedy this issue. There is no head gate on the Foley Slough as it is legally considered a distributary of the Silvies River.
>
> The other large bifurcation on the Silvies River critical for water management is the East Fork/West Fork split. At most flows, stream flow is to be almost equally divided between the two forks based on the water rights priority date and acres associated with each branch. However, most of the very senior water rights receive water from the West Fork, which means that at low flows upwards of roughly 70% of the water should be sent down the West Fork channel. Dams are present on both the East and West Forks and are used to manage the distribution of flows between the two branches.
>
> The main water users in the Silvies watershed are the Blue Mountain Cattle Company, Island Ranch, and the Bell–A Grazing Cooperative. Diversions to these users are monitored through routine manual discharge measurements of the diversions during the summer due to the scarcity of available flow.
>
> There is water use in the Silvies Valley (upstream of Harney Valley), but it is comparatively small and confined to the alluvial filled valley next to the river."

Notably, though, diversions above the Silvies River streamflow gage at Burns (USGS ID: 1039500) remove 40% of the streamflow during the July through September season. (Garcia et al, 2022). The flat valleys of wet meadows and meandering streams are connected by canyon segments with steeper gradients and step-pool stream structure.

A 1975 USGS study of inflow and outflow to and from Malheur Lake (Hubbard, 1975) found that “[m]ost of the streamflow from the basin is diverted for irrigation before it reaches Malheur Lake” and that “[i]n years of very low snowpack, all the flow is diverted and used before it reaches the lake, but in years of above-normal precipitation, such as the 1972 water year, about one-third of the runoff reaches the lake.” Discussing the USGS stream gage on the Silvies River near Burns, the study noted that “[m]uch less flow enters the lake than passes the upstream gaging station;” in the 1972 water year, 162,000 acre-feet passed the upstream gage with 55,000 acre-feet reaching the lake, while in the 1973 water year, 51,000 acre-feet passed the upstream gage with 1,000 acre-feet flowing into Malheur Lake. Stream gages do not currently exist downstream of the gage near Burns that could create a current or more detailed picture of streamflows across that lower portion of the river.

Figure 4. Hydrographs for the Silvies River comparing flows passing the gaging station near Burns with flows reaching Malheur Lake for Water Years 1972 and 1973. (From Hubbard, 1975).

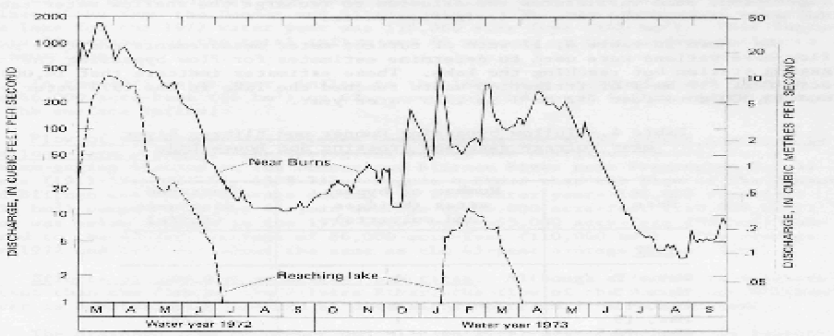

Figure 5 — Hydrographs for the Silvies River comparing flows passing the gaging station near Burns with flows reaching Malheur Lake.

Donner und Blitzen River

The Donner und Blitzen River, known locally as the "Blitzen," is the largest source of inflow to Malheur Lake. Its major source of water is from snowmelt on Steens Mountain. It has a drainage area of about 760 square miles (2,000 km^2) and a main channel length of about 70 miles (110 km). Its basin ranges in elevation from 4,090 feet (1,250 m) at Malheur Lake to 9,670 feet (2,950 m) at a summit in Steens Mountain. Channel slope on Steens Mountain above Fish Creek at river mile 48 (77 km) is 100 feet per mile (20 m/km); channel slope below Fish Creek in the Blitzen Valley is less than 10 feet per mile (2 m/km). Just south of Malheur Lake, the slope is less than 2 feet per mile (0.4 m/km). The upper part of the drainage area is covered with native grass and scattered juniper and aspen. The lower part consists of rangeland, some irrigated cropland, and artificial ponds and meadows established for wildlife habitat.

Gaging station Donner und Blitzen River near Voltage was reestablished for this study and is about 2 miles (3 km) upstream from Malheur Lake and just downstream from Sod House Dam. Water is diverted at and above Sod House Dam for irrigation. Most of this diverted water is used consumptively by

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Continuous streamflow data from 1973 to the present are available from the gage near Burns. However, no continuous streamflow data has been collected at the mouth, where the Silvies meets the lake, since the 1970s. In 1972 and 1973, when discharge at the stream gage near Burns was below about 50 cfs, no water reached the lake.

Donner und Blitzen River Sub-basin

The Donner und Blitzen River sub-basin is the smallest in size of the four sub-basins, covering 489,600 acres (765 square miles). The name means thunder and lighting in German and was assigned to the river by an Army commander who crossed the river during a thunderstorm in 1864. The river arises as an intermittent stream on the slopes west of Steens Mountain at the 6,500-foot elevation, where it gathers streamflow from snowmelt and spring discharge. The stream steeply descends to the Harney Basin. Numerous nearby springs create its tributaries including South Fork Blitzen River, Little Blitzen River, Big Indian Creek, Little Indian Creek, Fish Creek, Mud Creek, and Ankle Creek. It collects these and runs north or northwest descending rapidly to the plateau floor then turns northward and flows into Malheur Lake.

USGS explains that

> "About half of the river's annual discharge into Malheur Lake originates in the watershed of the main stem upstream of Frenchglen. The other half of the river's annual discharge into Malheur Lake originates in watersheds drained by Kiger, McCoy, Bridge, Mud, Krumbo, and Cucamonga Creeks . . ., and from spring discharge and diffuse groundwater inflow to the main stem between Frenchglen and Diamond Lane. In the lowlands, most reaches of the Donner und Blitzen River and its tributaries are gaining flow from groundwater upstream of Diamond Lane and losing flow to groundwater downstream of Diamond Lane."

(Garcia et al., 2022).

86.5 miles of the Donner und Blitzen River system are protected under the federal Wild and Scenic River Act as a Wild River Area. Congress made the first designation in 1988, adding 14.8 miles of tributaries in 2000, collectively including: the Donner und Blitzen from its headwaters to the confluence with the South Fork Blitzen and Little Blitzen, and the following tributaries: Little Blitzen River, South Fork Blitzen River, Big Indian Creek, Little Indian Creek and Fish Creek, Mud Creek from its source to its confluence with the Donner ünd Blitzen River; Ankle Creek from its headwaters to its confluence with the Donner ünd Blitzen River; and the South Fork of Ankle Creek from its source to its confluence with Ankle Creek.

Findings of several Outstandingly Remarkable Values support the Wild River designation including:

> "The Blitzen River supports a wild, native redband trout population and the Malheur mottled sculpin, both listed as sensitive species. It is recognized by anglers as one of Oregon's finest wild trout streams. Fish species in the Blitzen River above Page Springs Dam are redband trout, mountain whitefish, longnose dace and mottled sculpin. The redband trout is the species most commonly found in the system, indicating the presence of good stream habitat, water quality and quantity."

> ***
>
> "The Blitzen River drainage is highly valued for its abundant wildlife. The river area and adjacent uplands are used by an estimated 250 wildlife species. Mule deer winter in the lower four miles of the Blitzen River and the lower four miles of Fish Creek and summer in upper areas. Rocky Mountain elk and pronghorn antelope are also present.
>
> Raptors, such as the American kestrels, and great horned owls nest along canyon rims of the Blitzen River and its tributaries, and the cliffs are also home to nesting turkey vultures and ravens. Sage grouse stay in the upper, flatter terrain, and chukars and valley quail are found along the river."

BLM, Donner Ünd Blitzen Wild And Scenic River. Available here: https://www.blm.gov/programs/national-conservation-lands/oregon-washington/donner-und-blitzen-wsr (visited January 22, 2023).

Additionally, Congress designated the first ever Redband Trout Reserve on the Blitzen River system in 2000. 16 U.S. Code § 460nnn–72. The purposes of the Redband Trout Reserve are: "(1) to conserve, protect, and enhance the Donner und Blitzen River population of redband trout and the unique ecosystem of plants, fish, and wildlife of a river system; and (2) to provide opportunities for scientific research, environmental education, and fish and wildlife oriented recreation and access to the extent compatible with paragraph (1)." (*Id.* at (c)). In establishing the Reserve, Congress found that: "(1) Those portions of the Donner und Blitzen River in the Wilderness Area are an exceptional environmental resource that provides habitat for unique populations of native fish, migratory waterfowl, and other wildlife resources, including a unique population of redband trout [and] (2) Redband trout represent a unique natural history reflecting the Pleistocene connection between the lake basins of eastern Oregon and the Snake and Columbia Rivers." (*Id.* at (a)).

Silver Creek Sub-basin

Arising in the Blue Mountains, Silver Creek flows generally southeast through the Silver Creek Volcanic Field. It is the largest of the four sub-basins, covering 1,068,800 acres (1,670 square miles). Silver Creek is fed by tributaries and, at the base of the mountains, by large springs that discharge into the stream. Silver Creek meanders through a broad alluvial plain and turns southeast near Chickahominy Reservoir, traveling through the unincorporated community of Riley, where it is crossed by Highway 20 and Highway 395, respectively. Downstream of Riley, Silver Creek flows through a canyon of volcanic basalt. A dam impounds Silver Creek several miles downstream, forming Moon Reservoir. Silver Creek then splits into two streams; one portion heads southwest into the usually dry Silver Lake, while the other portion flows southeast through Warm Springs Valley into the Malheur National Wildlife Refuge, and finally Harney Lake.

USGS explains:

> "Silver Creek discharges onto the Harney Basin lowlands about 10 miles northwest of Riley. Chickahominy Creek, which is intermittent, is the only notable tributary to Silver Creek in the lowlands. Silver Creek fills Moon Reservoir (about 10 miles southeast of Riley) with spring snowmelt during normal precipitation years. The channel of Silver Creek south of Moon Reservoir meanders across a low-gradient plain and joins Harney Lake near Double O Road. During late-summer and early-autumn of most years, Silver Creek flows intermittently downstream of Riley owing to irrigation diversions, infiltration to groundwater, reduced flow from the uplands, and riparian ET. Warm Springs Creek, with headwaters in Warm Springs Valley (fig. 1), also discharges into Harney Lake and nearly all its flow originates from high-volume springs. In the absence of measurements, anecdotal evidence and a time series of satellite imagery indicate Warm Springs Creek perennially flows into Harney Lake during most years. Big Stick and Jackass Creeks, south and west (respectively) of Warm Springs Valley and Harney Lake, are intermittent along much of their course and rarely reach the valley lowlands (Piper and others, 1939)."

(Garcia et al., 2022).

The connection between Silver Creek and Harney Lake was constructed. Prior to the construction of the channel to Harney Lake, Silver Creek flowed into Silver Lake as a terminal lake.

> La Marche (2011) includes this description:
>
> "Silver Creek is smaller than the Silvies River in terms of watershed size, stream flow, and irrigation use. Typical of the major streams in the basin, Silver Creek also bifurcates in its' valleys: Silver Creek Valley (west of Burns) and the Warms Springs Valley just upstream of Harney Lake— the ultimate terminus for all three major watersheds in the basin"
>
> and
>
> "Monitoring of inflows to the refuge from the Silver Creek distributaries is very difficult due to channel gradients, presence of springs near the refuge which comingle water with the Silver distributaries, water control dikes on the refuge, and the numerous channels which drain into the refuge."

Silver Creek flow is captured in Moon Reservoir, Chickahominy Reservoir, and at Silver Creek dam. All are barriers to migratory fish.

Harney-Malheur Lakes Sub-basin

The Harney-Malheur Lakes sub-basin includes several streams that flow toward Harney and Malheur Lakes, or their associated sloughs.

Harney-Malheur Lakes Sub-basin Streams

Streams flowing from the north toward the lakes:

- Poison Creek
- Prater Creek
- Rattlesnake Creek
- Coffeepot Creek
- Cow Creek

Streams flowing from the south toward the lakes:

- Smyth Creek
- Riddle Creek

Although reportedly no water from these streams now reaches the lakes, for the two included in OWRD's Surface Water Availability Reporting System (SWARS), Rattlesnake Creek and Poison Creek, the model shows that at an 80% exceedance flow, streamflow reaches the mouths (at Nine Mile Slough) in all months under natural conditions (*i.e.* no diversions) and in some months shows that streamflow reaches Nine Mile Slough after accounting for the consumptive use of surface water diversions. An 80% exceedance flow means the flow in a stream that, based on statistical probability, will be exceeded 80% of the time (put another way, every ten years, two years would be expected to be drier). (OWRD's SWARS data is discussed further below). None of the streams are currently gaged, nor to our knowledge are there other flow measurements available for these streams (aside from 1941 gage data for Rattlesnake Cr.), making analysis of timing and streamflow of these streams difficult.

USGS describes this area as follows:

> "The northern region also includes the watersheds of many smaller creeks issuing from the uplands to the north and east of the Harney Basin lowlands north of Malheur Lake, the largest among these include Rattlesnake Creek, Rock Creek, Sagehen Creek, and Poison Creek. Upon reaching the lowlands, these smaller creeks are either diverted for irrigation or branch into braided sloughs. Streamflow from these small streams is completely lost to ET, as recharge to shallow groundwater, or diverted for irrigation prior to reaching Malheur Lake."

(Garcia et al., 2022).

Groundwater relation to Harney Basin rivers and streams

The rivers and streams of the Harney Basin are connected to groundwater. In parts of the basin, groundwater provides important base flow to streams, while in other parts surface water provides water that recharges the groundwater aquifer. The Groundwater Plan portion of the Harney Place Based Planning effort includes Step 2 and Step 3 reports, and strategies, focused on groundwater dependent ecosystems, including streams fed by groundwater. This report further summarizes information specific to groundwater influences on river and streamflows.

USGS explains:

> "Natural groundwater discharge to streams or base flow is the primary groundwater discharge mechanism in upland areas and occurs in limited areas in the Harney Basin lowlands . . . Base flow is the primary source of water in streams of the Harney Basin in late summer and autumn, when runoff from rain and snowmelt is minimal."
>
> and
>
> "Seepage measurements made during the study showed gaining perennial stream reaches in the lower parts of the uplands and in limited areas in the lowlands near the mountain front; however, across most of the lowland area, streams predominately lose water to the groundwater system."

(Garcia et al., 2022).

Gaining reaches, or streams that gain water from groundwater, and spring inputs are especially important for fish and other aquatic organisms that rely on cold, clean water. Groundwater discharge also provides the only base flow in many streams in the late summer and autumn after the snow melt period.

In the northern region of the basin, composed primarily of the Silvies River Sub-basin, "some larger spring complexes do occur in the northern uplands [that] are important sources of base flow to major upland streams, such as those in the headwaters of Emigrant Creek . . . ." (Garcia et al., 2022). In the western region, composed primarily of the Silver Creek Sub-basin, "there are important complexes that provide base flow to upper reaches and tributaries of Silver Creek." (*Id.*).

Compared to the other rivers systems in the basin, “springs and base flow provide a larger portion of the total annual streamflow in the Donner und Blitzen River and it discharges perennially to Malheur Lake without any reaches going dry.” (*Id.*). Springs are also the headwaters and contribute to smaller streams in the basin, such as Rattlesnake, Poison, and Sagehen Creeks (*Id.*). The report does not describe groundwater contributions to Prater or Cow Creeks.

Once in the lowlands, many streams “lose” streamflow to the groundwater system, providing groundwater recharge to the aquifer. USGS explains:

> “The major streams draining the uplands and conveying surface water across the Harney Basin lowlands include the Silvies River, Donner und Blitzen River, and Silver Creek. Seepage measurements made during this study on the Silvies River, Poison Creek, Rattlesnake Creek, and Silver Creek during late summer and early autumn low-flow periods provided evidence of groundwater recharge through channel losses in the Harney Basin lowlands (app. 6). Although measured during late summer to ensure base-flow conditions, the within-channel losses persist year-round from these streams. In addition to in-channel losses, during the springtime and early summer in many years these streams flood well beyond their meandering channels, filling topographic lows and creating ephemeral ponds and wetlands of varying sizes across the Harney Basin lowlands.”

(Garcia et al., 2022). The amounts of streamflow recharging groundwater are deGroundwater declines are likely to increase the volume of surface water that discharges to groundwater, which can change gaining reaches to losing reaches or increase the amount of loss that occurs within losing reaches (Barlow and Leake, 2012).

Active and inactive streamflow gages in the Harney Basin

As early as the 1900s Federal and state agencies measured streamflow at locations in the Harney Basins (Fig. 5; Fig. 6 – Table 2). However, the streamflow records at most of these gages are limited in duration. Not all of them were continuous on a daily basis and many of them are discontinued. Some gages were set up for specific studies and then discontinued when the studies were completed (Hubbard 1975). Three streamflow records in the Harney region (Silvies River at USGS gage 10393500, Donner und Blitzen River at USGS gage 10396000, and Silver Creek at USGS gage 10403000) are long-term and span many decades. Figure 5 shows these and other important gages. The figure also shows all of the stream site locations in the Harney region used by OWRD in developing its Surface Water Availability Reporting System (SWARS). Figure 6 - Table 2 also shows streamflow gages used to measure only the annual peak discharge.

The data gaps section at the end of this report identifies the need for additional stream gages to better understand the basin’s hydrology and streamflows.

Figure 5. Map showing active daily streamflow gages (bright red), inactive daily streamflow gages (half red/half purple), inactive peak-flow gages (blue), and OWRD Water Availability Reporting System (SWARS) stream points (yellow) in the Harney-Malheur Lakes Basin. SWARS points represent the downstream terminus of nested sub-watersheds, and are the locations where water availability is modeled in SWARS. Data are from USGS NWIS and Oregon Water Resources Department online hydrographic database.

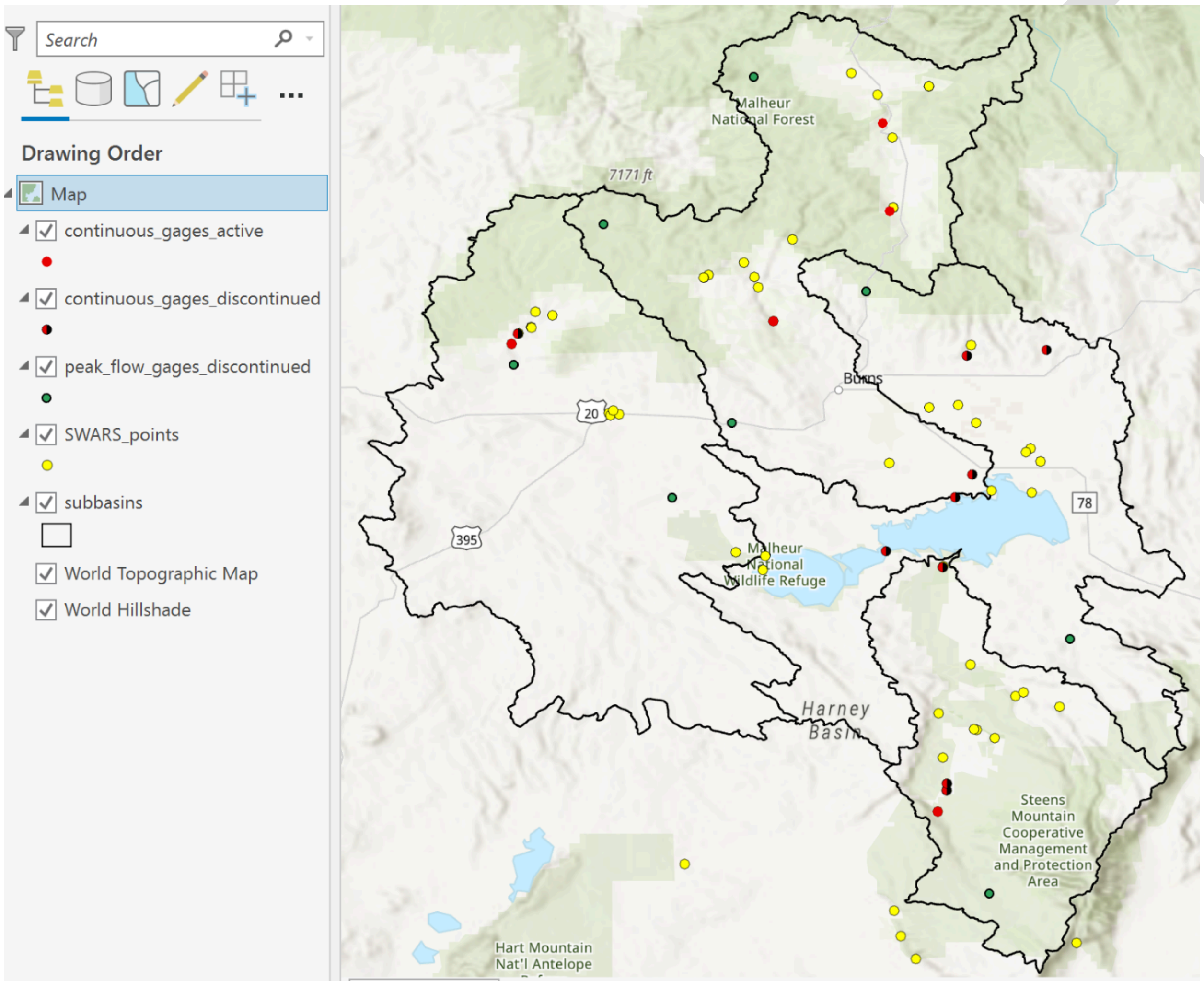


Figure 6. Table 2: USGS and OWRD continuous daily streamflow and peak-discharge stations in the Harney Basin, Oregon. Streamflow records between starting and ending years are not continuous for all stations listed. Gages with an "end year" of 2020 indicate currently-running stations.

Continuous daily streamflow stations					Hydrologic Unit Code		USGS operation		OWRD operation	
ID	Name	Drainage area (sq. mi.)	Latitude	Longitude	Number	Basin name	Start year	End year	Start year	End year
10392400	SILVIES R BL SODA SPRING NR SENECA, OR	294	44.088	-118.971	17120002	Silvies			2014	2020
10392500	SILVIES R NR SILVIES, OR	511	43.923	-118.958	17120002	Silvies			2014	2020
10393500	SILVIES RIVER NEAR BURNS,ORE	934	43.715	-119.177	17120002	Silvies	1904	1991	1992	2020
10394600	RATTLESNAKE CR NR HARNEY, OR	18.4	43.650	-118.812	17120001	Harney-Malheur	1941	1941		
10395000	EAST FORK SILVIES RIVER NEAR LAWEN, OR	na	43.426	-118.802	17120002	Silvies	1972	1977		
10395500	WEST FORK SILVIES RIVER NEAR LAWEN, OR	na	43.383	-118.834	17120001	Harney-Malheur	1972	1977		
10395505	FLOOD BYPASS SILVIES R NR BURNS, OR	na	43.383	-118.834	17120002	Silvies	1976	1976		
10395600	ROCK CREEK NEAR BURNS, OR	12.2	43.661	-118.662	17120001	Harney-Malheur	1964	1976		
10396000	DONNER UND BLITZEN RIVER NR FRENCHGLEN OR	200	42.791	-118.868	17120003	Donner and Blitzen	1912	2020		
10396500	MUD CR NR DIAMOND, OR	28.3	42.831	-118.850	17120003	Donner and Blitzen	1911	1930		
10397000	BRIDGE CREEK NR FRENCHGLEN, OR	30.0	42.844	-118.850	17120003	Donner and Blitzen	1913	1970		
10401500	DONNER UND BLITZEN RIVER NEAR VOLTAGE, OR	788	43.251	-118.858	17120003	Donner and Blitzen	1937	1977		
10402000	MALHEUR LAKE OUTLET AT NARROWS, OR	2,150	43.282	-118.965	17120001	Harney-Malheur	1972	1977		
10403000	SILVER CREEK NEAR RILEY, OR	228	43.692	-119.659	17120004	Silver	1952	1980		
10403400	SILVER CR BL NICOLL CR NR RILEY	265	43.672	-119.671	17120004	Silver			2010	2020

Peak-discharge stations					Hydrologic Unit Code		USGS operation	
ID	Name	Drainage area (sq. mi.)	Latitude	Longitude	Number	Basin name	Starting year	Ending year
10392300	SILVIES R NR SENECA, OR	18.3	44.175	-119.214	17120002	Silvies	1967	1981
10392800	CROWSFOOT CR NR BURNS, OR	8.3	43.898	-119.498	17120002	Silvies	1966	1979
10393900	DEVINE CAN NR BURNS, OR	4.96	43.771	-119.003	17120001	Harney-Malheur	1965	1981
10395200	SAGE HEN CR NR BURNS, OR	1.02	43.523	-119.255	17120002	Silvies	1969	1975
10395700	DONNER UND BLITZEN R TRIB NR FRENCHGLEN, OR	0.95	42.637	-118.770	17120003	Donner and Blitzen	1964	1974
10400000	MCCOY CREEK NEAR DIAMOND, OR	48.9	42.983	118.718	17120003	Donner and Blitzen	1911	1945
10401000	RIDDLE CR NR DIAMOND, OR	112	43.117	-118.618	17120001	Harney-Malheur	1917	1921
10403500	SILVER CR AB SUNTEX, OR	260	43.633	-119.668	17120004	Silver	1904	1925
10406000	SILVER CR NR NARROWS, OR	630	43.383	-119.368	17120004	Silver	1917	1923

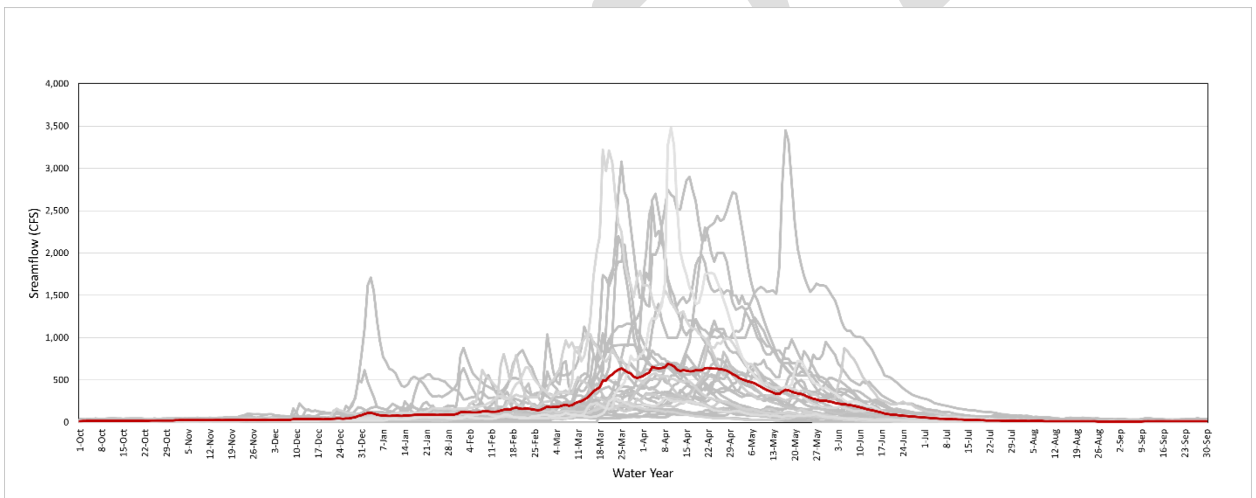
Discussion of streamflow gage records for the Donner und Blitzen River, Silvies River, and Silver Creek

The following graphs and discussion use available streamflow gaging information to better understand the hydrology of the Harney Basin. Due to the lack of long-term gages in the Harney-Malheur Lakes sub-basin, the figures and discussion focus only on the Silvies, Silver and Donner und Blitzen sub-basins.

Silvies River near Burns (USGS ID: 1039500)

The USGS began operating a stream gage (USGS ID: 10393500) on the Silvies River near Burns in 1903. OWRD took over operation of the gage and publication of streamflow records in the early 1990s. The longest continuous period of daily streamflow record for the gage is from water year (WY) 1923 to the present. The water year is defined as the period from October 1 to September 30. The drainage area upstream of the gage is 934 square miles. The drainage area of the entire Silvies River basin where it enters Malheur Lake is about 1,310 square miles. Approximately 20% and 80% of the total volume of consumptive use from surface water in the entire basin is diverted at locations upstream and downstream of the gage, respectively (OWRD SWARS, Cooper, 2002).

Figure 7. ***Silvies River daily streamflow at USGS-OWRD gage 10393500 (WY 1990-2019).*** *The red line indicates the mean of daily measured streamflow among all water years. Grey lines are measured streamflow for each individual water year.*



Daily streamflows, measured at the gage (USGS ID: 10393500), from an early period (WY 1923-1952) and the more most recent 30-year period (WY 1990-2019) are shown in figures 8 and 9, respectively. Mean-annual precipitation for the earlier period (13.7 inches) was less than the recent period (15.5 inches). Annual daily maximum streamflows ranged from 51 to 4,500 cfs during the earlier period (WY 1923 to 1952); and ranged from 150 to 3,480 cfs during the recent period (WY 1990-2019). Annual daily minimum streamflows for both periods ranged from 0 to 22 cfs. Streamflows above 1,500 cfs in the early period were confined from late March to early May. In the recent period, two flood events in 1997 and 2011 were outside of that period. The mean-daily streamflow plots for the two 30-year periods are compared in figure 7. The earlier period plot (blue line) has a higher peak which occurs on April 19 (846 cfs). However, for the recent 30-year period (red line) the highest peak occurs on April 9 (698 cfs). The earlier arrival of the maximum peak mean-daily streamflow, and the wider period over which high flows occur, during the recent period could be attributed to warmer air temperatures, decreased snowfall, and increased rainfall causing early seasonal high flows.

Figure 8. Silvies River mean-daily streamflow at USGS-OWRD gage 10393500 (WY 1923-1952).

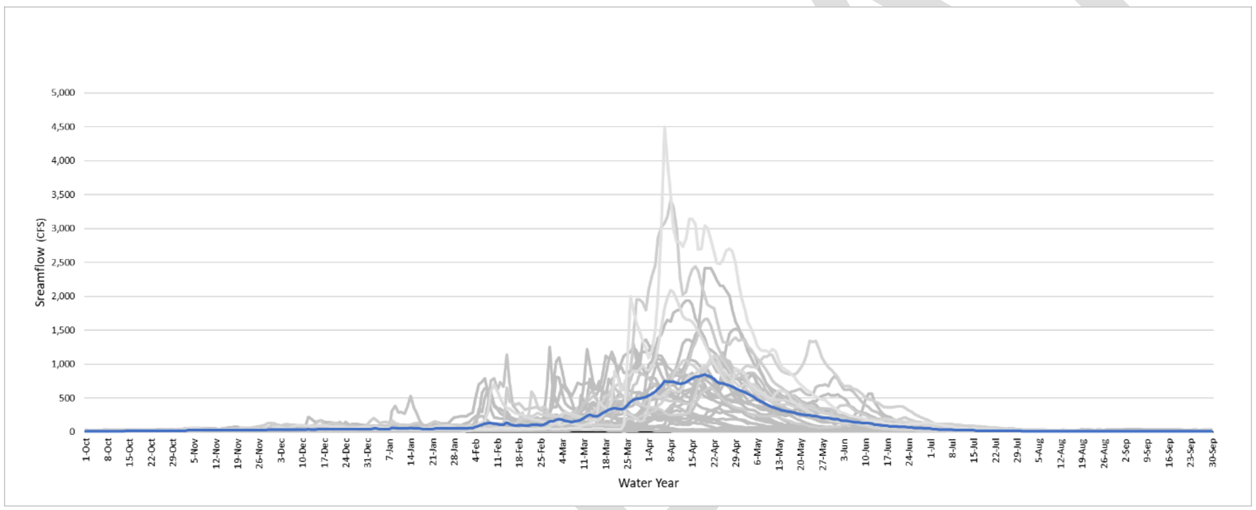
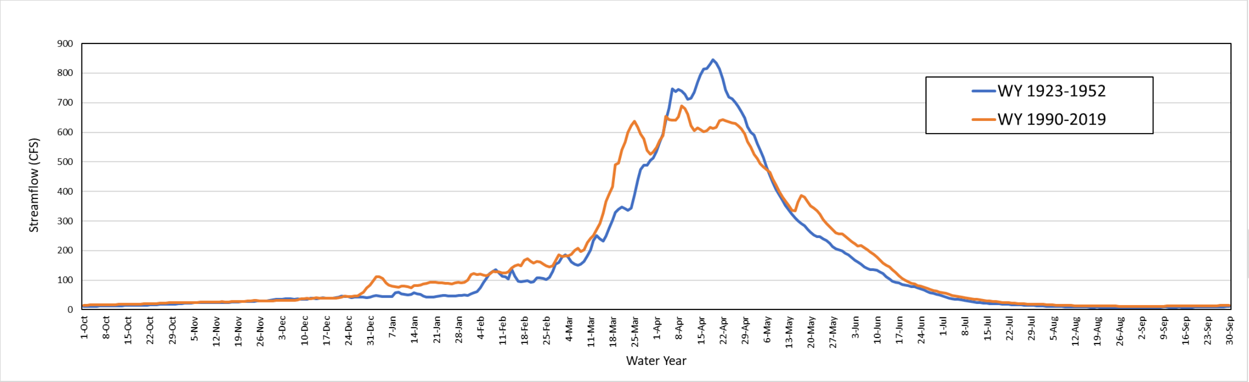


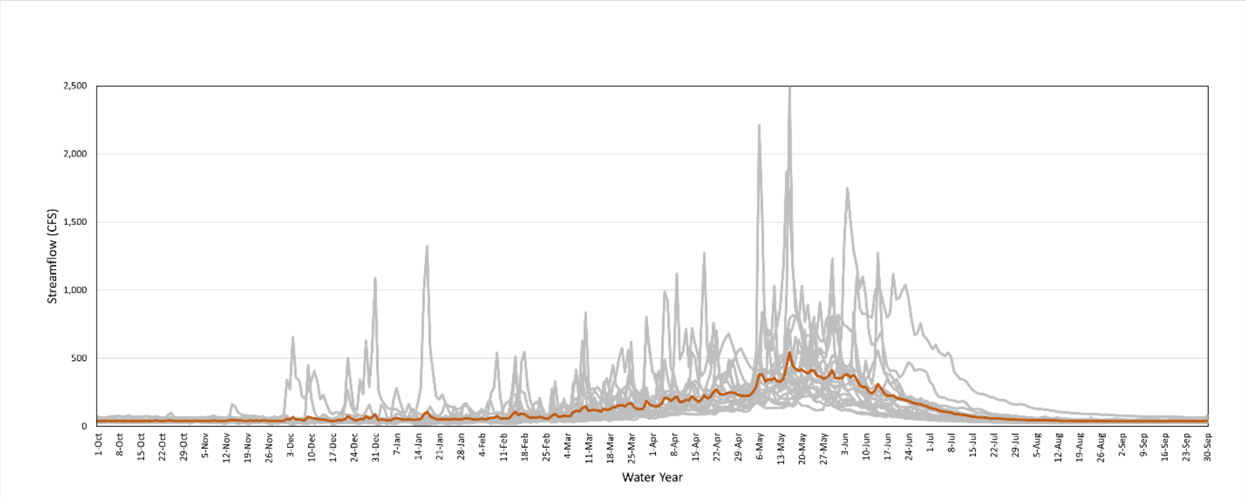
Figure 9. Silvies River mean-daily streamflow time period comparison at USGS-OWRD gage 10393500 (Water Years 1923-1952 compared with Water Years 1990-2019).



Donner und Blitzen near Frenchglen (USGS ID: 10396000)

Daily streamflow measurements at the gage (USGS ID: 10396000) on the Donner und Blitzen River near Frenchglen, Oregon began as early as 1911. The gage has been in continuous operation since 1939 and is located 3.5 miles southwest of Frenchglen and two miles downstream of Fish Creek. The drainage area upstream of the gage is approximately 200 square miles and has no regulation and a very small amount of water diversion. For perspective, the drainage area of the entire river basin upstream of Malheur Lake is 765 square miles. Based on the OWRD Water Availability System (SWARS), over 99% of the total volume of consumptive use from surface water in the Donner und Blitzen basin is withdrawn at locations downstream of the gage (Cooper, 2002). The absence of significant irrigation withdrawals upstream of the gage limits the effectiveness of using that gage to determine trends in water management in the basin.

Figure 10. Donner und Blitzen River daily streamflow at USGS gage 10396000 (WY 2000-2019). The red line indicates the mean of daily measured streamflow among all water years. Gray lines are measured streamflow for each individual water year.



A comparison of early (WY 1939-1958) and recent (WY 2000-2019) 20-year periods of daily-mean streamflow, measured at the gage (USGS ID: 10396000), are shown in figures 10, 11, and 12. Those two time periods were selected based on data availability. Having higher elevations compared to other basins in the Harney-Malheur Lake basin region, the Donner und Blitzen streamflow is more snow-dominated. Hence the annual daily maximum streamflow typically occurs in the spring from late April through June (fig. 12). The highest annual daily maximum streamflow (1,440 cfs) during the earlier period occurred on May 19, 1953, while the lowest annual daily maximum streamflow (355 cfs) occurred on April 26, 1946. Minimum streamflows for this period ranged from 18 to 32 cfs.

During the recent 20-year period (WY 2000-2019), the highest annual daily maximum streamflow (2,490 cfs) occurred on May 16, 2005 (fig.10). Annual daily minimum streamflows for this period ranged from 10.5 to 40 cfs.

Figure 11. Donner und Blitzen River mean-daily streamflow at USGS gage 10396000 (WY 1939-1958).

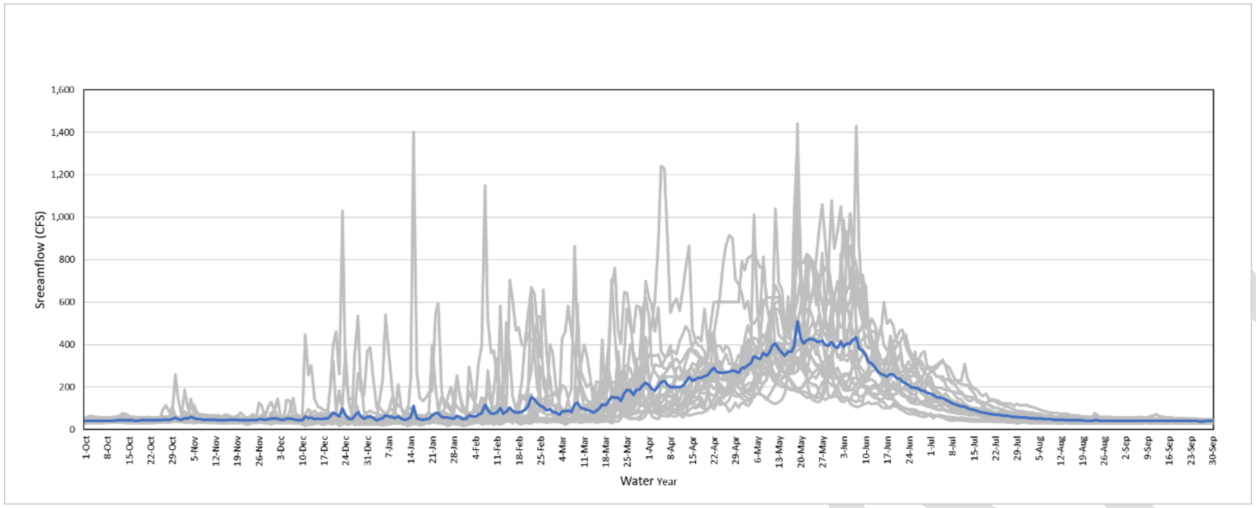
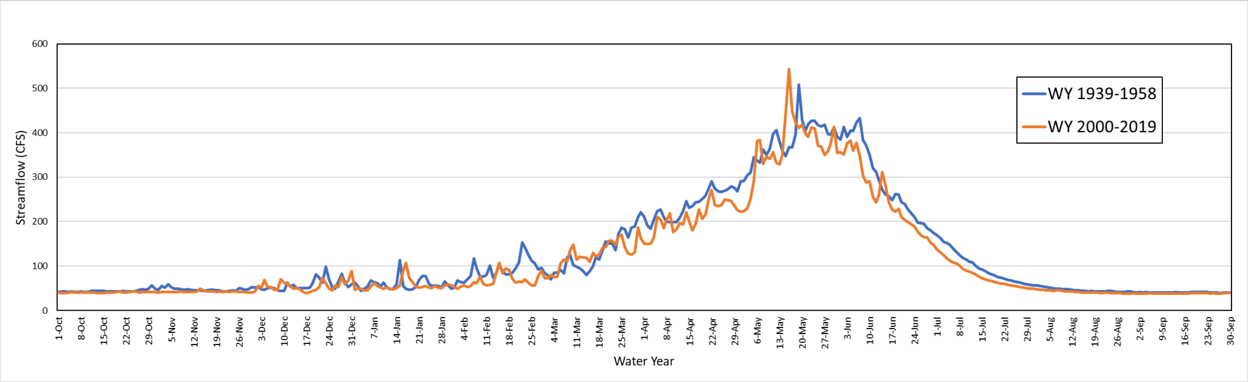


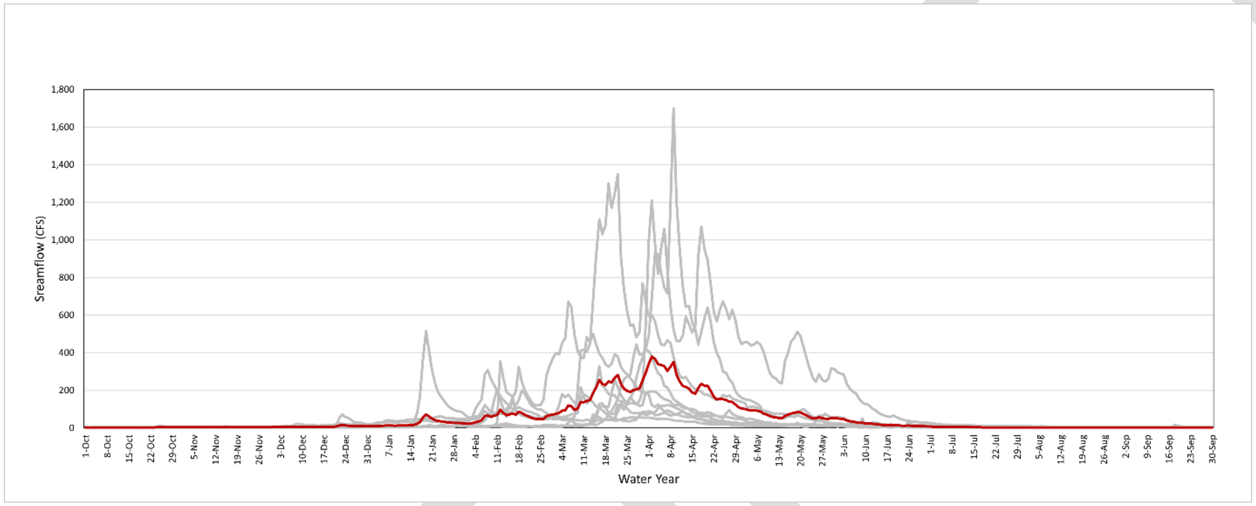
Figure 12. Donner und Blitzen River mean-daily streamflow time period comparison at USGS gage 10396000. (Water Years 1939-1958 compared with Water Years 2000-2019).



Silver Creek near Riley (USGS ID: 10403000)

From 1952 to 1980 the USGS operated a streamflow gage (USGS ID: 10403000) near Riley, Oregon on Silver Creek. The drainage area upstream of the gage is 228 square miles. The entire Silver Creek drainage area upstream of Harney Lake is approximately 1,670 square miles. According to the OWRD SWARS 98% of the total volume of consumptive use from surface water in the entire Silver Creek basin is diverted at locations downstream of the gage (Cooper, 2002).

Figure 13. Silver Creek daily streamflow at OWRD gage 10403400 (WY 2011-2019). The red line indicates the mean of daily measured streamflow among all water years. Grey lines are measured streamflow for each individual water year.



Daily streamflows, measured at the gage (USGS ID: 10403000), for the entire period (1952-1980) are shown in figure 14. Individual years and the mean-daily streamflow for the period are shown in gray and blue, respectively. Annual daily minimum streamflows over this period ranged from 0 to 2.8 cfs. Whereas annual daily maximum streamflows ranged from 96 to 1,380 cfs. The maximum streamflow (1,380 cfs) occurred on December 24, 1964 during a period of extreme flooding in the Pacific Northwest and California. Although this gage was discontinued in 1980, OWRD began operating a streamflow gage (OWRD ID: 10403400) on Silver Creek at a downstream location in 2010. The OWRD gage has an upstream drainage area of 265 square miles. Similar to the USGS gage (fig. 14), the OWRD gage streamflow record also has some variability (fig. 13). Annual daily minimum streamflows ranged from 0.06 to 3 cfs; and annual daily maximum streamflows ranged from 131 to 1,700 cfs. When the mean-daily streamflow plots for the two time periods are compared, the plot line for the 2011-2019 period (red line) has a greater magnitude than the earlier period plot line (blue line) (fig. 15). This is likely because the drainage area of the downstream gage is 16-percent greater than the upstream gage drainage area and the mean-annual precipitation of recent period was 0.5 inches greater than the earlier period. The figure also shows the peak mean-daily streamflows for the two time periods shifted from April 6 to April 2 possibly due to warmer air temperatures. Warmer air temperatures would cause earlier snowpack melting.

Figure 14. Silver Creek mean-daily streamflow at USGS gage 10403000 (WY 1952-1980).

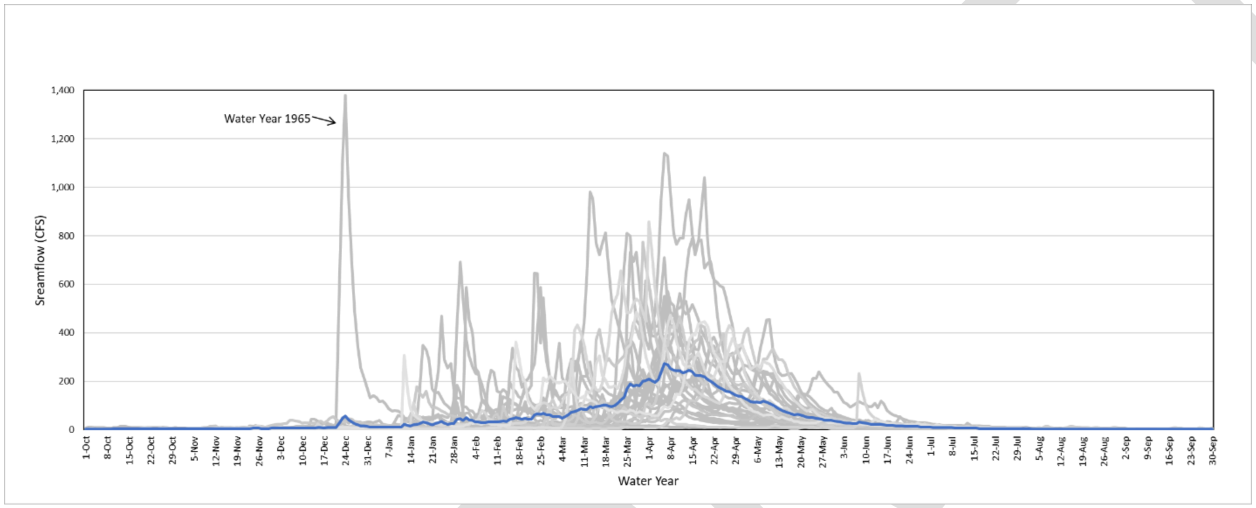
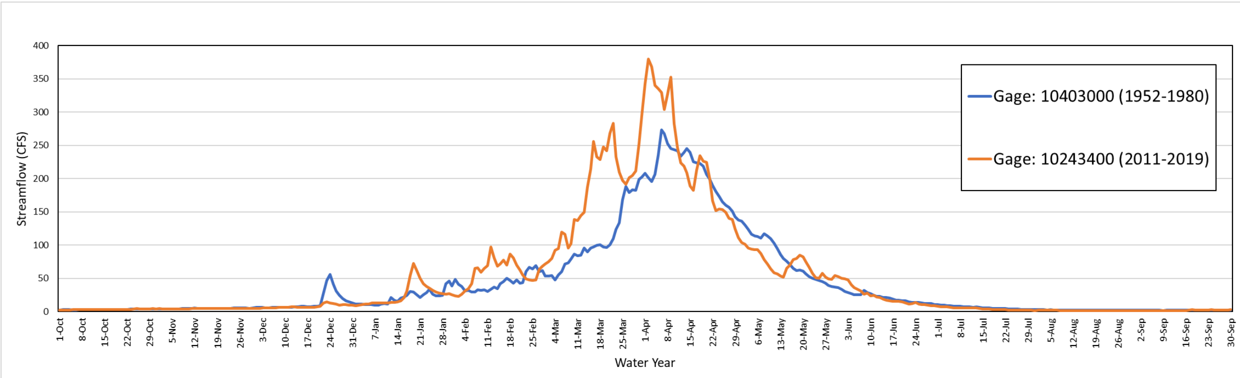


Figure 15. Silver Creek mean-daily streamflow time period comparison at USGS gage 10403000 and OWRD gage 10403400. (Water Years 1952-1980 compared with Water Years 2011-2019).



Comparing mean-daily streamflow gaging records from Silvies Rivers, Donner und Blitzen River, and Silver Creek

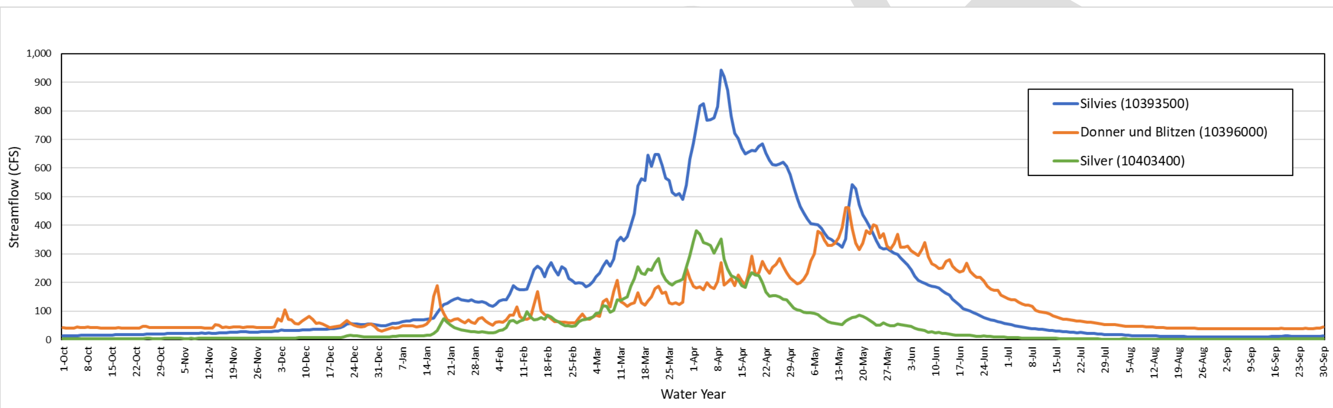
A comparison of the mean-daily streamflows from Donner und Blitzen River, Silver Creek, and Silvies River from 2011-2019 provides insights into hydrologic differences between the three basins (fig. 17). The Silvies gage has a greater magnitude of streamflow than the other two basins. It also has a larger upstream drainage area (934 square miles). Silver Creek and Silvies River (measured at their aforementioned gages) both peak in early April. However, the Donner und Blitzen River basin has higher mean elevation. As a consequence, it has a greater mean-annual precipitation and more snowfall and snowpack than the other two basins. Because high flows are snowmelt dominated, maximum annual streamflows typically occur in the spring, later than the other basins.

Water withdrawals upstream of the Donner und Blitzen gage are generally negligible; however, the other two gages reflect varying levels of consumptive use upstream. For irrigation period, USGS found that “[b]ased on mean annual estimates by OWRD’s water availability reporting system, diversions remove more than 40 percent of July–September streamflow upstream of the Silvies River streamgage and more than 10 percent of streamflow upstream of the Silver Creek streamgage (Cooper, 2002; Oregon Water Resources Department, 2018). Diversions upstream of the Donner und Blitzen River near Frenchglen are negligible during summer and autumn.” (Garcia et al., 2022).

Summary of Harney Basin Hydrology

The Silvies River has the greatest total magnitude of streamflow and more variability compared to the Silver Creek and Donner und Blitzen basins. However, flow from the Silvies during most years rarely reaches Malheur Lake. The Donner und Blitzen River maintains the most consistent late-season flow among the three basins due to its reliance on snowpack and groundwater, and discharges into Malheur Lake under most conditions. Silver Creek has the smallest watershed and lowest flow with the earliest annual maximum flows. All three streams exhibit substantial interannual variability for flood events, and evidence suggests that all three watersheds have been affected by recent changes to precipitation and temperature compared to historical conditions. The three systems are achieving peak flows earlier in the season on average, although the Donner und Blitzen appears to be changing at a slower rate. The preceding sections use best available data to compare among watersheds and between historical vs. current conditions, but true comparisons are hindered by different positions of the gages in their respective watersheds and for Silver Creek different gages operated at different times. Mean values are used in Figures 6 through 6 instead of median values, which could allow outlier events to skew daily mean flow. However, visual comparisons of mean, maximum, and minimum flows in Figures 10, 13, and 7 demonstrate the range for that period of record and the relative variability.

Figure 16. Comparison of mean daily streamflows at Donner und Blitzen River, Silvies Rivers, and Silver Creek for Water Years 2011-2019.

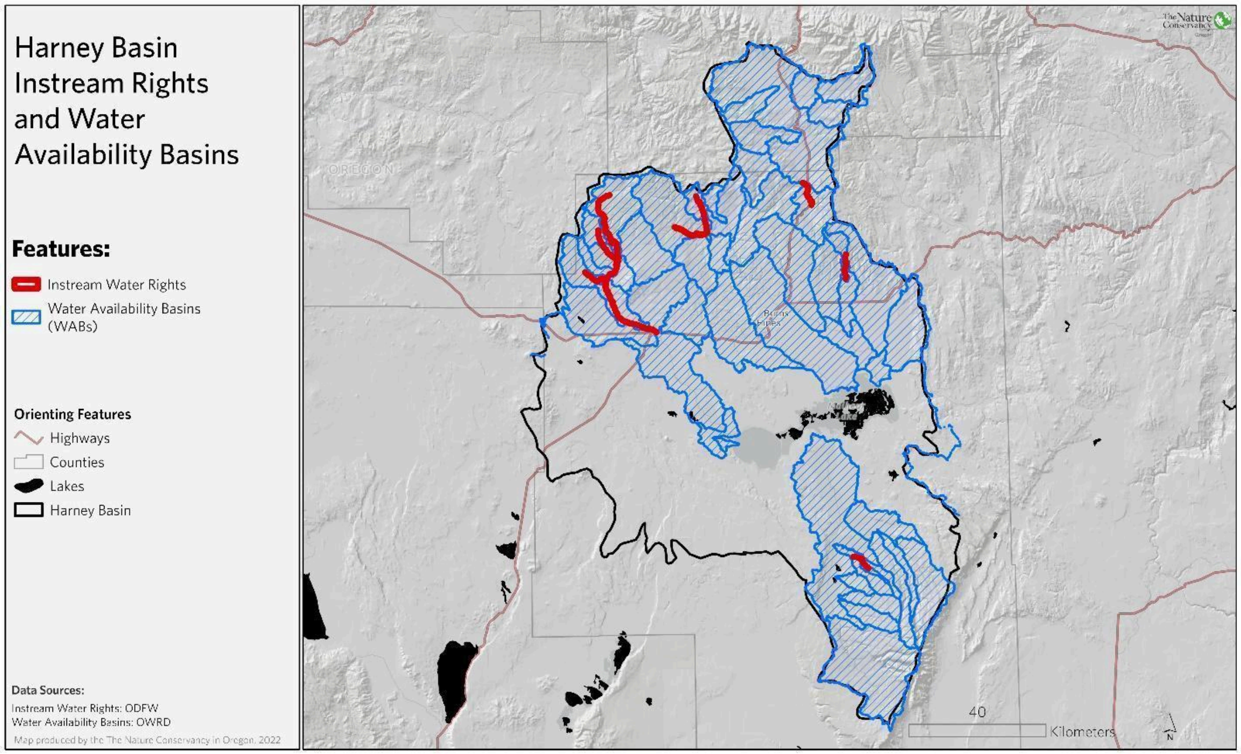


OWRD Surface Water Availability and Reporting System data

The OWRD Surface Water Availability Reporting System (SWARS) provides streamflow data for many stream points in the Harney Basin, with a total of 51 nested watersheds included. SWARS used a 30-year period streamflow record, 1958 to 1987, to develop the tables. The tables were developed based on measured streamflows, either directly from continuous records and miscellaneous measurements or indirectly by use of a regional regression analysis. Regional regression is a standard hydrologic technique to generalize streamflows from measured to unmeasured watersheds. (Cooper, 2002). To generate and provide this data, OWRD delineates the state into watersheds and sub-watersheds called Water Availability Basins (WABs). OWRD has populated a database for each WAB that estimates median monthly natural streamflow (at 50% and 80% exceedance levels), consumptive surface water diversions, and the instream flows expected to remain after withdrawals take place. (Cooper, 2002). The Water Availability Database is available on OWRD's website here: https://www.oregon.gov/owrd/access_data/

For many streams in the Harney Basin, SWARS provides the only information on streamflows expected after accounting for surface water diversions. The USGS StreamStats program can provide natural streamflow estimates at any point on the stream system, but to estimate expected streamflows (*ie* streamflows expected to occur after accounting for surface water diversions), additional work to incorporate surface water diversions would be required. Notably, of the nine redband trout populations identified in the Harney Basin by ODFW (2018), four are in streams for which no SWARS data is available (Prater Creek, Coffeepot Creek, Riddle Creek and Cow Creek).

Figure 17. Harney Basin Certificated Instream Water Rights and Water Availability Basins.



Comparisons of 50th percent exceedance expected streamflows from SWARS, StreamStats, and measured streamflow

Streamflow estimates from USGS StreamStats and OWRD SWARS, and measurements from stream gages, are compared below for the Silvies, Silver and Donner und Blitzen sub-basins (figures 18-20). The SWARS estimates of expected streamflow at 50% exceedance were evaluated with measured streamflow data. Streamflow at the three gages (USGS ID: 10393500, 10396000, and 10403000) shown are the median (or 50-percent exceedance) of each day of the year also based on the same period used in SWARS (1958-87). The measured streamflow and the SWARS estimates of expected streamflows for all three gages are well aligned throughout the year, and especially so during the low flow months. Additional stream gaging or measurements would be necessary to check the accuracy of SWARS at other locations. As an additional check these figures also contain estimated natural monthly streamflows at 50-percent exceedance from the USGS StreamStats program (U.S. Geological Survey 2016). However, the StreamStats monthly estimates were based on a wider range of various time periods and thus were not expected to track as closely to the measured streamflow data and the SWARS estimates.

Both SWARS and StreamStats use multiple regression equations to generate the streamflow estimates. These equations were created using the upstream basin characteristics and measured streamflow records from long-term streamflow gages in the surrounding region, but the models are somewhat different. The regression equations used in StreamStats and those in SWARS are presented and described in Risley et al. (2008) and Cooper (2002), respectively. As mentioned, the two sets of equations are created from different measured time periods and are thus different. Additionally, because of the limited density of long-term streamflow gages in the Harney sub-basins, these regression equations have much lower coefficient of determinations and higher standard errors compared to regression equations for most other regions in Oregon. In other words, the lack of measured streamflows due to the lack of stream gages creates challenges for building an accurate model to estimate streamflows

Even with these challenges, the three sources show a very similar overall monthly variation and pattern and both StreamStats and SWARS track the gaged data fairly closely. The main exception is the spring period (March through May) in the Donner und Blitzen, when SWARS and the gage data track pretty well while StreamStats estimates much higher flows. Based on this information, and the fact that the SWARS expected streamflows account for surface water diversions, SWARS estimates were used as the best available data surrogate in non-gaged streams.

Figure 18. Silvies River at USGS gage 10393500.

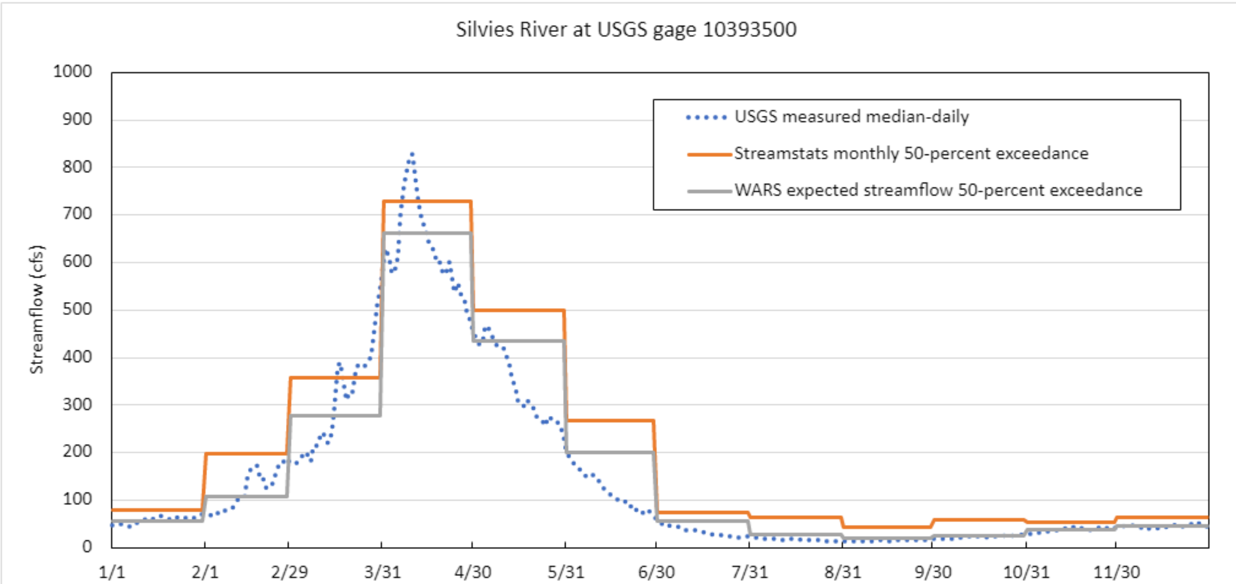


Figure 19. Donner und Blitzen River at USGS gage 10396000.

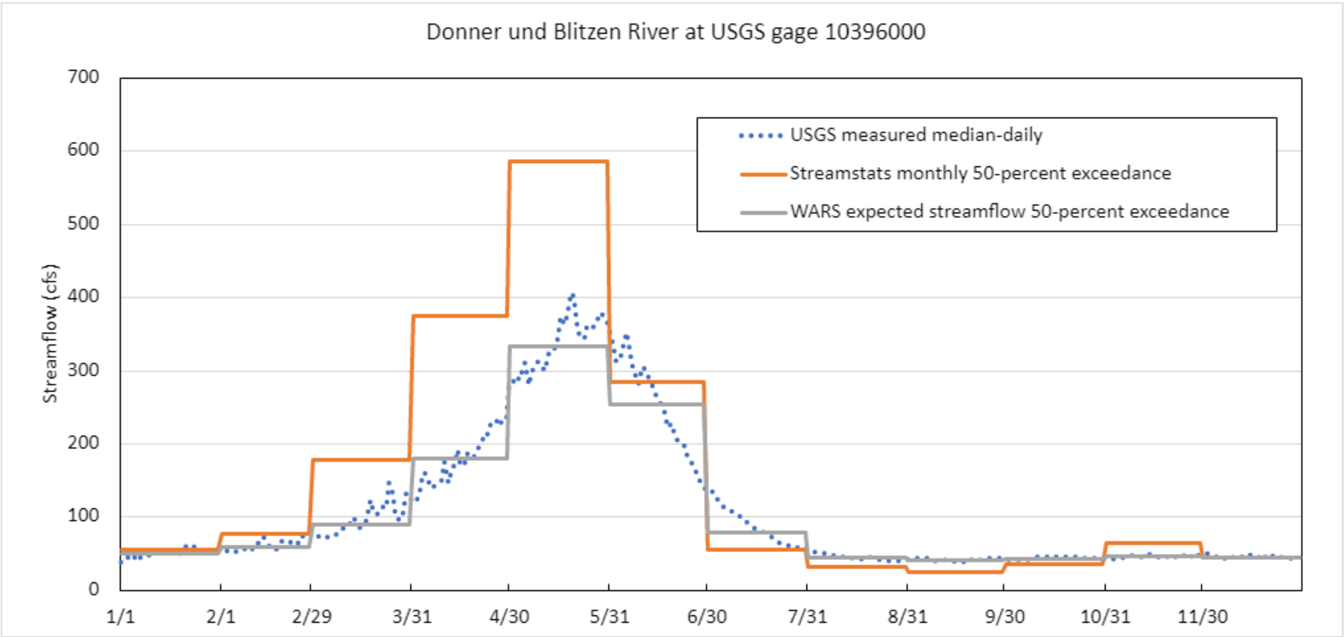
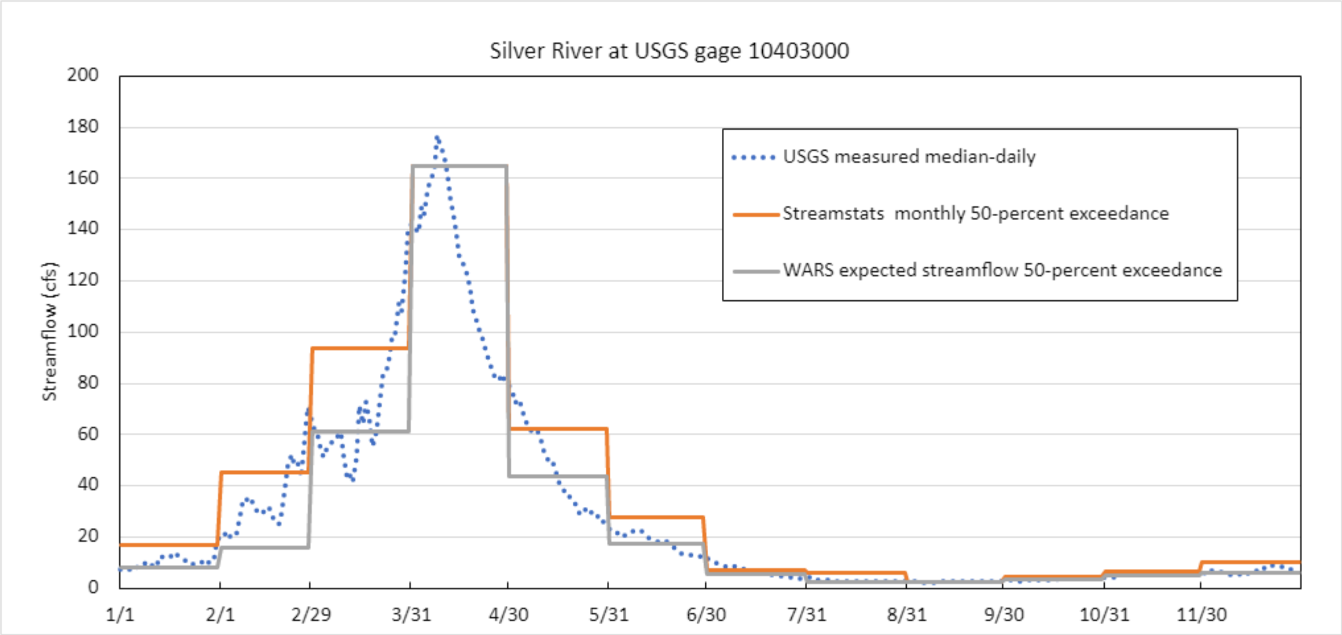


Figure 20. Silver Creek at USGS gage 10403000.



Double mass plots indicating historical anthropogenic/climatic changes in sub-basins

Double-mass curve analysis (Searcy and Hardison, 1960) was used to detect possible changes in runoff patterns that could indicate anthropogenic influences in the Silvies River, Donner und Blitzen River, and Silver Creek basins. Figures 21-23 show the X-Y relationship between cumulative annual streamflow volume and cumulative annual precipitation data over the entire period of the long-term streamflow records (USGS ID: 1393500, 10396000, and 10403000) for the three basins. The precipitation data are from the PRISM Climate Group, Oregon State University (PRISM Climate Group, 2021). They were computed from 4-kilometer gridded interpolated monthly precipitation and average-weighted for the 8-digit HUC sub-basin containing one of the three runoff gages.

The theory behind double-mass curve analysis is that if data values for two variables change proportionally over time, a graph of the accumulation of one quantity against the accumulation of another quantity during the same time period will plot as a straight line. A break in the slope of the double-mass curve means that the proportionality has changed. Precipitation data was used to remove the influence of climate from the streamflow data. With streamflow data, a change in slope can indicate flow diversion or augmentation, or alterations in basin land-use patterns that altered the basin water budget.

The drainage basins above the three long-term stream gages are unregulated by reservoirs of significant size. However, the construction of numerous small water bodies could cumulatively increase evaporation losses at the expense of streamflow. Additionally, USGS found that “[b]ased on mean annual estimates by OWRD’s water availability reporting system, diversions remove more than 40 percent of July–September streamflow upstream of the Silvies River stream gage and more than 10 percent of streamflow upstream of the Silver Creek stream gage (Cooper, 2002; Oregon Water Resources Department, 2018). Diversions upstream of the Donner und Blitzen River near Frenchglen are negligible during summer and autumn.” (Garcia et al, 2022). Some upland forested regions in the Silvies River and Silver Creek basins were logged during the 20th century. Logging can initially increase runoff to a stream because of decreased evapotranspiration losses.

A change in the slope of the Silvies River double-mass plot (fig. x) occurred in the early 1930s when it became less steep. This could indicate increased surface-water withdrawals and irrigation development. However, this was also an extremely dry period as shown in figure 21. It is also possible that more of the limited precipitation went into groundwater storage and less stream discharge. In the early 1980s the slope becomes steeper than the straight line. This could be an indication of increased logging which decreased evapotranspiration. This was also a period of above average precipitation. On the other hand, the Donner und Blitzen River double-mass plot (fig. 19) hardly shows any deviations from the straight line. This was expected since that upstream basin has not had any significant land-use changes. However, Donner und Blitzen River basin experienced the same dry and wet climate cycles as the Silvies River basin. Yet it does not show slope breaks in the early 1930s and 1980s. The Silver Creek double-mass plot (fig. 20) shows a more limited time series of less than 30 years. It may be more difficult to discern specific land-use changes in that plot. However, the plot shows the slope becomes less steep in 1958, which might indicate some surface-water diversions. The slope becomes steeper in the 1970s which might indicate increased logging and decreased evapotranspiration losses.

Figure 21. Donner und Blitzen River basin cumulative precipitation and cumulative streamflow at gage 10396000 (WY 1939-2012).

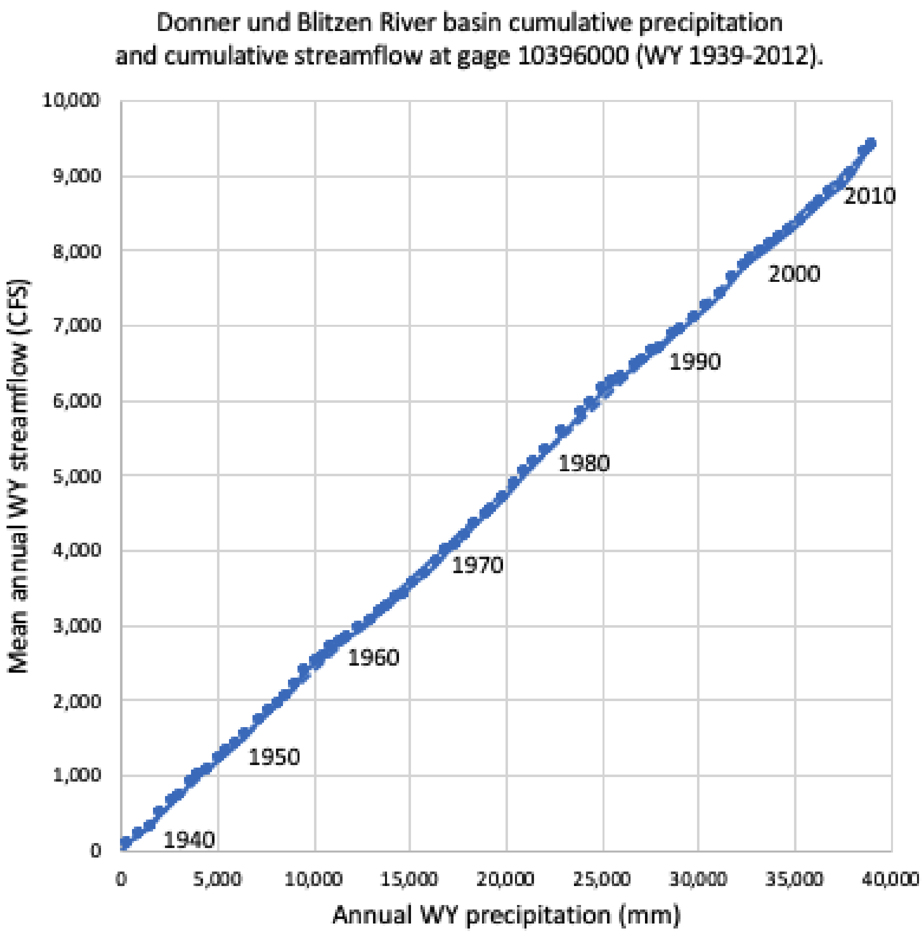


Figure 22. Silver Creek basin cumulative precipitation and cumulative streamflow at gage 10403000 (WY 1952-1980).

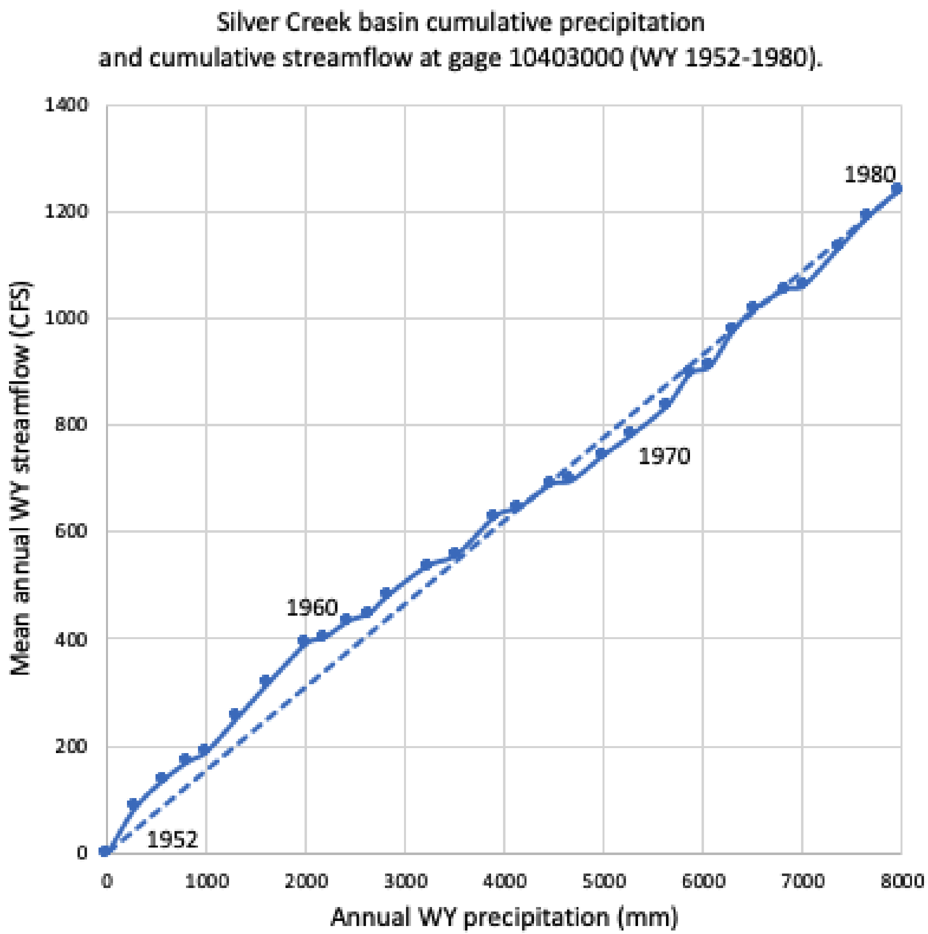
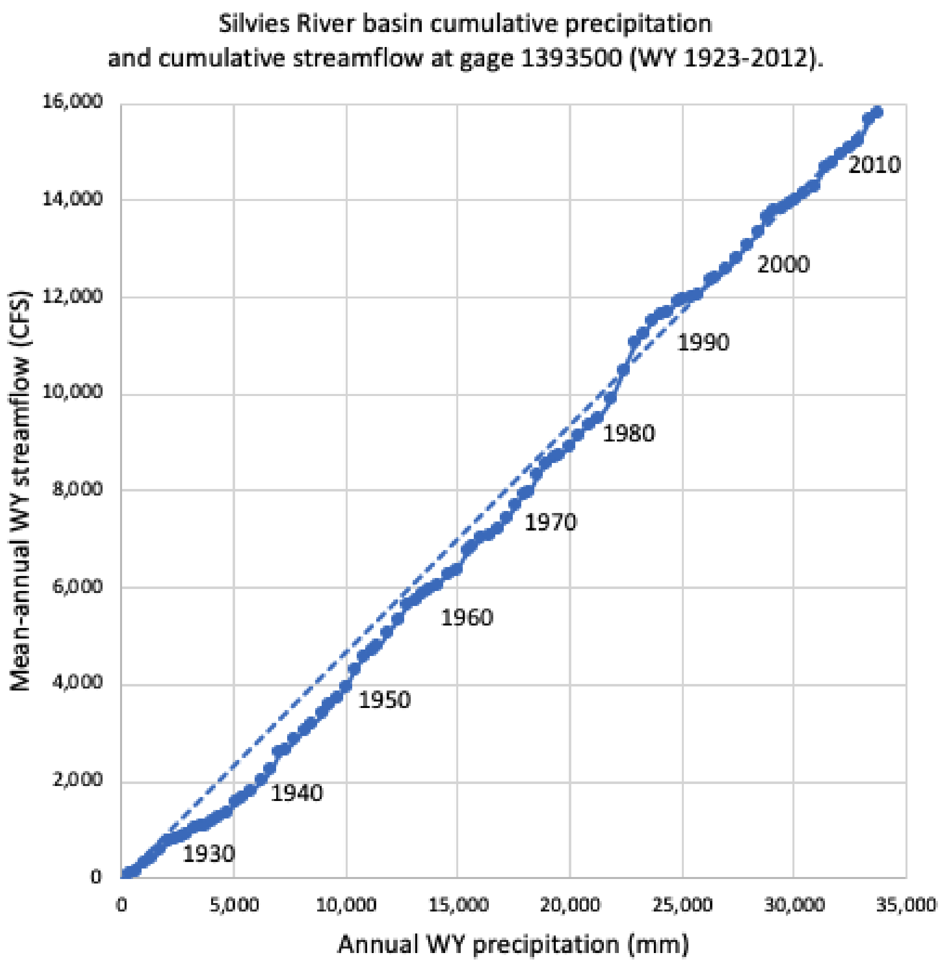


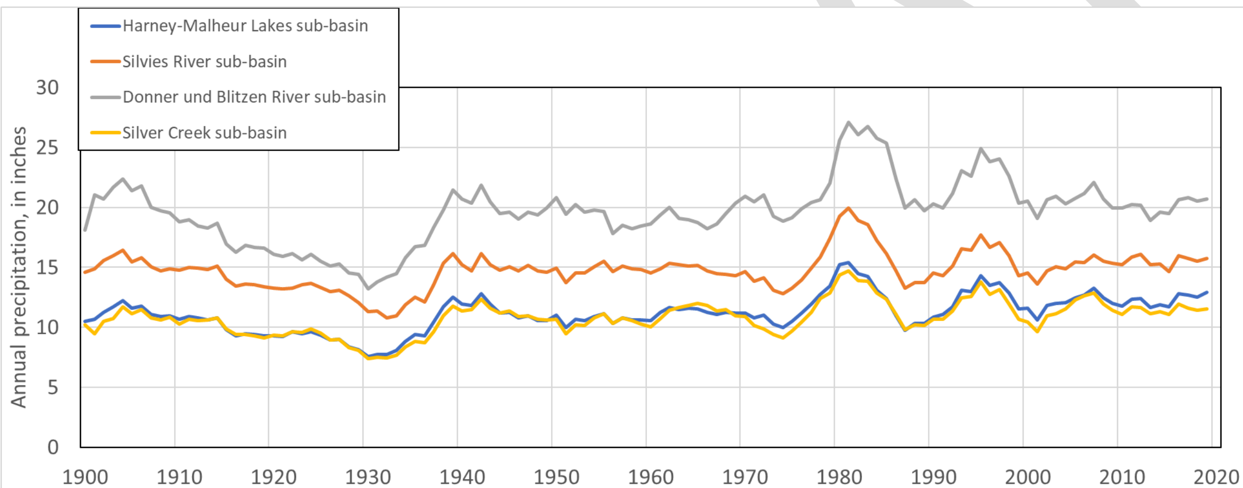
Figure 23. Silvies River basin cumulative precipitation and cumulative streamflow at gate 1393500 (WY 1923-2012).



Precipitation plot

Figure 24 compares 5-year moving average monthly precipitation between the four 8-digit HUC sub-basins in the Harney region from 1900 to 2020. The precipitation data are derived from a 4-kilometer gridded interpolated monthly precipitation time series created by the PRISM Climate Group, Oregon State University (PRISM Climate Group, 2021). Average-weighted precipitation was then computed for each of the four sub-basins using the USGS Geo Data Portal website (Blodgett and others, 2011). Higher elevation sub-basins, like the Donner und Blitzen and the Silvies Rivers, show a greater magnitude of precipitation than the lower elevation Harney-Malheur Lakes and Silver Creek sub-basins. However, all four precipitation time series follow very similar dry and wet cycle trends over the full period of 120 years. The driest and wettest periods occurred in the early 1930s and early 1980s, respectively.

Figure 24. Comparison of 5-year moving-average annual precipitation for the Donner und Blitzen, Silver, Silvies, and Harney-Malheur Lakes HUC8 sub-basins for 1900-2020. [Data from PRISM, http://www.prism.oregonstate.edu].



Water Quality

Surface Water Quality

There is limited information about the water quality of the Harney Basin. The Oregon Department of Environmental Quality (DEQ) has rudimentary data from regular monitoring. Additionally, there are limited data from special studies that are location or issue specific - such as remedial action reports or studies associated with the Malheur National Wildlife Refuge.

History of Water Quality Studies

The earliest water quality characterization of the Harney Basin was by Van Winkle (1914) who took samples from Harney Lake, the Silvies River, and the Donner und Blitzen River. The water samples were analyzed for a variety of common ions, total dissolved solids, silica, and iron. The purpose of the water quality survey was to determine the suitability of the water for irrigation and drinking purposes. The authors concluded that the water was usable for irrigation and drinking.

Concentrations of most dissolved constituents are many times higher in Harney Lake than they are in Malheur Lake. This difference is due to repetitive drying cycles and mineral-rich springs in the basin. The drying cycles of the lakes concentrate the salts in the bottom sediments of Harney Lake (Piper, Robinson, and Park, 1939). Harney Lake has always had higher concentrations of ions than Malheur Lake and thus supports a different fauna, one more similar to other terminal lakes with high salinity.

Prior to investigating water quality in the Harney Basin, many studies were pursued to better understand the basin's overall hydrography. Hubbard studied the hydrology of Malheur Lake in 1975. During the study, several water samples were taken. The samples were analyzed for metals and nutrients, but no analysis of water quality was conducted. The report concluded that "the chemistry of the lake is very complex, and that care must be exercised in using the water-quality data."

Malheur Lake exhibited extreme high-water from 1983-1985. Studies performed by Fuste and McKenzie (1987) characterized Malheur Lakes' chemical composition as variable, "from point to point in the lake, as well as from time to time (Hubbard, 1975; Johnson and others, 1984). These differences in water quality are largely a result of the hydraulics of the lake and hydrologic events. The lake as a whole becomes appreciably more saline during dry periods and more dilute during wet periods."

Fuste and McKenzie (1987) sampled more than 40 locations established throughout the Malheur and Harney Lakes system in 1984 and 1985 At each location, information was taken from vertical profiles of water temperature, dissolved oxygen, pH, and specific conductance and transparency (Secchi disc). Water samples were analyzed for dissolved major ions, nutrients, total-recoverable trace elements, dissolved trace elements, fecal coliform and other bacteria, and phytoplankton. The researchers found "(1) The concentrations of sodium, potassium, chloride, sulfate, silica, and dissolved solids and measurements of specific conductance progressively increase[d] from Malheur to Mud to Harney Lakes. Calcium and magnesium concentrations do locations throughout the Malheur and Harney Lakes system in 1984 and 1985. At each location, data was taken from vertical profiles of water temperature, dissolved oxygen, pH, and specific conductance and transparency (Secchi disc). Water samples were analyzed for major dissolved ions, nutrients, total-recoverable trace elements, dissolved trace elements, fecal coliform and other bacteria, and phytoplankton. The researchers found that, "(1) The concentrations of sodium, potassium [do] not show the same increase, which explains the sharp increase in the sodium-adsorption ratio (SAR) values. The prevailing cation dominance in 1984 was in the form of Na>>Ca>K>Mg in Malheur Lake and Na>>K>Ca>Mg in Harney Lake. (2) Sodium and chloride concentrations, sodium absorption rates (SAR), and specific conductance values increased from 1984 to 1985 in Malheur and Mud Lakes. No significant change was observed in Harney Lake. (3) Relative to the range of values measured in Malheur Lake in 1972 and 1973 (Hubbard, 1975), the 1984 and 1985 data indicate the lake to be of a more homogeneous composition."

More recent studies of water quality have been completed for the development of the Comprehensive Conservation Plan for the Malheur National Wildlife Refuge (Mayer et al, (2007). The researchers took samples in 2002 and 2003 in the Donner und Blitzen River and Malheur Lake. They found that "high water temperatures and low dissolved oxygen concentrations appear to be the most critical water quality issues of concern on the refuge. Water temperatures exceed the state standard even before the Blitzen flows onto the refuge and increase with distance downstream on the refuge. The most rapid increase occurs in the first 5-mile reach on the refuge. Low dissolved oxygen concentrations are below state standards at downstream sites during the summer baseflow period. Irrigation and wetland return flows are contributing low DO [dissolved oxygen] and higher BOD [biochemical oxygen demand] waters to the river and may be responsible for some of the low concentrations further downstream. But warmer temperatures downstream also undoubtedly contribute to the DO decreases. Both high water temperatures and low dissolved oxygen concentrations are detrimental to redband trout. Management practices that improve water temperature will also help improve dissolved oxygen. Additional discussion of Refuge water quality is included at the end of the Water Quality Section.

Other issues of concern are conductivity, turbidity and suspended sediment, total P [phosphorus], and total N [nitrogen]. All of these parameters increase on the refuge with distance downstream. Despite the fact that nutrient concentrations increase downstream, there does not seem to be much of a problem with eutrophication and planktonic algae in the river. Concentrations of chlorophyll a are very low throughout the river. This may be because of limited P availability, based on P concentrations and N:P ratios in the river.

Irrigation and wetland return flows are responsible for some of the observed water quality problems but certainly not all of them. The timing of conductivity increases downstream on the river seems to implicate return flows as sources of higher conductivity water.

Return flows are also implicated as a potential source of nutrients to the river. Concentrations of total N, total P, and BOD are higher and DO concentrations are lower in return flows."

Modern Water Quality Monitoring

The Oregon Department of Environment Quality (DEQ) has several programs to characterize and manage water quality. DEQ has developed a Water Quality Index (WQI) system (Brown, 2016) to track water quality changes at more than 160 sites across the state. There are three sites in the Harney basin that have been part of this program since 2013. DEQ also inventories and evaluates water quality data from across the state to provide an integrated water quality report of those waterbodies that fail to meet water quality standards. These impairments are referred to as the 303(d) list which refers to section 303(d) of the Clean Water Act. DEQ reports to the Environmental Protection Agency (EPA) on a regular basis. The last report was provided in 2022 and data is being gathered to report on which waters in Oregon do not meet standards for 2024. A waterbody can attain a water quality standard (improving) or exceeding a water quality standard (declining).

In 2020, DEQ published a five-year monitoring plan to propose, evaluate, prioritize, and implement monitoring activities. The full Water Quality Monitoring Strategy can be found on DEQ's website.

Water Quality Standards

Water quality standards are established to protect beneficial uses of the state's waters. Beneficial uses are designated for all waters of the state in the Oregon Administrative Rules for water quality standards (Chapter 340, Division 41). In some cases, beneficial uses vary by waterbody or reach. In other cases, uses are designated for all waters in a basin or sub-basin. Water quality standards include designated beneficial uses and water quality criteria established to protect the sensitive beneficial uses. For example, the uses most sensitive to dissolved oxygen are fish and aquatic life. Fish and other aquatic organisms need an adequate supply of oxygen in the water to be healthy and productive. In this case, the criteria identify minimal amounts of dissolved oxygen that need to be in the water to protect the fish. In other cases, such as bacteria or some toxic substances, human health is the most sensitive beneficial use. These criteria identify the maximum concentration that may be in the water without risk to aquatic organisms or human health.

Water Quality Index

DEQ has 163 river and stream stations across the state that are monitored 6 times a year for 'traditional' water quality parameters. These data are used in the status and trend assessment, with annual summaries available on the DEQ web site: http://www.oregon.gov/deq/wq/Pages/WQI.aspx. The index, use, and limitations are described by Brown (2016). The DEQ Water Quality Index program has only three sites in the Harney Basin that are monitored 6 times a year for 'traditional' water quality parameters for status and trend assessment, with annual summaries (Figure 25, Table 3).

Figure 25. Table 3:Water Quality Index for Sites in the Harney Basin (from Brown, 2017)

Oregon Department of Environmental Quality

OWQI Basin Summary

Station	Location Description	Land Use	Water Year Range	OWQI Score	OWQI Status	OWQI Trend and Magnitude		10 Year OWQI Trend - Includes data from 1981-2015	Sub-Index Status and Trend							
									Temp	pH	DO	BOD	TS	N	P	Bact
HARNEY BASIN																
12265	Donner & Blitzen River at Page Springs Campground	Range	2013-17	91	Excellent	-		Insufficient Data								
13014	SF Blitzen R at Blitzen Crossing	Range	2013-17	92	Excellent	-		Insufficient Data								
33929	Silvies River at West Loop Road	Range	2013-17	85	Good	-		Insufficient Data								

Status

- = Excellent (90-100)
- = Good (85-89)
- = Fair (80-84)
- = Poor (60-70)
- = Very Poor (10-59)

Trend

- ↑ = Improving Trend
- NT = No Trend
- ↓ = Declining Trend
- NA = Insufficient Data

Sub-Index

- **Temp** = Temperature
- **pH** = pH
- **DO** = Dissolved Oxygen
- **BOD** = Biochemical Oxygen Demand
- **TS** = Total Solids
- **N** = Nitrogen
- **P** = Phosphorus
- **Bact** = Bacteria (e.coli)

Variables included in the index are dissolved oxygen (DO percent saturation and concentration), biochemical oxygen demand (BOD), pH, total solids, ammonia and nitrate nitrogen, total phosphorus, temperature, and bacteria (E. coli). Index scores range from 10 (worst case) to 100 (ideal water quality). The 2020 update (Table 4 from Brown, 2021) categorizes Page Springs and Blitzen Crossing sample sites as excellent water quality index status (score of 91 and 92 respectively) and the Silvies River at West Loop Road as good water quality index (score of 85).

Figure 26. Table 4: History of Water Quality Index of Two Harney Basin Sites (from Brown, 2021)

Station	Location Description	Basin	Land Use	Water Year Range	OWQI Status								
					2012	2013	2014	2015	2016	2017	2018	2019	2020
13014	SF Blitzen R at Blitzen Crossing	Oregon Closed Lakes	Range	2013-20		Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
33	Silvies River at West Loop Road	Oregon Closed	Rang	2013		Fair	Fair	Goo	Goo	Goo	Goo	Goo	Goo

92 9		Lakes	e	-20				d	d	d	d	d	d

Integrated Water Quality Report

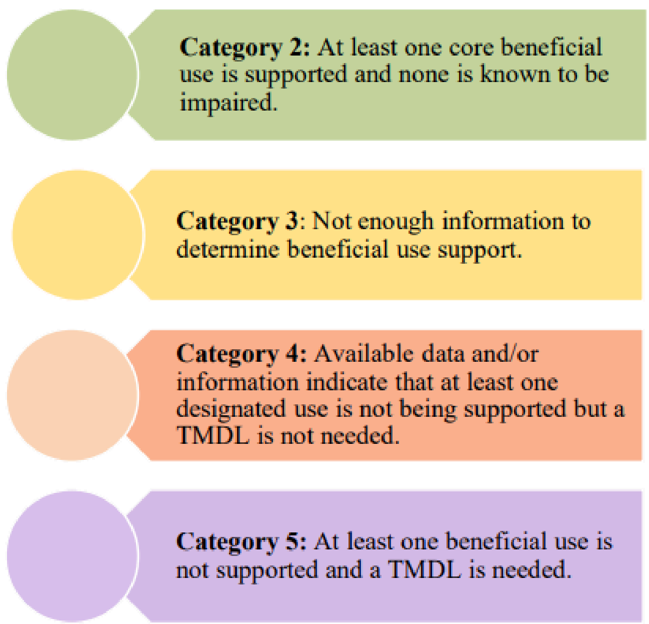
Every two years, DEQ is required to analyze the condition of thousands of miles of Oregon waterways, using monitoring data provided by a wide variety of organizations and individuals, including the agency's own measurements. The information is compiled in an interactive online map that allows users to pinpoint everything from small sections of rivers and streams, lakes, coastal waters or entire watersheds, and learn what might be impairing water quality (see https://www.oregon.gov/deq/wq/Pages/epaApprovedIR.aspx).

The 2022 DEQ Integrated Report was approved by the U.S. Environmental Protection Agency in September of 2022. The Integrated Report is developed to satisfy the Clean Water Act's requirement for Oregon to report on the quality of its surface waters every two years. The report is a combination of the Clean Water Act 305(b) which requires the development of the report and section 303(d) which requires the development of a list of impaired waterbodies. The 303(d) list identifies waters that do not meet state water quality standards. The Integrated Report describes the status of water quality (Figure 1) in Oregon and details a list of waterbodies considered to be impaired. When a waterbody is impaired its pollutant levels have exceeded the protective water quality standards. Surface waters are assigned a parameter category for a specific assess Category 5 listings indicate that a designated use or water quality standard is not attainted and a TMDL is needed. This category constitutes the section 303(d) list that EPA will approve or disapprove under the Clean

Water Act. Category 4C impairments are caused by pollution, not a pollutant. Parameters in Category 4 indicated that a TMDL is not needed to address the pollutant.

All the streams on the 303(d) list are identified in Table 3.

In the Harney Basin, many sites were assessed in 2018 and 2022 for a multitude of parameters such as dissolved oxygen (DO), temperature, pH, and iron (Figure 2, Table 4).



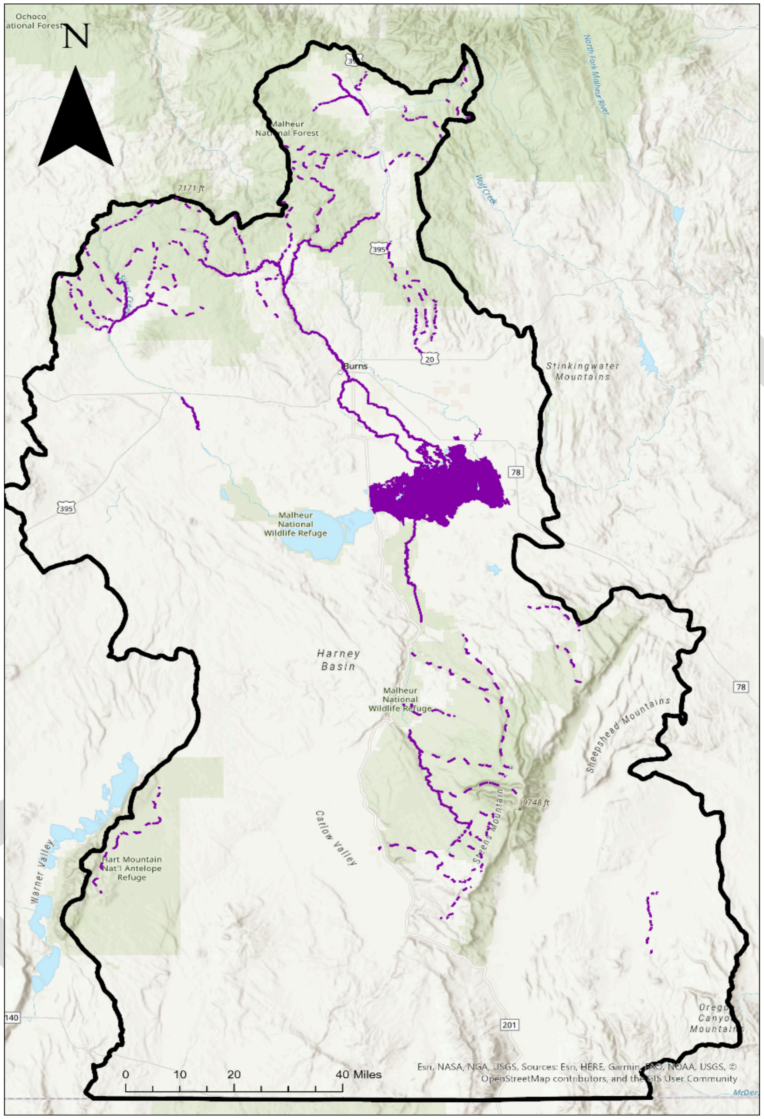


Figure 27. Water Quality Impaired Water Bodies in the Harney Basin (DEQ 2022)

The State has identified stream segments that fail to meet water quality standards (Table 5). The Environmental Protection Agency, under the federal Clean Water Act sets ranked priorities for “impaired waters needing development of a Total Maximum Daily Load as Category 5 (Table 4) on the 303(d) list" (DEQ Submission Schedule, 2022). The Malheur Lakes Basin (Harney Basin) is a low priority for setting Total Maximum Daily Load allocations. The basin is not on the current schedule that DEQ reports to EPA.

Figure 28. Table 5: Impaired Water Bodies Reported to EPA (from DEQ, 2022)

Assessment Unit Name	HU_8_NAME	Pollutant	Measurement Stations[1]
Coffeepot Creek	Harney-Malheur Lakes	Temperature	
Rattlesnake Creek	Harney-Malheur Lakes	Temperature	MNF-066
Paul Creek	Harney-Malheur Lakes	Temperature	
Headwaters Riddle Creek	Harney-Malheur Lakes	Temperature	
Lower Scotty Creek	Silvies	Temperature	
Van Aspen Creek-Silvies River	Silvies	BioCriteria	
Upper Bear Creek	Silvies	Temperature	MNF-027; MNF-043
Antelope Creek	Silvies	BioCriteria	
Camp Creek	Silvies	BioCriteria	
Camp Creek	Silvies	Temperature	MNF-013; MNF-023
Flat Creek-Silvies River	Silvies	Temperature	MNF-007
Mountain Creek	Silvies	BioCriteria	OR_BU-1053
Upper Trout Creek	Silvies	Temperature	MNF-162
Myrtle Creek	Silvies	Temperature	MNF-055; MNF-057
Whiskey Creek-Emigrant Creek	Silvies	Temperature	MNF-124; MNF-128; MNF-129; MNF-088

1

Bear Canyon Creek	Silvies	BioCriteria	
Sawtooth Creek	Silvies	Temperature	
Hay Creek	Silvies	Temperature	
Skull Creek	Silvies	Temperature	
Ankle Creek	Donner und Blitzen	Temperature	
Deep Creek-Donner und Blitzen River	Donner und Blitzen	Temperature	
Little Blitzen River	Donner und Blitzen	Temperature	
Mud Creek-Donner und Blitzen River	Donner und Blitzen	Temperature	
Bridge Creek	Donner und Blitzen	Temperature	
Fivemile Lake-Donner und Blitzen River	Donner und Blitzen	Iron (total)	
Fivemile Lake-Donner und Blitzen River	Donner und Blitzen	Temperature	
Krumbo Creek	Donner und Blitzen	Temperature	
McCoy Creek	Donner und Blitzen	Temperature	
Egypt Creek	Silver	Temperature	
Upper Wickiup Creek	Silver	Temperature	
Still Spring Creek-Silver Creek	Silver	BioCriteria	
Dodson Creek	Silver	BioCriteria	
Sawmill Creek	Silver	Temperature	MNF-069
Nicoll Creek	Silver	BioCriteria	
Nicoll Creek	Silver	Temperature	MNF-061
Dairy Creek-Silver Creek	Silver	BioCriteria	

Figure 29. Table 6: Category 5 Waterbodies in the Harney Basin (from DEQ, 2022)

Assessment Unit Name	Assessment Unit Description	Parameter	Status *	Beneficial Uses	Year Assessed/Year Listed
Malheur Slough	Lake/Reservoir Unit	Chlorophyll-a	5		**2022**/2022
Silvies River	Trout Creek to Emigrant Creek	Dissolved Oxygen (Year-Round)	5	Fish and Aquatic Life	**2022**/2018
		Dissolved Oxygen (spawning)	5	Fish and Aquatic Life	**2022**/2018
		pH	5		**2022**/2018
		Temperature, Numeric (Year-Round)	5	Fish and Aquatic Life	**2018**/2004
Emigrant Creek	Bear Canyon Creek to Silvies River	Temperature, Numeric (Year-Round	5	Fish and Aquatic Life	**2022**/1998
EF Silvies River	Emigrant Creek to Malheur Lake	Dissolved Oxygen (Year-Round)	5	Fish and Aquatic Life	**2022**/2004
		Dissolved Oxygen (Spawning)	5	Fish and Aquatic Life	**2022**/2012
		Temperature, Numeric (Year-Round)	5	Fish and Aquatic Life	**2018**/2004
		Iron	5	Fish and Aquatic Life	**2022**/2018
Donner und Blitzen River	Grain Camp Dam to Malheur Lake	Temperature, Numeric (Year-Round)	5	Fish and Aquatic Life	2002/2004
Wickiup Creek	Egypt Creek to Silver Creek	Temperature, Numeric (Year-Round)	5	Fish and Aquatic Life	1998/1998
Silver Creek	Dodson Creek to Wikiup Creek	Temperature, Numeric (Year-Round)	5	Fish and Aquatic Life	**2022**/1998

Water quality standard exceedances in the Harney Basin

The standards most exceeded in the Harney Basin are temperature and dissolved oxygen. Limited waterbody segments in the Harney Basin have elevated iron and pH.

Temperature

Increases in temperature adversely impact many fish species that require cool or cold water. Fish require different temperature water based on species and life history stage. Oregon's temperature limits are based on the most sensitive species and the life history stage of those species at the location and season of concern. Generally, water temperatures increase as flow decreases. Therefore, reducing flow in waterbodies that are connected to downstream temperature-impaired waterbodies can result in higher stream temperatures and stressed conditions for aquatic life, particularly during the summer months when streamflow is lowest. **The critical warm period when stream conditions are most likely to exceed the year-round temperature standards is July 1 – September 30.**

The temperature standard (Sturdevant, 2008) for the Malheur Lakes Basin is for "cool water species". Stream reaches that have summer temperatures that exceed the cool water species threshold are listed as impaired. While they are identified as impaired there is limited information on the reason for their impairment. Often the reason for impaired temperature is the lack of streamside riparian vegetation that prevents solar heating through shading. Many of the reaches in the Harney basin flow through non-forested (sage or meadow) environments that have had riparian vegetation removed, altered, or are absent of shrub and tree species naturally. It is possible that widespread groundwater declines in the Silvies and Silver Creek watersheds have impacted temperature by decreasing streamflow via capture or induced recharge (Barlow and Leake, 2012). Decreased streamflow reduces depth of water in-channel, which reduces thermal inertia and amplifies the effect of incoming solar radiation (Sinokrot and Gulliver, 2000).

Dissolved Oxygen

Decreased dissolved oxygen levels adversely impact aquatic life. Oregon's dissolved oxygen limits are based on the most sensitive species and the life history stage of those species at the location and season of concern. Reduced flows may increase water temperature and reduce surface area and turbulence, which can decrease dissolved oxygen. Therefore, reducing flow in waterbodies that are connected to downstream dissolved oxygen-impaired waterbodies can result in lower stream dissolved oxygen levels and stressed conditions for aquatic life, particularly during the summer months when streamflow is lowest. **The critical warm period when stream conditions are most likely to exceed the year-round dissolved oxygen standards is July 1 – September 30.**

pH

pH is a measure of how acidic or basic (alkaline) the water is. Water with a pH greater than 7 is alkaline, water with a pH of less than 7 is acidic. Every species of aquatic life has adapted to a specific range of pH. Fish exposed to changes in pH outside their normal range can be stressed or even die. Stress leaves fish vulnerable to disease, degrading their health. Additionally, alkaline conditions can transform nitrogen in the water column into a more toxic form of ammonia that can poison fish. Withdrawals from the stream will reduce the stream's heat capacity and cause a greater fluctuation in daytime and nighttime stream temperatures. When nutrients and sunlight are sufficiently present, higher stream temperatures lead to more algal growth. During the day, algae absorb carbon dioxide from the water for cell growth, raising pH. At night, photosynthesis stops and algae continue to respire, releasing carbon dioxide and lowering pH. This cycle creates diel fluctuations in pH. Additional withdrawals from a stream that is already impaired for pH will lead to larger diel fluctuations in pH. Fish and aquatic insects are sensitive to imbalances in pH. Low pH levels (below 5) may lead to death and high pH levels (9-14) can harm fish by denaturing cellular membranes. These pH imbalances result in the diminution of the habitat of sensitive, threatened, or endangered fish species.

Iron

Iron is common in many rocks and is an important component of many soils. Iron is an essential trace element required by both plants and animals. Ferrous (Fe^{2+}) and ferric (Fe^{3+}) irons are the primary forms of concern in the aquatic environment. Ferrous iron is colorless (clear) while ferric iron will show up as a rust-colored stain in the water. Iron bacteria may also be present in streams associated with mining waste or ground water recharge. A rust-colored slime often forms rocks and other surfaces when iron bacteria are present. Iron and manganese often occur together. High concentrations of these metals can result in discolored water. Where water supplies are used for domestic purposes, elevated iron and manganese concentrations can result in stained plumbing fixtures and an unpleasant metallic taste to the water. Iron deposits can build up in pressure tanks, storage tanks, water heaters, and pipelines, decreasing capacity, reducing pressure, and increasing maintenance. Iron and manganese concentrations of concern are generally established based on aesthetic and economic considerations (unpleasant tastes and coloration) rather than toxicity. A reduction in streamflow will lead to an increased concentration of iron and manganese in the water column. This may result in increased bacterial growth and an increase in aesthetic, recreational, and domestic water system impacts.

Biocriteria

Biocriteria is defined by DEQ administrative rule as: "Waters of the State must be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities". The criteria is measured by macroinvertebrate taxa loss. The listing is limited by sample limitations. Few stream segments in the Harney Basin have been sampled for macroinvertebrates.

The impaired waterbodies in the Harney Basin are dominated by temperatures that exceed criteria resulting from likely low flows and reduced riparian shade. Additionally low oxygen also likely reflects warmer water and low flow.

Toxic Materials

DEQ conducts state-wide toxics monitoring of surface water, sediment and fish on a 5-year rotating basin plan. The first round of toxics monitoring in Southeast Oregon was conducted in 2013 and again in 2018. "Toxics" are very broad groups of chemicals that includes legacy and current use pesticides, some metals, industrial chemicals, combustion by-products, and some pharmaceutical and personal care products.

In 2019, the DEQ Laboratory transitioned the Toxics Monitoring Program from the rotating basin basis used since 2008 to a network basis (DEQ, 2019). The initial network consists of 60 sites statewide. This change allows the program to collect data from across the state more frequently, identify trends at selected sites, and apply the most current analytical methods in each basin. Past data, land use, assessment unit overlap, 303(d) listing status and spatial coverage all factored into the selection of network sites. Two sites are in the Harney basin: Silvies River at West Loop Road and Donner und Blitzen River at RM 11.9. The 2017 DEQ report identified few toxic pollutants in the samples from the Harney basin.

Water Quality Plans

Oregon Agricultural Water Quality Plan

The Harney Soil and Water Conservation District (HSWCD) developed a Local Advisory Committee (LAC) to deliberate and develop an Agricultural Area Management Plan to address water quality concerns in accordance with Oregon State Law. The LAC was organized in 2003 and, with technical advisors, developed a plan for the area. The plan was finalized in 2003 and is reviewed by Oregon Department of Agriculture (ODA) every two years. The latest version of the Agricultural Water Quality (AgWQ) Plan was completed in 2020 (Greater Harney Basin Local Advisory Committee, 2020). The 2017 review of the Plan by DEQ concluded that "little data exists in the Greater Harney Basin AgWQ Management Area to assess water quality status and trends. There is no continuous temperature data from 2001 forward, which gives little insight into natural and anthropogenic contributions to water temperature. Continuous temperature, dissolved oxygen, and pH data would be useful in this AgWQ Management Area to understand diurnal fluctuations. Additional data is needed to evaluate site potential vegetation on agricultural lands, which will require remote sensing data to determine tree heights and calculate effective shade." ODA and DEQ have developed a Memorandum of Agreement of Collaboration on Achieving Water Quality Goals (see https://www.oregon.gov/deq/wq/Documents/nps2023odaMOAfc.pdf).

Federal Water Quality Plans

Oregon DEQ signed a Memorandum of Understanding with the Forest Service (USFS) in 2019 (see https://www.oregon.gov/deq/FilterDocs/FSdeqWQmou2.pdf) and the Bureau of Land Management (BLM) in 2017 (https://www.oregon.gov/deq/FilterDocs/blmDEQmou.pdf). Each agreement commits the federal agencies to conduct best management practices and develop Water Quality Restoration Plans to meet Oregon's water quality standards during the land management planning process as well as apply best management practices (BMPs).

The BLM Andrews Management Plan for the South Steens explicitly states that "management of riparian areas is an important component of restoring water quality. To reasonably prevent the degradation of water quality, BMPs will be continued or prescribed and implemented at the activity plan level. These BMPs will also be directed toward management practices to facilitate maintenance or improvement of attributes (i.e., vegetation, channel geometry) identified through Proper Functioning Condition (PFC) assessment or other qualitative or quantitative methods." PFC methods are described in Dickard and others (2015).

Subbasin Water Quality Issues

While monitoring data is insufficient to distinguish water quality from the four separate subbasins (Silver Creek, Silvies River, Donner und Blitzen River and the immediate drainage to Malheur and Harney Lakes) , there is evidence that the Donner und Blitzen drainage has good surface water quality (index sites are rated excellent). Temperature studies of the Donner und Blitzen River and Bridge Creek canal (Watershed Sciences, LLC, 2000) show increasing temperatures downstream. Alternatively, there is evidence that stream temperatures are being affected by sources cooling the flow in both measured streams as well.

The Silvies is rated "good" from the one index site but has elevated temperatures, phosphorus, and biochemical-oxygen demand. The Silvies River is the focal watershed for the Agricultural Water Quality management area plan for the greater Harney Basin. However, recent monitoring (DEQ, 2017) has not shown a measurable change in water quality.

Silver Creek water quality is poorly documented and the measurements that have been conducted by the U.S. Forest Service show elevated temperatures. The intermittent streams flowing into the Harney Basin (Poison Creek, Cow Creek, Prather Creek, etc.) are all temperature limited although insufficient data are available to place them on the 303(d) list.

Information Gaps

Surface water quality in the Harney Basin (the lowland portions of the Silvies River, Silver Creek, and Blitzen River) is only minimally understood. There is more information in the Blitzen River basin from the monitoring and analysis by Mayer and others (2007) than either the Silvies River or Silver Creek. The primary water quality parameter of concern is temperature as it relates to cool water fish habitat and use. The temperature standard varies for core use by cold-water species, use by redband trout, and migration corridors. With the limited knowledge of redband trout life histories in the Harney Basin, the difference between migration corridor and use area is uncertain.

The nature of closed basins accumulate materials in the underlying geology through the loss of water due to evaporation rather than downstream flushing. Accumulations of heavy metals, especially iron and arsenic are of concern. The limited monitoring of surface waters is of little use in identifying potential sources and locations of accumulations of metals and other pollutants (either natural or anthropogenic). DEQ (2015) concludes in the evaluation of toxics in Oregon's waters that "high levels of, possibly naturally occurring, inorganic arsenic and iron may warrant additional sampling" for the Closed Lakes basin when evaluating the larger area of closed basins in Oregon that include Warner Lakes, Lake Abert and the Harney Lake Basin.

Building a Better Understanding of Harney Basin Surface Water Quality

There is little likelihood of a large-scale monitoring program being initiated in the Harney Basin by the Oregon Department of Environmental Quality. A cooperative water quality monitoring program that systematically samples streams across the basin in a diagnostic manner in cooperation with the federal land management agencies could be undertaken by the watershed council.

Development of a spatially structured sampling plan to get a geographic balance of streams and a sample size that is representative of the conditions in the basin would be important. Such a sampling scheme could be structured by subbasin with assistance from the DEQ Volunteer Water Quality Program. The program provides support including technical assistance in monitoring design, equipment loans, data management, and analysis.

A discussion with the Volunteer Water Quality Monitoring Program staff can help in the development of a funding proposal to the Oregon Watershed Enhancement Board or other funding entities.

Water Quality on the Malheur National Wildlife Refuge

Refuge management practices designed to manage water and migratory bird habitat have the potential to adversely impact redband trout through water quality degradation. Irrigation and water management on the refuge may decrease flows, exacerbate high water temperatures, reduce dissolved oxygen concentration, increase turbidity, increase nutrient loading, and degrade fish habitat. Nutrients, fecal coliforms, and other pathogens associated with cattle manure, hayed meadows, and wetlands may enter the Blitzen River via irrigation return flows. These pollutants may decrease water quality (e.g., increased water temperatures, reduced DO, increased algal blooms) and impact native fish species. The Blitzen River is a 303(d) listed stream for water temperature, dissolved oxygen, and turbidity. Because water quality is impaired with respect to state standards, the entire Blitzen watershed must comply with Total Maximum Daily Loading (TMDL) criteria as specified within the Clean Water Act. The TMDL for the Blitzen River is scheduled to be completed by 2010. A TMDL study may be conducted by the U.S. Environmental Protection Agency and Oregon State Department of Environmental Quality (DEQ) in the future. After TMDL criteria are established, Malheur NWR must monitor and meet regulatory standards for discharges and pollutant loading into the Blitzen River. The refuge will improve water quality by employing best management practices (BMPs), which will eventually be used to establish TMDL water quality standards for the Blitzen Valley watershed. (Mayer et al., 2007).

There are several previous hydrology and water quality studies for the Malheur NWR area that will be mentioned here briefly. Most of these studies have focused on the area upstream of the refuge or on Malheur Lake itself. Rinella and Schuler (1992) conducted a reconnaissance investigation of water quality, sediment, and biota to determine if irrigation drain water was causing harmful effects of human health or fish and wildlife resources. Although they found high concentrations of As, Bo, and Hg in Malheur Lake samples and in some biological samples, they did not believe there were problems associated with agricultural drainage from the Blitzen River Basin. The authors did report that the concentration of dissolved solids and inorganic constituents, including N and P, increased downstream in the Blitzen River. In the 1990s, concern became heightened for Great Basin redband trout. In response to a petition for listing, the FWS prepared a status review of the fish (USFWS, 2000). Factors given as contributing to the demise of the fish included warm temperatures, poor water quality, habitat degradation, irrigation diversions, limited fish passage at dams, and the introduction of carp in the Blitzen River and Malheur Lake. The increased concern for the fish and the river produced several studies looking at water quality and water temperature in the Blitzen River and tributaries.

Roy et al. (2001) measured water temperatures, turbidity, pH, and dissolved oxygen at several sites along the Blitzen River and Bridge Creek through the refuge in the summer of 1999. They reported a general increase in water temperatures and conductivity downstream in the refuge, with all Blitzen River sites and the two downstream Bridge Creek sites exceeding the state temperature standard (17.8EC at the time). Turbidity was generally low, but increased during manipulation of water control structures on the refuge. pH appeared to decrease downstream through the refuge and was always between 7.0 and 9.0. Dissolved oxygen decreased downstream as well, and frequently fell below the state criteria of 6.5 mg/L. Dissolved oxygen was consistently lowest at Sodhouse Lane, the most downstream site on the refuge.

Watershed Sciences (2002) conducted a Forward Looking Infrared (FLIR) survey of water temperatures on Bridge Creek and the Little Blitzen River on August 17, 1999. Although Bridge Creek is a spring-fed stream, the channel flows through a very low-gradient, 2-mile section known as the Bridge Creek Canal, between East Canal and the mouth of Bridge Creek. Water is backed up in this section with a diversion dam and water temperatures increased considerably through this reach. Water temperatures in Bridge Creek were about 12˚C six miles upstream of the confluence with the Blitzen River, 18˚C at the upstream end of Bridge Creek Canal, and 22˚C at the mouth of Bridge Creek. Penn et al. (2023) published data associated with simulated stream temperature in the Donner und Blitzen River Basin for water years 1980 through 2021 using the Precipitation-Runoff Modeling System with the "stream_temp" module. The model may provide a valuable tool in the future.

Based on the water quality results from this study, the main water quality parameters of concern in the Blitzen Valley are conductivity, dissolved oxygen, turbidity and suspended sediment, total P, and total N. Dissolved oxygen decreases and conductivity, turbidity, suspended sediment, total P, and total N increase with distance downstream. Low dissolved oxygen concentrations, in particular, are a big concern downstream during the summer baseflow period. Concentrations are below state standards at downstream sites. Irrigation and wetland return flows are contributing low DO- and higher BOD-waters to the river and may be responsible for some of the low concentrations further downstream. But warmer temperatures downstream also undoubtedly contribute to the DO decreases. Late season increases in river turbidity and TSS may be related to dam operations. These two parameters increase at about the time that the dams are opened, in late July and early August (Mayer et al., 2007)

The timing of conductivity increases downstream on the river seems to implicate return flows as sources of higher conductivity water. The return flows are generally much higher than the river conductivities. The increases downstream in the river are observed to occur through the irrigation season and reach maximums in late July, coinciding with the end of the irrigation season on the refuge. Return flows are also implicated as a potential source of nutrients to the river. Concentrations of both macronutrients are higher in the return flows and they increase downstream in the river. The wetlands, particularly the wet meadows, appear to be a source of P and possibly N, based on the nutrient budget for the Westside P Ranch Area.

River, stream and riparian habitat and function

Stream habitat is characterized by a suite of interacting variables, including flow, temperature, sediment properties, channel structure, and water quality conditions. Habitat complexity, an emergent characteristic of these variables, is positively correlated with resilience, diversity, and abundance of aquatic organisms (Menge et al., 1985). Physical or structural complexity can create ecological refuge from predators (e.g., Diehl, 1992) as well as hydraulic refuge from disturbances like flooding or drought (Pearsons et al., 1992). Water quality complexity can indicate thermal refuge for cold- or warm-water obligate organisms (Isaak et al., 2015), oxygenated refuge from anoxic conditions (Smith et al., 2020), and other benefits. Climate, anthropogenic inputs and alterations, naturally occurring disturbance events, and ecosystem engineers can all alter stream habitat characteristics and complexity.

Stream function also depends on lateral, longitudinal, and vertical connectivity. Lateral connectivity is the interaction between a stream and its floodplain. The benefits of lateral connectivity include flood attenuation that decreases scouring of downstream habitat, external (or "allochthonous") inputs of nutrients and/or organic matter, and water quality and temperature buffering due to exchange between channel water and shallow subsurface water (or "hyporheic" water). Lateral connectivity can be interrupted by floodplain development, stream channelization, or stream incision. Longitudinal connectivity is the hydrologic connection within a stream network—in other words, the connectivity between a given stream reach and its adjacent upstream and downstream reaches. Longitudinal connectivity is critical for fish passage, macroinvertebrate drift, sediment transport, geomorphological cycling, and downstream habitat development. The most common factor impacting longitudinal connectivity is dam development, though in-line ponds, weirs, and culverts may also have a deleterious impact. Finally, vertical connectivity is the connection between channel water and groundwater. Vertical connectivity increases water quality complexity, improves resilience of stream networks to drought or low-flow conditions, and can provide habitat for obligate groundwater-dependent species. [References needed]

The riparian area is the wet terrestrial fringe at the interface between a flowing water body and the surrounding upland habitat. Maintaining streamflow is important to riparian conservation in eastern Oregon ecoregions (Oregon Conservation Strategy, 2016). All streams have associated riparian habitat, even if the hydrologic connection is intermittent or ephemeral (e.g., seasonal flood events from snowmelt in ephemeral streams). The term "riparian" originates from the Latin word *riparius*, which means of or pertaining to the bank of a river (Cooper and Merritt, 2012). Riparian habitats provide important habitat for amphibians, reptiles, birds, mammals, and plants (Oregon Conservation Strategy, 2016). Riparian meadows include natural spring-seep habitats that are extremely important for a wide variety of species, including Greater Sage-Grouse chicks and butterflies.

In addition to contributing a significant amount of local and regional biodiversity, riparian wetlands can regulate stream temperatures by providing shade, decrease flood risk in adjacent streams, and add nutrients or organic matter resources to streams through biogeochemical cycling (Cooper and Merritt, 2012). Important functions of riparian vegetation include protecting banks from erosion, influencing in-channel aquatic habitats, maintaining favorable water temperature for fish through shading, filtering runoff, and providing nutrients to support terrestrial and aquatic life (Oregon Conservation Strategy, 2016).

Riparian habitats are threatened by anthropogenic activities like being drained for agriculture; dewatering due to dams, groundwater pumping, and stream diversions; gravel mining; livestock grazing; and other activities (Cooper and Merritt, 2012 and references therein).

Riparian habitat conditions in the Harney Basin

An analysis of riparian habitat conditions across the basin would require time and resources not available in this process. Riparian habitat conditions influence streamflow, stream temperature, streamside habitat, and the food web of the stream. Issues and goals related to improving riparian condition are well recognized, though, and are included in each of the three sub-basin watershed assessments prepared by the Harney County Watershed Council (for Silvies River, Malheur-Lakes and Silver Creek sub-basins) and in the Greater Harney Basin Water Quality Management Area Plan. The need to complete a thorough inventory of riparian habitats and riparian conditions is identified as a data gap.

Natural watershed features that contribute to natural water storage capacity and streamflows

Protecting and restoring natural watershed features, such as riparian areas, wetlands, and floodplains and their connection to streams, can help store water naturally, helping mitigate declining summer flows. While an assessment of these conditions is beyond the scope of this report, it is an important consideration especially as the climate warms. The Surface Water-Groundwater Interactions report addresses some of these concepts.

Fish, wildlife and plant species associated with Harney Basin rivers and streams

Fish species and their distribution in the Harney Basin

Harney Basin streams, lakes and reservoirs are inhabited by several native and non-native fishes. This section provides an overview of those fishes and their distribution and includes a more detailed discussion regarding redband trout for which more information is readily available.

Fish fauna of the Harney Basin likely originated from tributaries of the Columbia River through two distinct periods when the two basins were hydrologically connected. Connection to the Malheur River during the Pleistocene provided the opportunity for Columbia River species to colonize portions of the Malheur Lakes Basin. The current fish assemblage in the Blitzen River, upland tributaries of the Silvies, and hydrographically isolated creeks closely resembles that of the middle or upper Snake River (Bisson and Bond 1971) and includes redside shiners, a form of mottled sculpin, redband trout and whitefish and suckers. The list below contains native (historically present) and non-native (historically absent) fishes that currently exist within the Harney Basin.

<u>Native fishes of the Harney Basin</u>
Mountain whitefish, *Prosopium williamsoni*
Bridgelip sucker, *Catostomus columbianus*
Largescale sucker, *Catostomus macrocheilus*
Northern pikeminnow, *Ptychocheilus oregonensis*
Chiselmouth, *Acrocheilus alutaceus*
Speckled dace, *Rhinichthys asculus*
Longnose dace, *Rhinichthys cataractae*
Malheur mottled sculpin, *Cottus bendirei* (federally designated as a Species of Concern)
Mottled sculpin, *Cottus bairdi*
Redside shiner, *Richardsonius balteatus*
Tui chub, *Gila bicolor*
Redband trout, *Oncorhynchus mykiss spp.* (State designated as Sensitive, federally designated as a Species of Concern)

<u>Non-native fishes in the Harney Basin</u>
Green sunfish, *Lepomis cyanellus*
Pumpkinseed, *Lepomis gibbosus*
Bluegill, *Lepomis macrochirus*
Smallmouth bass, *Micropterus dolomieu*
Largemouth bass, *Micropterus salmoides*
Common carp, *Cyprinus carpio*
Black bullhead, *Ameiurus melas*
Yellow bullhead, *Ameiurus natalis*
Yellow perch, *Perca flavescens*

Recent fish distribution information is available from a Harney Basin Wetlands Initiative inventory of aquatic resources conducted with the specific objective of determining the extent of carp distribution in the Harney Basin. (Esquivel 2018). As a part of the work, fish surveys were conducted in many of the tributaries of Malheur Lake. Table X lists the fish collected during the 2016-2018 field seasons, with information compiled in the report regarding their origin (native or alien), habitat characteristics (benthic, water column, hider) and tolerance classification (sensitive, intermediate, or tolerant). The sampling also included macroinvertebrates and water quality parameters.

The report concludes that "[n]ative fish species collected in this monitoring project were typical for the Harney Basin and included redband trout, bridgelip and largescale sucker, chiselmouth, northern pikeminnow, redside shiner, tui chub, longnose and speckled dace, and native sculpins. The percentage of native fish collected in Silver Creek, the lower Silvies River and the Blitzen River was relatively high and ranged from 84.5 – 99.1 %. Non-native species were more abundant in the Upper Silvies River and constituted 36.4 % of the total fish community."

Figure 30. Table 7: Fish Collected in the Harney Basin 2016-2018 (Esquivel 2018, Table 5)

Family/Species	Scientific Name	Origin	Habitat	Overall Tolerance	Silver Creek	Lower Silvies River	Upper Silvies River	Blitzen River
Catostomidae								
Bridgelip sucker	*Catostomus columbianus*	N	B	T	X	X	X	
Largescale sucker	*Catostomus macrocheilus*	N	B	T		X	X	
Centrarchidae								
Green sunfish	*Lepomis cyanellus*	A	W	T			X	X
Pumpkinseed	*Lepomis gibbosus*	A	W	T		X	X	
Bluegill	*Lepomis macrochirus*	A	W	T			X	
Smallmouth bass	*Micropterus dolomieu*	A	W	I		X	X	

Cottidae								
Sculpin species	*Cottus spp.*	N	B	I	X	X	X	X
Cyprinidae								
Chiselmouth	*Acrocheilus alutaceus*	N	B	I		X	X	
Common carp	*Cyprinus carpio*	A	B	T	X			X
Northern pikeminnow	*Ptychocheilus oregonensis*	N	W	T		X	X	
Redside shiner	*Richardsonius balteatus*	N	W	I	X	X	X	X
Longnose dace	*Rhinichthys cataractae*	N	B	I	X	X	X	X
Speckled dace	*Rhinichthys osculus*	N	B	I			X	X
Dace species	*Rhinichthys sp.*	N	B	I	X			
Tui chub	*Siphateles bicolor*	N	W	T		X		
Ictaluridae								
Black bullhead	*Ameiurus melas*	A	H	T			X	X
Yellow bullhead	*Ameiurus natalis*	A	H	T				
Percidae								
Yellow perch	*Perca flavescens*	A	W	I		X		
Salmonidae								

Redband trout	*Oncorhynchus mykiss spp.*	N	H	S	X	X	X	[X*]

Key
Origin: N, native; A, alien
Habitat: B, benthic; W, water column, H, hider
Tolerance: S, sensitive; I, intermediate; T, tolerant
Waterbodies: X- present

(* Note: Esquivel Table 5 shows no redband in the Donner und Blitzen, but at p. 18 reports presence there.)

Additionally, a recent project by USGS and partners, Fishes of the Harney Basin Revisited, provides an interactive fish distribution website displaying the result of numerous recent fish surveys conducted throughout the Harney Basin. That data can be viewed here: https://tableau.usgs.gov/views/Fishes_HarneyBasin_DataMap/FishesofHarneyBasinMapTool?%3Aembed=y&%3Aiid=1&%3AisGuestRedirectFromVizportal=y

Harney Basin Redband Trout

a) General description of redband trout

Redband trout is the name that has been given to coastal rainbow trout occurring east of the Cascade Crest. Redband trout, and rainbow trout west of the Cascades, are the resident forms of *O. mykiss*. The name redband comes from the red stripe that runs down the middle of the body of the fish. The anadromous (*i.e.* ocean going) form of redband and rainbow trout is steelhead.

Studies have shown genetic differences between coastal and interior *O. mykiss*, and in many cases interior populations are managed separately from coastal *O. mykiss*." (ICRT 2016). There are streams where both anadromous and resident *O. mykiss* exist, but not in the Harney Basin whose streams are no longer connected to the ocean.

The following map of the distribution of interior redband in the United States, shows the Harney Basin populations in the context of the overall species distribution.

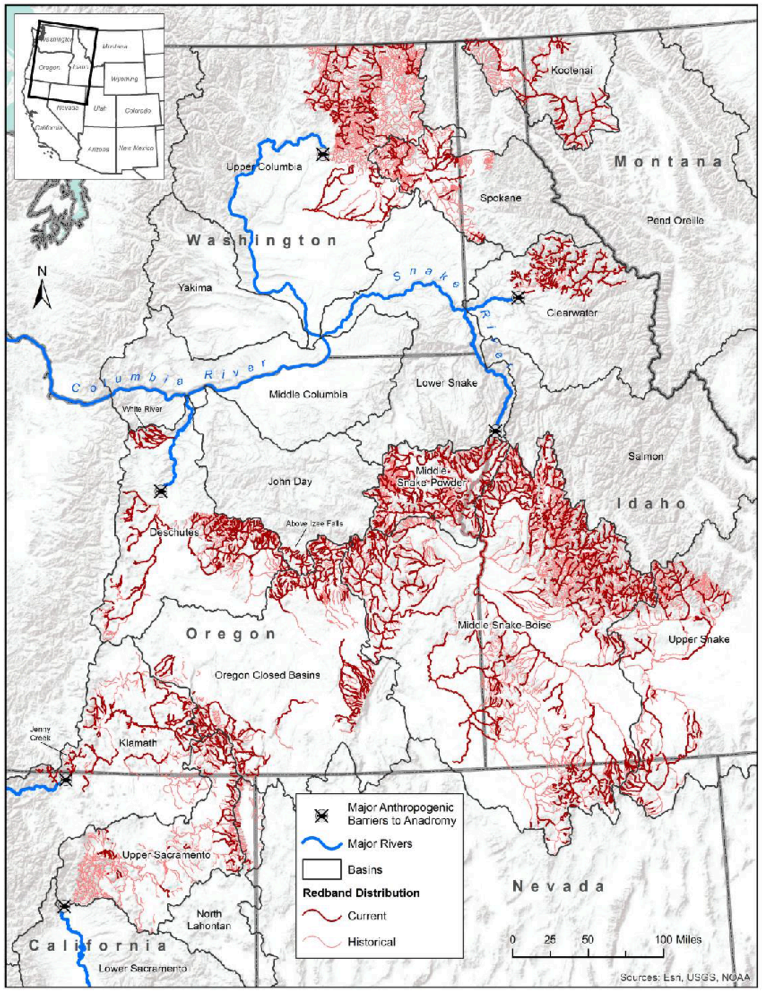

Kootenai
Montana
Upper Columbia
Spokane
Pend Oreille
Washington
Snake River
Yakima
Clearwater
Columbia River
Middle Columbia
Lower Snake
White River
Salmon
John Day
Middle Snake-Powder
Idaho
Above Izee Falls
Deschutes
Middle Snake-Boise
Oregon
Upper Snake
Oregon Closed Basins
Jenny Creek
Klamath
Major Anthropogenic Barriers to Anadromy
Major Rivers
Basins
Redband Distribution
Current
Historical
Upper Sacramento
Nevada
North Lahontan
California
Lower Sacramento
0 25 50 100 Miles
Sources: Esri, USGS, NOAA

Figure 31. Distribution of interior Redband in the United States. Map shows current Redband distribution (red lines) overlaid on estimated historical Redband distribution (light lines). Data are based mostly on the status assessment workshop in 2012, but in Oregon also includes distributions of known Redband populations that are isolated above barriers within drainages that have anadromous salmonids. (IRCT 2016).

The Conservation Strategy for Interior Redband, developed by state fish and wildlife agencies, federal agencies, Indian Tribes, and Trout Unlimited to provide a framework for long-term conservation of Interior Redband, explains:

> "Redband occupy a variety of freshwater habitats, from small streams to large rivers and lakes. Stream-dwelling forms live in a variety of vegetative and elevational biomes, ranging from high-desert streams in arid landscapes to forested montane streams. Their adaptation to such a wide range of environmental conditions may help explain why Redband remain the most widely distributed native salmonid in the Columbia River Basin (Thurow et al. 1997). However, many populations have declined in occurrence and abundance (Thurow et al. 1997), due largely to hybridization and competition with nonnative salmonids, and to land use that has resulted in habitat fragmentation, flow alteration, and degraded stream and riparian habitat.
>
> In the interior Columbia River Basin, numerous studies have been conducted at several spatial scales on the habitat preferences of Redband and Rainbow Trout in streams. In vegetated montane streams, the presence of Redband has been positively related to the abundance of pools and negatively related to stream gradient (Muhlfeld et al. 2001), whereas in lowland desert streams, Redband presence has been associated more closely with shaded reaches of stream that block solar radiation and contain cooler stream temperatures (Li et al. 1994; Zoellick 1999, 2004).
>
> Redband populations exhibit broad phenotypic diversity, including variable age-at-maturity, frequency and timing of spawning, seasonal timing and patterns of migration, longevity, habitat selection, temperature tolerance, and a host of other characteristics (Thurow et al. 2007). Life history traits of Redband are variable. At least three basic life history strategies have been described, based on how Redband use their available hydrologic network during their life cycle. Redband that migrate from lentic waters [*e.g.* lakes and reservoirs] to tributaries, mostly as a reproductive strategy, can express an adfluvial strategy. An example is the Kamloops Rainbow Trout that were historically present in Canadian lakes, Crescent Lake, Washington, and several isolated lake basins within the Northern Great Basin in Oregon (Moyle et al. 1989; Behnke 1992). Where Redband utilize both relatively larger streams and rivers and lower-order tributaries, they can be characterized as using a fluvial strategy. Redband with more restricted movements within stream networks are considered resident fish. Movement among habitats and populations may be an important mechanism for maintenance of genetic variability in populations (Leary et al. 1992) and for their persistence in variable environments (Rieman and Clayton 1997; Rieman and Dunham 2000). Local adaptation and selection for unique alleles

resulting from isolation may also contribute to total genetic variability in the species (e.g. Lesica and Allendorf 1995; Gamperl et al. 2002). . .”

(ICRT 2016 (footnote omitted)).

ODFW's Native Fish Status Report further explains that:
"The ability of a population to express multiple life history strategies is dependent on the extent of accessible high quality habitat. Access to a wide diversity of habitats including small streams suitable for spawning and large streams and lakes adequate for rearing large adults, provides a population with the opportunity to express a migratory life history. Populations that express both resident and migratory life histories have a greater ability to persist through drought years, (re)colonize new habitats, and mix with other populations."

(ODFW 2019).

Retaining adfluvial and fluvial life histories is desirable, in part, because those life histories produce larger fish and larger females are more fecund (i.e. produce more eggs) (Helfman et al. 1999). Having these life history present in a stream or river system provides resiliency for redband trout against drought. Resident redband trout are also desirable because they provide redundancy for redband trout populations allowing populations to repopulate areas downstream when mortality events occur.

In general, redband trout typically spawn in the spring when water temperatures are rising to above 6-7 °C (Schill et al. 2009, Behnke 2002), though some populations occupying large spring fed streams spawn almost year around because the water temperature is cold and consistent (Li et al. 2007). Eggs remain in gravel for 4-7 weeks (Sigler and Sigler 1987), hatching in late spring or early summer. Typically redband trout mature and spawn in 2-3 years, though males may mature one year earlier, and repeat spawning is common in many populations (Schill et al. 2009, Behnke 2002). Three year old females had better hatching success than two year-old females. [Reference needed].

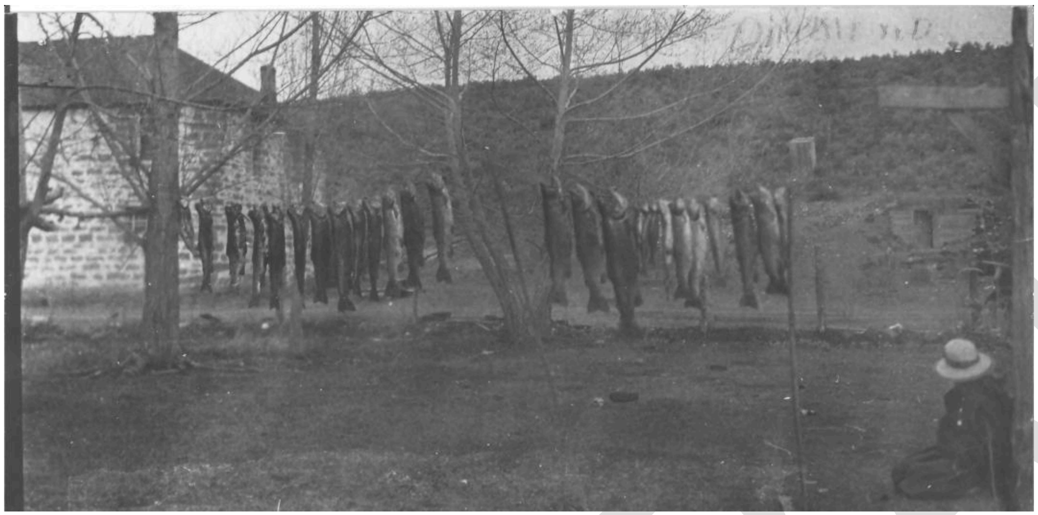
A 2012 range-wide inland/interior redband trout assessment found that the species occur in only 42% its estimated historical range, but it was not viewed as being at imminent risk of extinction (Muhlfeld et al. 2015); however, the long-term persistence of redband trout is dependent upon continued and strategic conservation efforts. (ICRT 2016).

b) Harney Basin redband trout

The Harney Basin has supported significant runs of large redband trout which appear to resemble steelhead in size. As reported in History of America, Harney County "[t]he rivers and creeks in the Blitzen Valley on the western slopes of Steens Mountain were suitable for good fishing in earlier years. One family of five is said to have camped on the Little Blitzen for a week and taken over 500 fish." Historic catches of fish are shown in figures x and x below. 28 to 30 inch long redband are reportedly even still caught in some parts of the basin.

Figure 32. Studio portrait of Dr. L.E. Hibbard with a display of four rainbow trout caught in the Blitzen River near Frenchglen, Oregon. The fish are strung on a slender branch. (Credit: Claire McGill Luce Western History Room, Harney County Library).

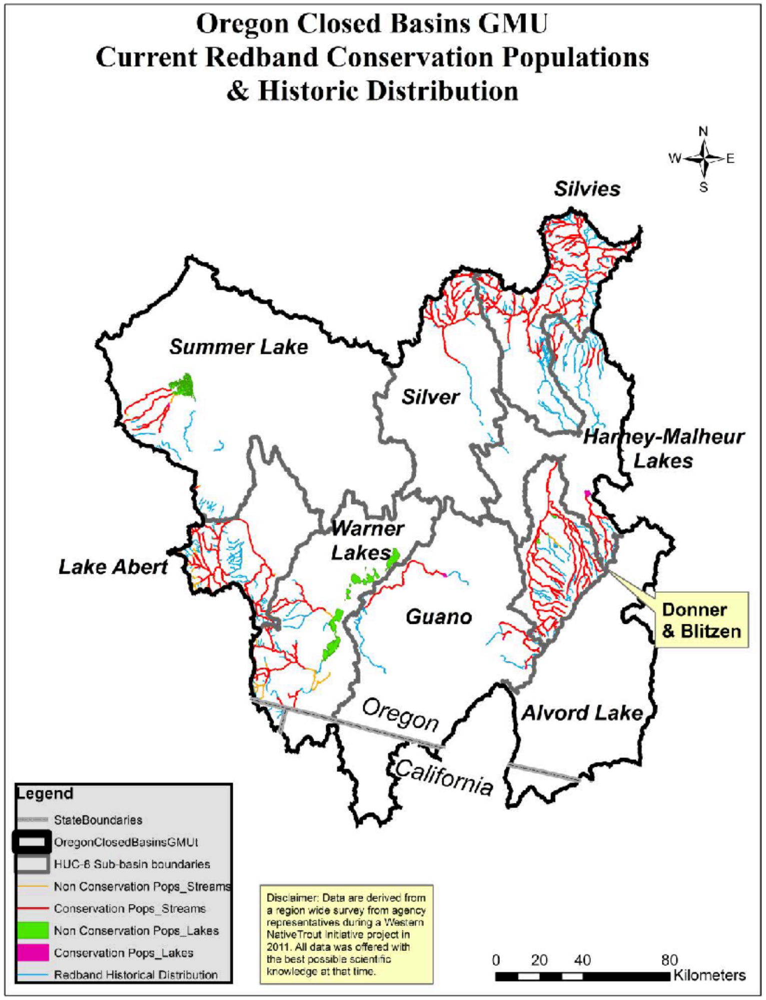
Figure 33. Historic photo taken in Diamond shows off a large catch (note this may be a mixed catch that includes redband, and also steelhead and Chinook salmon from the nearby South Fork of the Malheur River). (Credit: Claire McGill Luce Western History Room, Harney County Library).



Harney Basin redband trout are likely descendants of steelhead that travelled between the basin and the ocean via the Malheur, Snake and Columbia Rivers before the connection was lost. The skeleton of a fish estimated to be as large as 22 pounds was found on the Harney Lake playa. (Gehr, K.D., 1980).

The Harney Basin continues to provide important habitat for redband trout and includes four out of eight sub-basins within the Closed Basins of southeast Oregon that support redband trout. (ICRT 2016). Each of the four subbasins in the Harney Basin supports redband trout: Silvies River, Silver Creek, Harney-Malheur Lakes and Donner Und Blitzen. (*Id.*). The other Closed Basins of southeast Oregon hosting redband trout are Catlow Valley, Fort Rock, Chewaucan and Warner Lakes. (*Id.*) Redband distribution throughout the Closed

Figure 34. Oregon Closed Basins GMU Redband distribution based on 2011 Western Native Trout Initiative. (ICRT 2016).



The Harney Basin contains a significant amount of stream habitat currently inhabited by redband trout. It also contains a significant amount of habitat that is believed to have been historically occupied that is not occupied today shown in blue on figure 34.

In the Harney Basin, redband generally express one of three migratory strategies:

> "The stream resident form is the predominant life history strategy in all populations. Resident trout remain in smaller tributary streams for their entire life cycle, never out-migrating to larger more productive habitats to rear and mature. In small systems (less than 35 stream kilometers of fish distribution), such as the disjunct streams east of Burns (Rattlesnake, Prater, Cow, Coffeepot and Poison creeks), that do not have hydrologic connection to larger rivers and lakes, the habitat is capable of supporting only a resident life history type. Adfluvial and fluvial migratory forms are suspected to exist in most other populations when habitat conditions are suitable (Bowers et al. 1999). An adfluvial fish is one that spawns in small headwater streams and migrates to a large productive lake to rear and mature; a fluvial fish migrates to larger stream and river habitats to rear and mature before returning to its spawning reaches upstream. Currently, only redband trout in the Blitzen River have consistent access to Malheur Lake to rear. Redband trout in Silver Creek and Silvies River have the potential to express a migratory life history when conditions in connected rivers/streams allow."

(ODFW 2018 (ODFW's Draft Malheur Lakes Redband Trout Conservation Plan). This Public Draft plan was released for public comment. While it was not finalized because it was withdrawn for further work, it remains a valuable source of data and analysis regarding Harney Basin redband trout.

Additionally, redband trout in the isolated Riddle Creek watershed can express an adfluvial life history when conditions in Dry Lake are suitable.

Malheur Refuge is currently exploring management actions it can implement in the Blitzen Valley to promote the adfluvial redband life history by using two existing impoundments (Boca Lake and Krumbo Reservoir). Both of these bodies of water support trout and are connected to tributary streams (Krumbo, Bridge and Mud Creeks).

c) Redband status range-wide and in the Harney Basin
The U.S. Fish and Wildlife Service (USFWS) lists Interior Redband Trout (*Oncorhynchus mykiss spp*.), including those in the Harney Basin, as a Species of Concern under the Endangered Species Act. https://www.fws.gov/pacific/fisheries/IntRedbandTrout.cfm (visited 3-24-2019). USFWS explains that "[h]abitat loss, fragmentation of current habitat, isolation of existing populations, and hybridization with coastal rainbow trout and cutthroat trout are the principal issues facing inland redband trout." (*Id.*). To protect and conserve the interior redband trout, a Conservation Agreement was signed in 2014 by six states (including Oregon), four federal agencies (including

USFW, USFWS, BLM), one non-governmental organization and multiple tribal governments. The USFWS explains that "[a] Conservation Agreement is a cooperative effort among agencies and tribes to promote conservation of a species, reduce potential threats to the species, and potentially preclude future needs for listing under the ESA as threatened or endangered." (*Id.*).

ODFW reports that:

> "The U.S. Fish and Wildlife Service (USFWS) was petitioned in 1997 to list Great Basin redband trout in southern Oregon, northern California and northwest Nevada as threatened or endangered under the Endangered Species Act (Rhew 2007, USFWS 2000). The petition cited habitat degradation, fragmentation, and competition and predation by non-native fish as threats significant to redband trout. The petitioners argued that these threats, combined with prolonged periods of drought, have resulted in a decline in fish abundance that threatens their continued survival. The USFWS findings published in 2000 determined that listing was not warranted for two primary reasons. First, since the last regional drought redband trout abundance had rebounded and moderate densities were recorded throughout their distribution. Second, restoration activities in some basins had significantly improved aquatic habitat condition."

(ODFW 2018).

The Conservation Strategy for Interior Redband, developed by state fish and wildlife agencies, federal agencies, Indian Tribes, and Trout Unlimited, was developed to provide a framework for long-term conservation of Interior Redband. (ICRT, 2016). The report explains that "[i]mplementation of the Strategy is intended to be a collaborative and cooperative effort among signatories and other interested parties to support long-term conservation and management of the species throughout its range. Full implementation of the Strategy is expected to significantly reduce or eliminate threats to Redband populations and their ecosystems. This will substantially reduce the likelihood of its future listing under the Endangered Species Act of 1974, as amended (ESA), and implementation of the Strategy will also provide additional measures to enhance Redband populations and habitats that would not be required under the ESA. This document was designed to meet the requirements of a conservation strategy as specified in the USFWS policy for the evaluation of conservation efforts (68 FR 15100, 3/28/2003). These criteria are designed to ensure the certainty that the conservation effort will be implemented, and, when implemented, the conservation efforts will be effective." (ICRT 2016). The Strategy outlines key redband conservation measures for the Oregon Closed Basins.

For the Harney Basin, the intent of the Conservation Strategy for Interior Redband is to emulate ODFW's draft Malheur Lakes Redband Trout Conservation Plan. (ICRT 2016).

<u>State status</u>

ODFW reports that:

> "The Native Fish Status Report (NFSR, ODFW 2005) indicated that the aggregations of redband trout populations in Malheur Lakes are compromised and in need of conservation and restoration measures. Based on the assessment in the NFSR the Malheur Lakes redband trout is one of 51 fish species/population aggregates included on the state sensitive species list (ODFW 2008). This list identifies species, subspecies or populations that are facing one or more threats to their population and/or habitat. Malheur Lakes Basin redband trout populations are listed as sensitive, facing one or more threats to their populations and/or habitat. Implementation of appropriate conservation measures to address these threats may prevent them from declining to the point of qualifying for threatened or endangered species status.
>
> The NFSR (ODFW 2005) categorizes redband trout in the Malheur Lakes basin as potentially at risk of extinction due to habitat fragmentation and a relatively high number of disconnected populations. The Status Report also documented a lack of information pertaining to population level productivity. The lack of reliable data prevents the effective management and conservation of fish populations therefore the report considers a lack of information as a potential risk factor. The status assessment was based on interim criteria as outlined in the Native Fish Conservation Policy. This conservation plan develops a suite of metrics specific to interior trout species and available data in order to better assess population status (Chapter 2).
>
> Silvies River (Malheur Lakes) redband trout are designated as Strategy Species/Populations in ODFW's Oregon Conservation Strategy (ODFW 2006). A strategy species is defined as one that is 'low and declining' or otherwise at-risk. Strategy species are designated based on conservation need and opportunity and considered the state's highest conservation priority. The purpose of identifying these species is to prevent further decline and, where possible, to restore their populations."

(ODFW 2018).

d) Risk assessment for Harney Basin populations

ODFW (2018) risk assessment analysis found that of the nine redband trout populations in the Malheur Lakes SMU (*i.e.* Harney Basin), one was rated at low risk (viable), six at moderate risk, and two at high risk. Zaroban (1999) developed a tolerance classification for fish species of sensitive, intermediate and tolerant. Redband trout are classified as sensitive to degraded habitat (Esquival 2018), highlighting the importance of maintaining and restoring healthy habitat.

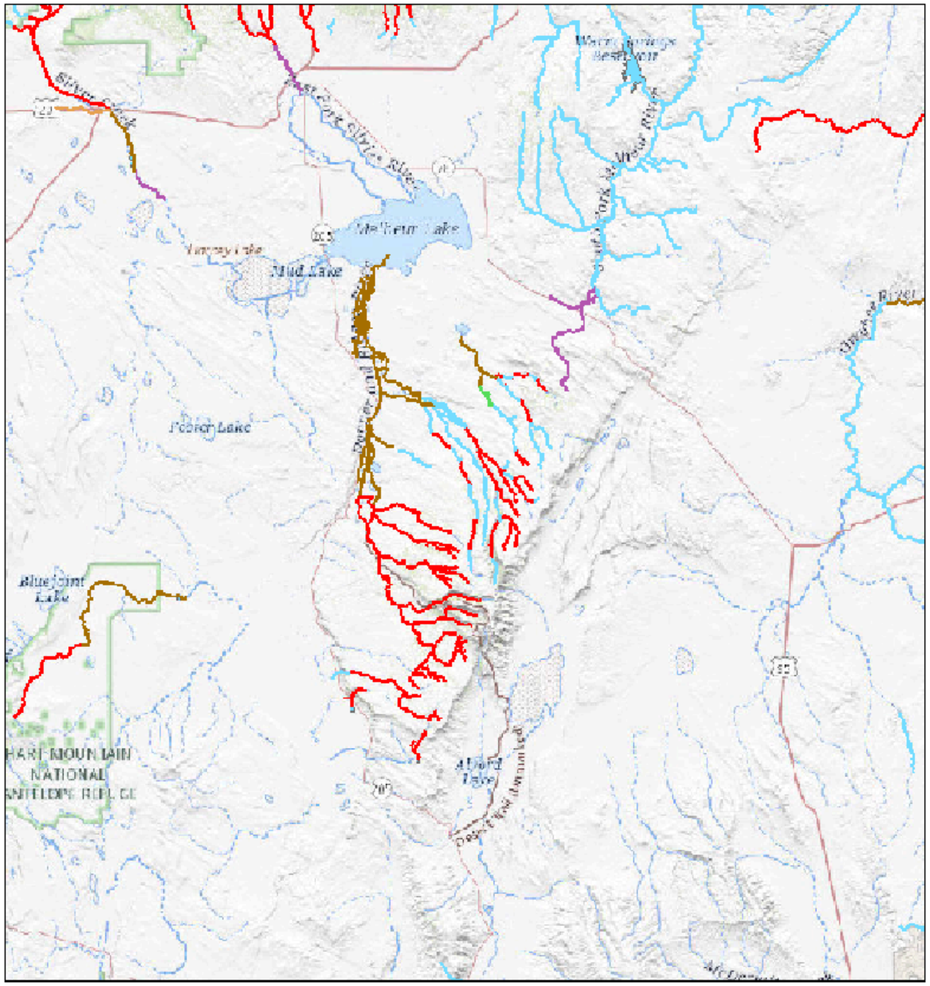
*Figure 35. Table 8. Population risk assessment results for Malheur Lakes SMU. Criteria scores in parentheses. * - Denotes core population. Strata denoted by shading. (ODFW, 2018)).*

Population	Abundance	Productivity	Spatial Structure	Diversity	Current Viability Risk
Silver	Very Low (5)	Low (4)	High (1)	Low (3.5)	***Moderate***
Silvies*	Very Low (5)	Low (4)	High (2.3)	Low (3.5)	***Moderate***
Poison	Very Low (5)	Low (4)	Moderate (2.7)	Low (4)	***Moderate***
Prater	High (1)	High (1)	High (1.7)	High (2)	***High***
Rattlesnake	Very Low (5)	Low (4)	High (2.3)	Low (3.5)	***Moderate***
Coffeepot	Moderate (3)	Moderate (3)	High (2)	Low (3.5)	***Moderate***
Cow	High (1)	High (0)	High (1)	Low (3.5)	***High***
Riddle	Very Low (5)	Moderate (3)	Moderate (2.7)	Low (4)	***Moderate***
Blitzen*	Very Low (5)	Very Low (5)	Low (3.7)	Very Low (5)	***Low***

The following maps show redband distribution and use in the Harney Basin.

Figure 36. Two maps showing redband trout distribution and use in the Harney Basin. (ODFW Data Viewer. https://nrimp.dfw.state.or.us/FHD_FPB_Viewer/index.html (Accessed July 20, 2023).

Oregon Fish Habitat Distribution & Barriers



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1:1,283,982

0 5 10 20 mi

0 12.5 25 50 km

- Redband Trout (lake)

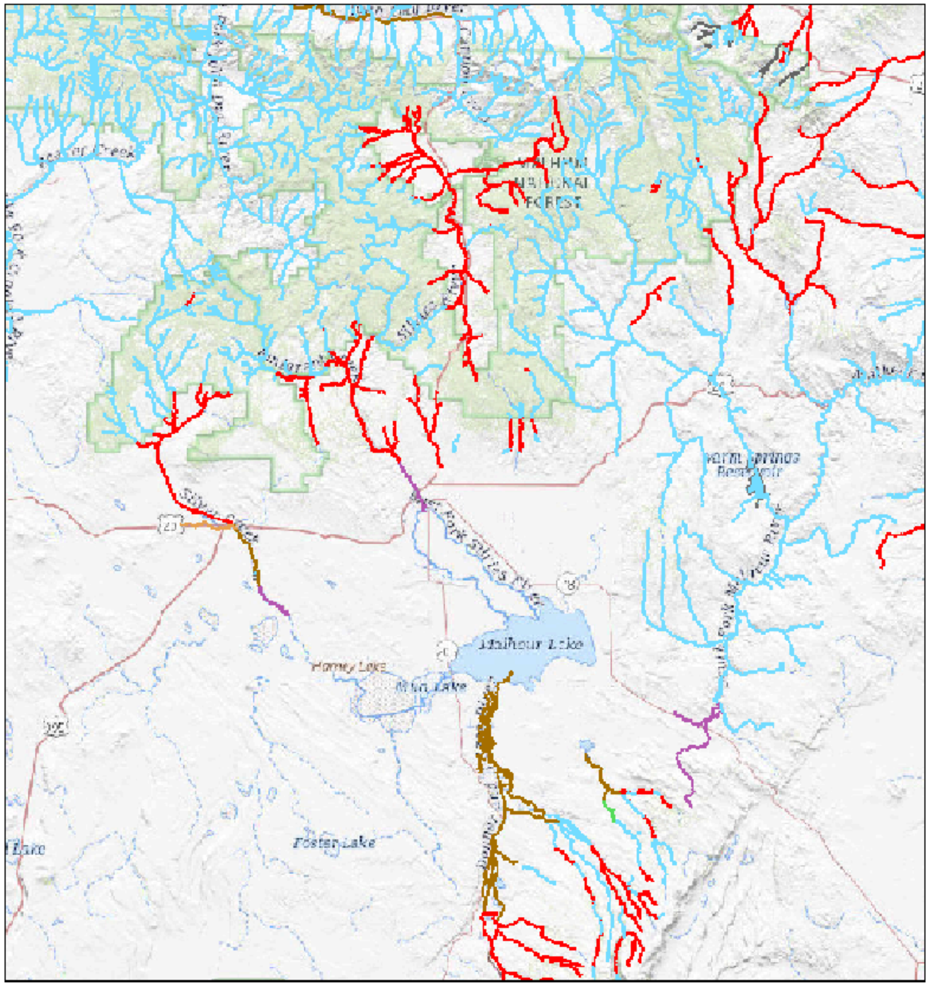
Redband Trout

- Foraging, Migration and Overwintering
- Historical
- Migration
- Rearing
- Resident, multiple uses
- Spawning
- Unknown

USGS TNM – National Hydrography Dataset. Data Refreshed July, 2023., ODFW, numerous state and federal natural resource agencies including tribes have contributed to the development of these data, USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program, Geographic

ODFW Web Map
ODFW

Oregon Fish Habitat Distribution & Barriers



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Redband Trout (lake)

Redband Trout

Foraging, Migration and Overwintering

Historical

Migration

Rearing

Resident, multiple uses

Spawning

Unknown

1:1,283,982

0 5 10 20 mi

0 12.5 25 50 km

USGS TNM – National Hydrography Dataset. Data Refreshed July, 2023., ODFW, numerous state and federal natural resource agencies including tribes have contributed to the development of these data, USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program, Geographic

ODFW Web Map
ODFW

ODFW (2018) (available upon request) contains data and analysis regarding redband troutin the Harney Basin and will be a good resource as strategies are developed.

Earlier fish surveys in the Harney Basin

Several earlier studies of fish distribution add to the picture. Fish in the Harney Basin were sampled as early as 1904 as part of the effort to determine the fish fauna of the lakes in southeastern Oregon with samples taken from the Malheur Lake basin. (Snyder, 1908). Samples were taken from Silvies River, Silver Creek and Warm Springs. This early work was primarily to determine the origin of the fish fauna. It seems likely that in some of these historical reports, rainbow trout found were actually what would today be called redband trout. A summary and references for some of the historical surveys is included in Appendix A.

Fish Passage Barriers, Connectivity to the Lakes, and Screening

Fish passage barriers, which include infrastructure such as dams and culverts, connectivity problems associated with low streamflows and poor water quality, and lack of functional fish screens on water diversions, can impact fish movement patterns and prevent or retard fish from accessing vital habitat. Removing a single migration barrier can deliver impressive benefits by improving access to fish habitat, while reconnecting that stream habitat can provide the access to habitats that fish need to flourish. (ODOT: https://www.oregon.gov/odot/geoenvironmental/pages/fish-passage.aspx (visited 7-02-2023)).

Fish Passage Barriers

Malheur Lake historically provided rearing habitat for adfluvial redband trout but that use has been significantly diminished because access to the lake has been impaired or eliminated by dams and diversions on the tributary streams (Silvies River, Blitzen River, Silver Creek and others) and the lake was colonized by carp (Cyprinus carpio). An adfluvial fish is one that spawns in small headwater streams and migrates to a large productive lake to rear and mature. Currently, only redband trout in the Blitzen River have consistent access to Malheur Lake to rear.

The Malheur National Wildlife Refuge has expended significant resources to provide access for redband trout to Malheur Lake by providing fish passage on the Blitzen River. Studies of migration and passage (Anderson 2009) suggest: “the majority of Blitzen redband trout migrated upstream of Page Dam to spawn and that most trout spawned in the mainstem and not the tributaries.” The Page Springs Gauging weir is a high priority fish passage barrier off refuge lands as identified by the ODFW Fish Passage Barrier Priority List (ODFW 2019).

The removal of this barrier is addressed in the Steens Mountain Cooperative Management and Protection Act of 2000 (PL 106-399). Section 302 § (4) states:”

REMOVAL OF DAM—The Secretary shall remove the dam located below the mouth of Fish Creek and above Page Springs if removal of the dam is scientifically justified and funds are available for such purpose."

To date the dam has not been removed. The Bureau of Land Management has funded an evaluation of the removal of the Page Springs dam. A design for the removal should be completed in 2023. The Steens Act may pose a complication because it says nothing in the Act allows for the violation of the Wilderness Act, which could mean the weir would need to be removed without mechanized means.

A proposal to provide fish passage at Dunn Dam is partially funded and awaiting potential full funding for 2023. With the completion of these two projects Donner und Blitzen River should have volitional fish passage throughout the lower reaches to Malheur Lake. To date the dam has not been removed.

Anderson and others (2009) have described the history of blockage of passage as: "Extensive channelization of the river and construction of diversion ditches throughout the valley occurred principally between 1910 and 1915. Although some diversion dams were likely constructed during this early period, the current diversion structures were constructed in the 1930s by the Civilian Conservation Corps (Hosford and Pribyl 1983). These dams had fish passage provisions, but the efficiency of the passage structures was likely poor, based on historical reports of trout attempting passage stacking up below the dams (Hosford and Pribyl 1983).

Figure 37. Table 9: Barrier Diversion Capacity for Structures providing water for the Malheur National Wildlife Refuge on the Blitzen River (USFWS 2013).

Structures	Number of Diversion Canals	Cubic Feet per Second
Page Springs	2	200
Old Buckaroo	1	10
Grain Camp	2	303
Busse	2	166
Dunn	2	84
Sodhouse	1	37
Total	10	800

Migration and passage of redband trout on the Blitzen River was studied in 1999/2000 by Roy and Roy and Bowers (per comm), 2007 and 2008 (Anderson, 2009; Anderson et al., 2009). The Anderson studies concluded: "the majority of Blitzen redband trout migrated upstream of Page Dam to spawn and that most trout spawned in the mainstem and not the tributaries. Roy and Roy and Bowers data suggested a similar pattern and their data even suggested there may be some spawning downstream of Page Springs dam. There were little data to suggest redband trout attempted to enter lower tributaries (e.g., Bridge and Mud creeks) even after newly installed passage was provided.

Roy, Roy and Bowers (Pers. Comm.), and Anderson, 2009 and Anderson et al., 2009 determined that upstream trout migration occurred from March to July, but the peak migration occurred during late April and early May. Anderson, 2009 and Anderson et al., 2009 identified passage problems at two of the three dams evaluated. The study recommended: "prioritizing fish passage at the Busse Dam and Grain Camp Dam for conservation and enhancement efforts." Since that time the U.S. Fish and Wildlife Service has constructed fish passage structures at both facilities and a fish trap for carp at the Grain Camp Dam. Malheur Refuge dams on the mainstem of the Blitzen River were constructed with passage (step-pool) by the Civilian Conservation Corps (CCC) in the 1930s. Dunn Dam, a former private dam on the mainstem of the lower Blitzen River also was constructed with fish passage. A major issue with ineffective passage at these dams were improper operation of the passage facilities.

According to Roy (Pers. Comm.), in 1999, the Refuge began implementing an extensive effort to improve fish passage in all of its existing main-stem dams by installing Denil Fishways (Denils) at several dams, reconnect tributary stream (McCoy, Bridge and Mud creeks) using Denils, screen diversion, prohibit carp from entering the Blitzen River from Malheur Lake or allowing "free movement" of carp in the river by adding a fish traps to the newly installed Denils, and managing the dams in a manner that prohibited carp from migrating upstream. In addition, the Refuge began implementing wetland/water management strategies that significantly reduced the populations of carp in the adjacent wetlands in the Blitzen Valley that served as spawning/rearing habitat for carp. These efforts reduced carp abundance in the river.

Roy 1999/2000, conducted a mark/recapture study using PIT tags to determine the number of redband trout migrating upstream during the spring spawn and to evaluate passage efficacy. The data suggested that as many as 4,000 individual fish migrated through the Refuge and that, if properly managed, the modifications (additions of Denils) to the existing CCC-era passage structures were effective at allowing fish passage.

ODFW's Fish Passage Priority List (2019) identifies 15 fish passage barriers in the Harney Basin as shown in Figure 38. More detailed information on these barriers is included as Appendix C.

Figure 38. Table 10. Fish Passage Priority List for the Harney Basin (ODFW 2019).

Owner	Barrier Name	Barrier Type	Stream Name	Species in need of passage at barrier and biological status	2019 Group Rank
BLM	Page Springs Gauging Weir	Dam	Donner und Blitzen River	Redband trout	Group 2
Unknown	Unknown 1.4 miles upstreaam of 5-mile dam	Dam	Silvies River	Redband trout	Group 3
ODFW	Yellow Jacket Dam	Dam	Yellowjacket Creek	Redband trout	Group 5
Unknown	Old Mill Dam	Dam	Silvies River	Redband trout (historical)	Group 7
Unknown	Fivemile Dam	Dam	Silvies River	Redband trout (historical)	Group 8
Ralph Eason	Fred Scott Reservoir	Dam	Indian Ford Creek	Redband trout	Group 15
Unknown	Silver Creek Dam	Dam	Silver Creek	Redband trout	Group 15
Unknown	Unknown	Dam	Dairy Creek	Redband trout	Group 15
ODFW	Chickahominy Reservoir	Dam	Chickahominy Creek	Redband trout	Group 15
Hammond Ranches	Kern Reservoir Dam	Dam	Dry Krumbo Creek	Redband trout	Group 15
Hoyt and Sons	Miller Reservoir (Harney)	Dam	Gould Creek	Redband trout	Group 15
Private	Little Kiger Creek Diversion	Dam	Little Kiger Creek	Redband Trout	Group 15
Siskiyou Field Institute	Alder Creek	Dam	Alder Creek	Redband trout	Group 15
Private	Kiger Creek Diversion	Dam	Kiger Creek	Redband trout	Group 16
Sagehen Land Company/Ketscher Cattle Co	Moon Reservoir	Dam	Silver Creek	Redband trout (historical)	Group 16

A 2014 Aquatic Restoration Environmental Assessment prepared by Malheur National Forest identifies existing culverts on the Malheur National Forest, including in the Harney Basin, that represent potential fish passage restoration needs and projects. (Malheur NF 2014). The number and location of many impediments to passage in the Harney Basin are undocumented in large part due to lack of access to private property. (*Id.*).

ODFW (2018) also contains additional information on barriers and partial barriers, including some information on culverts.

It should be noted that identifying and carrying out fish passage projects in the basin can be complicated by the prevalence and extent of non-native fish, especially carp, and the role that barriers may play in controlling spread of invasive fish. On the flip side, removing barriers can improve water quality, which may help control the spread of non-native fish.

Connectivity

Connectivity to the lakes has been affected by low flows and diversion structures. There has been significant alteration to the Lower Blitzen River, Silvies River, and Silver Creek. Between 1907 and 1913 several diversion dams were constructed for 17.5 miles along the Blitzen River with a multitude of ditches and dikes to manage water for agriculture purposes. Today, there are six active diversions on the Blitzen River (Table 2) that provide water for wildlife management on the Malheur Refuge (USFWS 2013). The Refuge maintains a minimum flow of 25 cfs below the diversions for aquatic life. The mean annual discharge of the Blitzen River at the USGS gage is estimated at 126 cfs. The average flow reaching the lake from the Blitzen River is approximately 83 cfs (USFWS 2013). Similarly, while the Silvies River has a larger catchment there is significantly less inflow to the lake than would occur under natural conditions primarily due to upstream diversions and withdrawals, resulting in the Silvies River delivering water to the lake only two or three times in a decade (USFWS 2013).

Inflow to Malheur Lake was studied for the 1972 and 1973 water years (Hubbard 1975). Hubbard found that inflow from the Silvies amounted to 1% to 33% of the surface flow into Malheur Lake during these two water years, reporting that "[a] comparison of flows monitored near the inflow points to the lake with records of flow for upstream gaging stations reflects the extensive diversions for irrigation in the Silvies River basin and for refuge management in the Donner und Blitzen River basin. Because of these diversions, a large quantity of the annual snowmelt runoff does not reach Malheur Lake." Hubbard determined that the inflow of water to Malheur Lake is from four principal sources; surface runoff from the Silvies and Donner und Blitzen Rivers, Sodhouse Spring on the periphery of the lake, and direct precipitation on the lake surface. During spring flooding, water enters the lake through the East Fork and West Fork of the Silvies River channels and at many points between the two channels. The Donner und Blitzen River contributed between 66% and 98% of the surface input to Malheur Lake in the same years.

Piper and Robinson (1932) likewise indicated that the Silvies River had little surface connection to Malheur Lake. They characterized the influence as: "Only infrequently is the run-off so large that water flows entirely across the subarea into Malheur Slough and thence into Malheur Lake."

Identifying connectivity issues across the basin is an important area needing more analysis.

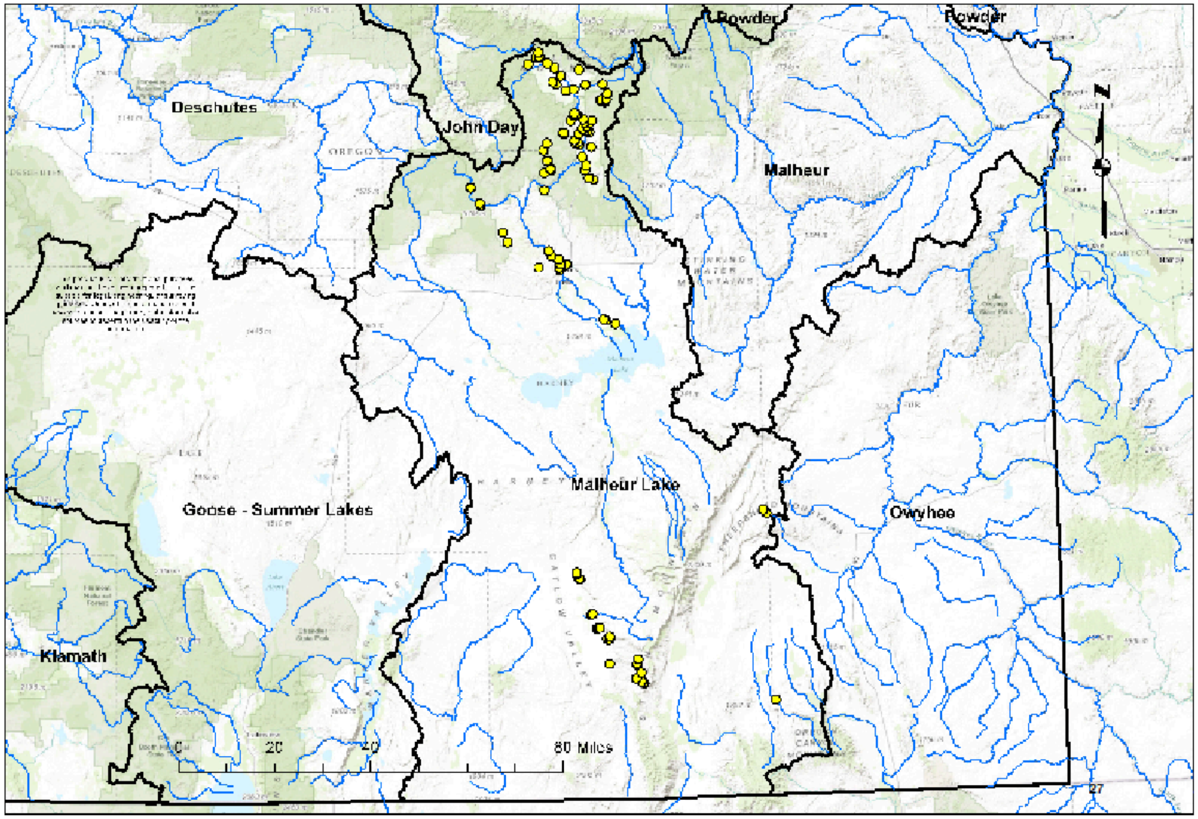
Screening

In addition to other barriers and impediments, unscreened diversions can also impact movement patterns (ODFW 2018). Further, diversions lacking fish screens can result in fish mortality and injury resulting from fish being diverted with the water into fields, ditches and machinery.

Oregon has long recognized the importance of fish screening, passing the first fish screening law 125 years ago in 1898. Unfortunately, many diversions remain unscreened. ODFW maintains a Priority Unscreened Diversion Inventory that identifies diversions at high priority for screening, based on criteria established by the legislature (ORS 498.306(14)).

In the Harney Basin, there are currently 99 diversions on the Priority Unscreened Diversion Inventory, which are shown on Figure 39 below. (List attached as Appendix B).

Figure 39. Map of Priority Unscreened Diversion Inventory locations for Malheur Lakes Basin. (https//efaidnbmnnnibpcajpcglclefindmkaj/https://www.dfw.state.or.us/fish/screening/docs/pudi/appendix_b_figure_14.pdf (visited July 15, 2023))



The Oregon Legislature established a pilot cost-share program for the construction, installation, and maintenance of fish screening devices at eligible diversions, which became permanent in 1995. (ORS 498.306). However, a significant challenge for a closed basin such as the Harney Basin is that the majority of funding has been provided through the Pacific Coastal Salmon Recovery Fund by the National Oceanic and Atmospheric Administration with expenditures largely restricted to anadromous salmon and steelhead. (*See*

ODFW website: https//efaidnbmnnnibpcajpcglclefindmkaj/https://www.dfw.state.or.us/fish/screening/docs/2015_Screens_final.pdf). ODFW's cost share program can partner on screening for non-anadromous species, but funds are very limited, coming mainly from the Sport Fishing License Surcharge fund and ODOT funds administered by ODFW. The USFWS Partners for Fish and Wildlife Program may be a good program to work with for technical and financial support.

In addition to the cost-share program, water users may be allowed a tax credit for 50 percent of their net costs of construction (ORS 315.138).

Amphibians

The Harney Basin is home to five species of amphibians: Sierran Chorus, Columbia Spotted Frog, Long-toed Salamander, Great Basin Spadefoot Toad, and the Western Toad. They rely on various aquatic habitats including streams and stream edges, but also wetlands, ponds and lakes that are described in other Step 2 reports. The distribution of these species across the Harney Basin is shown on the following maps.

Figure 40. Distribution of Malheur Lake Basin Amphibians. (Map created by ODFW, 2020).

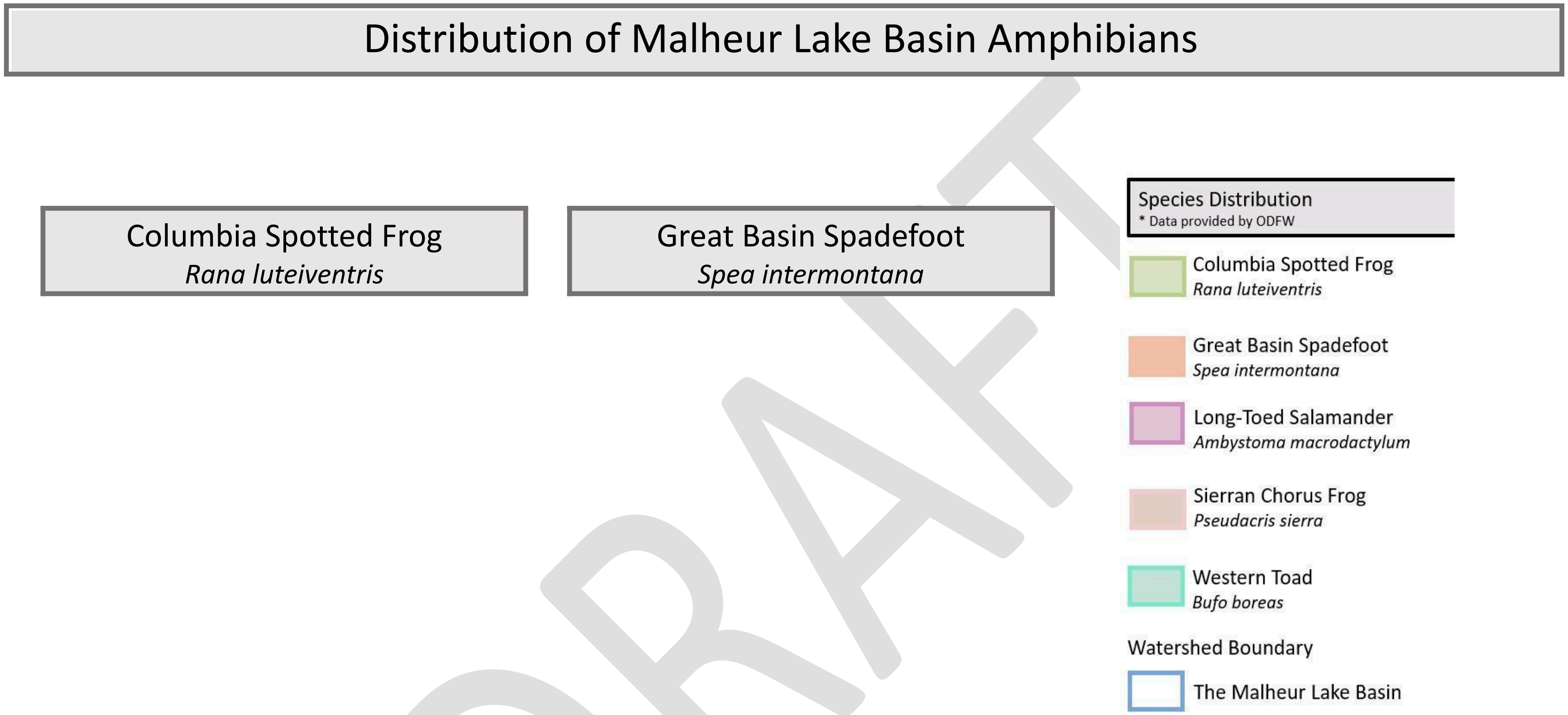
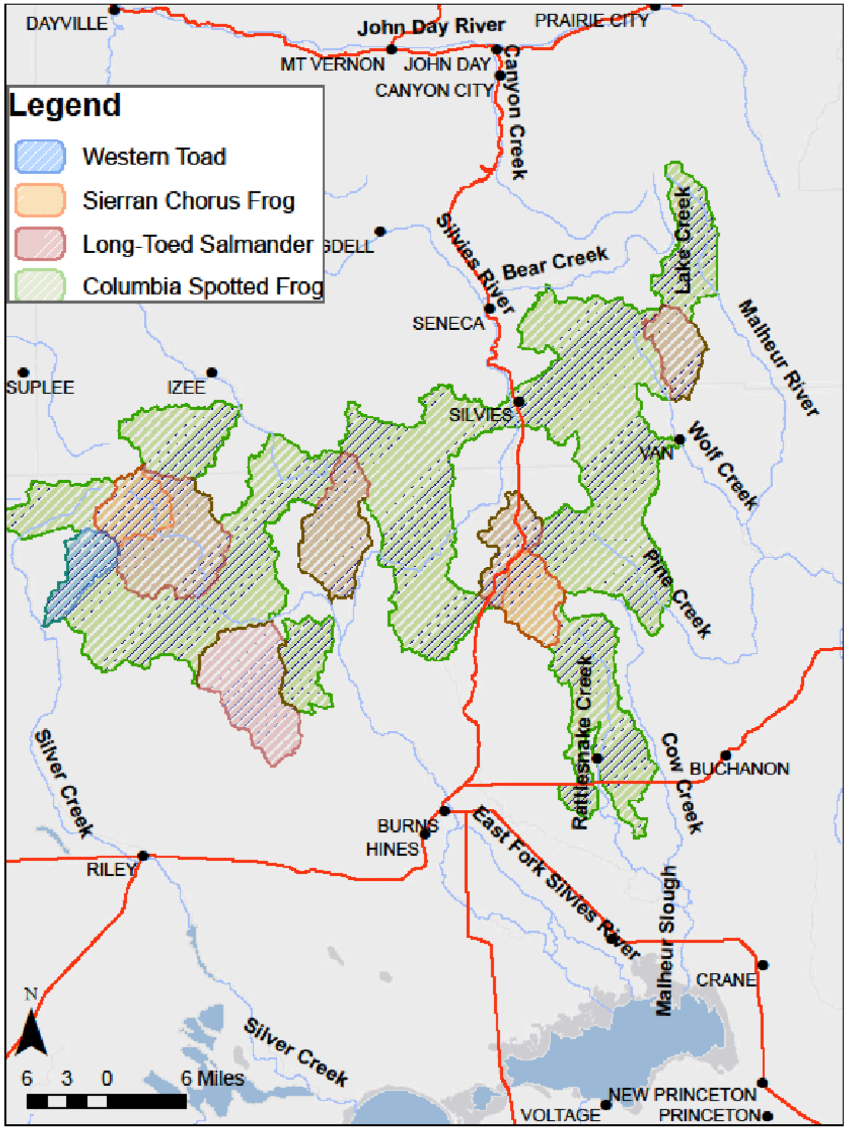


Figure 41. Amphibian distribution in the Silvies Basin. (Map created by ODFW, 2020).



The general life histories for each of these species are described as:

Sierran Chorus Frog (*Pseudacris sierra*): Found in forested habitat, desert oases, and agricultural lands. Breeds from November-July in marshes, lakes, ponds, roadside ditches, reservoirs, slow streams and ephemeral and permanent wetlands.

Columbia Spotted Frog (*Rana luteiventris*): Habitat is diverse and includes wetlands, ponds, lakes, springs, and low gradient streams, backwaters, and side channels. Often found in open areas and grasslands. Fragmented populations in southeastern Oregon may be experiencing species level differentiation. Breeds communally from February-July in shallow standing water, often above a grassy substrate.

Long-toed Salamander (*Ambystoma macrodactylum*): Frequents lowland plains and desert sagebrush as well as high elevation rocky lakes and meadows. Specific habitat includes the rocks and rotting logs near the water's edge of lakes, ponds, and slow-moving streams. Timing of reproduction is variable and based on elevation and latitude: the Harney Basin is near the southern portion of this species' range which means breeding can occur in fall, winter, and early spring. Adults may remain active year-round if the conditions are favorable. Long-toed salamander larvae may overwinter in the natal body of water depending on season and conditions.

Great Basin Spadefoot Toad (*Spea intermontana*): Habitat includes sagebrush lowlands, pinyon-juniper woodlands, and agricultural lands. Reproduction in the Great Basin region is typically associated with winter and spring rainfall. Breeding habitat consists of both ephemeral and permanent bodies of water.

Western Toad (*Bufo boreas*): A habitat generalist, this species occurs in desert streams and springs, montane forests and meadows, and grasslands and woodlands. Can be found in lakes, rivers, streams, ponds, and reservoirs. Active during the day at higher elevations and at night at lower elevations. Western toad will conceal themselves underground in rodent burrows or by burying. Lays eggs in the shallow margins of lakes/reservoirs, streams, and ponds within vegetation.

(Stebbins, R. C., 2003. Western Reptiles and Amphibians (3rd ed.). The Peterson Field Guide Series. Houghton Mifflin Co., New York, New York. 533p.).

Birds

Riverine systems and associated woody riparian habitat provide some of the most important nesting habitat in the Harney Basin. Woody riparian habitat provides nesting habitat for a large percentage of passerines (such as Eastern Kingbird, Yellow Warbler, Bullock's Oriole, and Song Sparrow) and for some cavity nesting, river associated species such as Common Merganser and Wood Ducks. A similar suite of species use the riverine woody riparian habitat as the meadow-associated woody riparian habitat. This includes Willow Flycatcher and Yellow-breasted Chat, both Oregon Conservation Strategy Species.

Several species of nesting birds in Harney County nest in river banks, including Northern Rough-Winged Swallow, a species experiencing regional declines according to the Partners in Flight Avian Conservation Assessment Database (Partners in Flight, 2023). While they are not specifically associated with rivers or woody riparian habitat, river condition can influence available nest habitat, as can later season run-off events that flood nest burrows.

Freshwater mussels

Freshwater mussels are a key organism native to many of Oregon’s rivers and streams. They provide substantial benefits to native fish, aquatic ecosystems, and humans, playing an important role in aquatic food webs, water quality, nutrient cycling, and habitat quality. Freshwater mussels must filter water to feed, breathe, and reproduce, and an individual mussel has been shown to filter up to 18 gallons of water per day. Additionally, dense mussel beds can substantially improve water clarity, increase the abundance and diversity of other invertebrates, including important food sources for juvenile salmonids, and can improve conditions for young lamprey. They also have a long history of cultural importance to Oregon's tribal communities.

Three genera of native freshwater mussel are present in the Harney basin: the western ridged mussel (*Gonidea angulata*), the western pearlshell (*Margaritifera falcata*), and floaters (*Anodonta sp.*). Historically, these species were found in at least 24 waterbodies across the four subwatersheds (Donner und Blitzen, Harney-Malheur Lakes, Silvies, and Silver). However, systematic surveys have not been undertaken and just 35% of observations date prior to 2000, suggesting that the species' historic ranges may not be well understood. Freshwater mussels inhabit rivers, creeks, lakes and reservoirs, ponds, and canals, including waterbodies like the Donner und Blitzen, the Malheur River, the Silvies River, multiple creeks, and even Malheur Lake (floaters last reported prior to 1950). Western pearlshell have generally been observed further upstream in basin waterbodies, while floaters and western ridged mussel more commonly co-occur in middle and lower sections of waterbodies.

The California and winged floaters, as well as the western ridged mussel, are Species of Greatest Conservation Need in Oregon's Conservation Strategy. Rangewide, the floaters and western ridged mussel have been ranked Vulnerable (IUCN Red List), with the western ridged mussel having declined across an estimated 43% of its range (Blevins et al. 2017).

In 2020, the western ridged mussel (*Gonidae angulate*) was petitioned for protection under the federal Endangered Species Act, and is currently undergoing review, as a result of the rangewide decline, as well as recent concerning observations of acute mass mortality events leading to major, sudden declines in mussel bed densities. More recent freshwater mussel surveys at the Malheur National Wildlife Refuge suggest a relatively large and reproducing population of western ridged mussel in the Blitzen River. As compared to observations of the species in the Silvies River and other basin streams, as well as to observations in other Oregon rivers, the Blitzen River is a significant regional population that warrants monitoring and protection.

Figure 42. Western ridged mussel from the Blitzen River. (Credit: USFWS).

The western ridged mussel requires the stable and consistent habitat conditions, including discharge and water-quality, that are characteristic of groundwater dependent ecosystems (Fisheries and Oceans Canada 2017). The western ridged mussel is only found in clear, low-turbidity habitats that are connected to perennially-flowing water for host fish availability. It is expected to live up to about 30 years and have been found to exceed 60 years of age. It can reach a size of about 5 inches in length. Like other native northwestern mussels it has a parasitic lifestage specific to certain fish species, which appear to be sculpin but more research is needed on this issue. They are highly sensitive to fluctuating water conditions or seasonal anoxia (Fisheries and Oceans Canada 2017).

Wetland and Riparian Plants and Plant Communities

There are a number of listings of plant communities and plant species of concern for Oregon that identify communities and species of concern for each County or region in Oregon. The Oregon Watershed Enhancement Board has identified Priority Ecological Systems and Rare or At-Risk Plant Communities as a part of their land acquisition program to identify priorities for conservation acquisition through purchase or easement.

Priority Ecological Systems

The priority ecological systems identified for the Oregon Closed Basins are all riparian or wetland systems. The priority ecological systems identified are:

- Alkaline wetlands
- Aquatic bed
- Foothill and lower montane riparian woodland
- Freshwater emergent marsh
- Lowland riparian forest and shrubland
- Subalpine or montane wet meadow

Each of these ecological systems is dependent on shallow surface water (either groundwater or surface flooding) and their condition could be used to reflect the conditions of water resources in the Harney Basin.

Rare or At-Risk Plant Communities

The Oregon Watershed Enhancement Board has also identified the following plant communities as rare or at-risk. A significant number of them are riparian or phreatophyte communities dependent on shallow ground water tables

Figure 43. Table 11: Rare or At-Risk Plant Communities of the Oregon Closed Basin (OWEB, 2004)

Plant Community	Habitat
Arroyo willow - creek dogwood	Riparian
Basin big sagebrush / basin wildrye	
Basin big sagebrush / needle-and-thread	

Basin wildrye bottomlands	Swales
Black cottonwood - white alder	Riparian
Black cottonwood / black hawthorn	Riparian
Black cottonwood / coyote willow	Riparian
Black cottonwood / pacific willow riparian	Riparian
Black hawthorn - woods rose	Riparian
Chokecherry	
Coyote willow - pacific willow	Riparian
Drummond willow / Holm sedge	Riparian wetland
Mountain alder - western birch	Riparian
Mountain big sagebrush / western needlegrass	
Quaking aspen / aquatic sedge	Riparian wetland
Quaking aspen / mountain alder - birch – currant	Riparian
Sandberg bluegrass - Lemmon alkaligrass	Wetland
Scouler willow	Riparian wetland
Silver sagebrush / basin wildrye	Sage depressions
Silver sagebrush / tufted hairgrass	Playas Wetlands
Tufted hairgrass - Douglas' sedge alkaline prairie	Wetlands Playas
Western birch - creek dogwood	Riparian
Wyoming big sagebrush - squawapple / idaho fescue	

Sensitive plant species have been identified in planning documents for federal land management agencies. The Three Rivers Management Plan has identified a number of plant species with protected status of to be used for assessment (Table 2).

Figure 44. Table 12: Plant Species of Concern in the Three Rivers Resource Management Plan (BLM, 1991)

Common Name	Scientific Name	Status	ORBIC
Deschutes milkvetch	Astragalus tegetarioides	C	1
Barron valley collomia	Collomia renacta	C	1
Cusick's buckwheat	Eriogonum cusickii	C	1
Prostrate buckwheat	Eriogonum procidium	S BLM	1
Bog's Lake Hedge Hyssop	Gratiola heterosepala	C	1
Shelly's ivesia	Ivesia rhyparia var. shellyi	C	1
Biddle's lupine	Lupinus biddlei	C	4
Cusick's lupine	Lupinus Cusickii	C	1
Oregon semaphoregrass	Pleuropogon oreganus	C & S	1
Columbia cress	Rorippa columbiae	C	1
Malheur wirelettuce	Stephanomeria malheurensis	LE & S	1
Leiburg's clover	Trifolium leibergii	C	1
Iodine bush	Allenrolfea occidentalis	A	2
Brandegee's onion	Allium brandegei	A	
Sierra onion	Allium campanulatum	A	
Rock melic	Melica stricta	A	2

Sensitive Species List (Three Rivers Resource Management Plan, 1991)
A = Assessment Species for BLM
C = Candidate for federal listing
LE = Federally Listed as Endangered
S = State Listed
S BLM = Sensitive Species for the Bureau of Land Management
ORBIC List (Oregon Biodiversity Information Center, 2019)
1 Threatened or Endangered Throughout Range
2 Threatened, Endangered or Extirpated from Oregon, but Secure or Abundant Elsewhere
3 Review

A detailed list of plant species that have records of occurrence in Harney County produced by the Oregon Biodiversity Program is an additional resource (OBIC, 2019). Many of the species identified are desert species. There are a number of wetland or shallow water dependent species as well.

Species dependent on shallow water
A few species might be of concern as they relate to water resource planning. The two species reflect the variable water regimes of the Harney Valley.

Columbia cress (*Rorippa columbiae*) is a low-growing perennial plant with stems usually 1-3 dm long. Along the Columbia River, phenology is tied to the water regime, which fluctuates widely within and between years; flowering has been reported from April to October. At the non-Columbia River sites, flowering appears to occur during a shorter period, typically June-August. Growth of *Rorippa columbiae* is largely determined by water availability. At Malheur Lake, (Harney County Oregon), reported population sizes vary considerably. Kaye and Massey (1991) reported five groups of plants covering an area over 3000 m2 in 1990. Nora Taylor (personal communication, 1992) described one large group of more than 500 stems and two smaller groups of plants. The records in the Oregon Natural Heritage Program Data Base indicate two large populations with more than 1000 stems each in 1991. Population size is apparently varying from year to year, probably depending on soil moisture.

Iodine Bush (Allenrolfea occidentalis) is a low-lying shrub of the southwestern United States and northern Mexico, where it grows in sandy, often salty, distinctly alkaline soils, such as desert washes and saline dry lakebeds. It is a common member of the alkali flat ecosystem.

Plant Species of Cultural Significance
Couture and others[2] have identified plant species of cultural use by the Burns Paiute tribal members (Couture et al., 1986). The species are listed in table 3 with highlights of riparian and phreatophyte plants.

Figure 45. Table 13: Plant Species of Cultural Significance to the Burns Paiute Tribe as reported by Couture et al.(1986)

Common Name	Scientific Name	General Use
Aspen	Populus tremuloides	bark for working hides
Biscuit root	Lomatium canbyi	Roots eaten

[2] Couture, Marilyn D., Mary F. Ricks, and Lucile Housley. 1986. Foraging Behavior of a Contemporary Northern Great Basin Population. Journal of California and Great Basin Anthropology 8(2):150-160.

Biscuit root	Lomatium cous	Roots eaten
Biscuit root	Lomatium gormanii	Roots eaten
Biscuit root	Lomatium hendersonii	Roots eaten
Biscuit root	Lomatium naudicauli	Roots eaten
Bitterroot	Lewesia redivia	Roots eaten
Black Hawthorne	Crataegus douglasii	Berries eaten
Blazing Star/Stickleaf	Mentzelia laevicaulis	Seeds eaten
Huckleberry	Vaccinium membranaceum V. ovalifolium	Berries eaten
Buckberry/Silver buffalo berry	Sheperdia argenta Eleagnus argentae	Berries eaten
Camas	Camassia quamash	Root eaten
Wild carrot	Perideridia bolanderi P. oregana	Root eaten
Indian Epos	Carum oreganum	Root eaten
Indian Ricegrass	Oryzosis hymenoides	Seeds eaten
	Sium cicutaefolium	Root eaten
Cattail	Typha latifolia	Seed, shoots and root eaten/building material
Chokecherry	Prunus virginiana P. subcordata	Berries eaten
Big headed clover	Trifolium macrocephalum	Nectar as a sweetener
Golden Currant	Ribes aureum	Berries eaten
Current	Ribes cereum	Berries eaten
Death camas	Zygadenus venenosus	Poisonous
Delphinium	Delphinium nuttalinum.	Poisonous
Dogbane	Apocynum cannabinum	Bark as cordage

Dogwood	Cornus stolonifera	Basketry
Great Basin Wild Rye	Elymus cinereus	
Juniper	Juniperus occidentalis	Berries eaten and used medicinally, wood for fuel, building material
Mariposa Lilly	Calochortus macrocarpus	Root eaten
Mint	Mentha arvensis	Leaves and stems as tea
Mountain Mahogany	Cercocarpus ledifolius	Digging sticks
Wild onion	Allium acuminatum A. macrum A. madidum	Roots, leaves and seeds eaten
Penstemon	Penstomen speciosus	Leaves medicinally
Pigweed	Chenopodium album	Seeds eaten
Ponderosa Pine	Pinus ponderosa	Seeds eaten, pitch as waterproof, cambium as sweetener
Pacific Wild Plum	Prunus subcordata	Fruit eaten
Rabbitbrush	Chrysothamus nauseosus	Sap chewed
Rose	Rosa woodsii	Hips (fruit) eaten and used as beads
Sagebrush	Artemisia tridentata	Bark for cordage and weaving; wood for fuel; leaves medicinally
Salt brush	Atriplex sp.	Seeds eaten
Seepweed Piaute weed	Suaeda intermedia S. depressa	Seeds eaten
Sunflower	Helianthes hookeri H. annus H. bolanderi	Seeds eaten

Balsam root	Balsamorhiza hookeri B. sagotta	Seeds and roots eaten
Tansy mustard	Descurainia sophia	Seeds eaten
Tobacco	Nicotiana attenuata	Smoked
Tule	Scirpus validus	Shoots and roots eaten, stems for cordage and basketry
Willow	Salix sp.	basketry
Wyethia/Mule's ears	Wyethia amplexicaulis	Stems and seeds eaten, leaves medicinally
Yampush	Perideridia bolanderi P. gairdneri	
Yarrow	Achillea millifolium	Leaves medicinally
Yellow bell	Fritillaria pudica	Roots eaten

Step 2 Data Gaps

Note: some of these are true data gaps, while others may reflect areas where data exist but was not readily available to us.

1) Uniform information on water quality (see the end of the Water quality section for more information and discussion).
2) Streamflow data: Continuous data from streamflow gages is patchily distributed in time and space. More consistent discharge information from additional gages would help provide a clearer hydrologic understanding of the streams and rivers in the basin.
3) Data for watersheds not included in OWRD's Surface Water Availability Reporting System (SWARS). SWARS is not available for significant parts of the Harney Basin, including some of the watersheds important to redband trout (Coffeepot, Cow, Prater, and Riddle Creeks).
4) Data on how much and at what points on the stream system water is being diverted and what the amount of consumptive use. Lack of data on consumptive uses in the basin, as highlighted by OWRD's SWARS tables. This data can help build a better picture of the timing and magnitude of streamflows.

5) Improved information on species distribution, including fish and fresh water mussels.
6) Specific species of host fish for Western Ridged mussel in the Harney Basin.
7) Riparian conditions (and the spatial relationship of those to populations of fish and other species of concern).
8) Impacts of watershed conditions across the Harney Basin on streamflow and water quantity.
9) Relation between water quality and invasive species distribution/spread.
10) Relation between streamflow, stream temperatures, and groundwater depletion.

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APPENDIX A – Summary of Historic Fish Surveys

An extensive survey of fish in the Malheur Lake basin was conducted by Pete Bisson (Bisson, 1969) who sampled some 45 locations in the basin (Figure 1).

Figure 46. Fish Sample Sites (from Bisson and Bond, 1971).

The work focused on native species but the list of species found (Table 1 from Bisson and Bond, 1971) includes each species by sample stream. Sampling in the Malheur River and John Day River was also conducted to compare the fish faunas.

Figure 47. Table 1 from Bisson and Bond (1971).

TABLE 1. KNOWN DISTRIBUTION OF FISHES IN THE HARNEY BASIN AND ADJACENT DRAINAGES.

	Richardsonius balteatus	*Gila bicolor*	*Acrocheilus alutaceus*	*Ptychocheilus oregonensis*	*Rhinichthys cataractae*	*Rhinichthys osculus*	*Catostomus columbianus*	*Catostomus macrocheilus*	*Salmo gairdnerii*	*Prosopium williamsoni*	*Cottus bairdi*
Malheur R.[1]	×	×	×	×	×	×	×	×	×	×	×
Blitzen R.	×	×		×	×	×	×		×	×	×
Kiger Cr.	×				×	×	×		×		×
McCoy Cr.	×					×			×		
Riddle Cr.	×					×			×		×
Smyth Cr.	×					×			×		
Silver Cr.	×	×			×	×	×		×		×
Chickahominy Cr.	×	×				×			×		
Warm Springs	×	×				×	×				
Poison Cr.						×			×		×
Devine Cr.						×			×		
Rattlesnake Cr.						×			×		×
Silvies R.	×	×	×	×	×	×	×	×	×		×
Scotty Cr.						×			×		×
Emigrant Cr.	×				×	×	×		×		
John Day R.[1]	×		×	×	×	×	×	×	×		×
So. Fk. John Day (above falls)[1]	×					×	×		×		

[1] Species present in adjacent drainages but not found in the Harney Basin include: Malheur R.—*Lampetra tridentata*, *R. osculus* (= *Rhinichthys umatilla*), *Cottus beldingi*, *Cottus confusus*, *Cottus rhotheus*; John Day R. —*Lampetra tridentata*, *Catostomus platyrhynchus*, *Salmo clarki lewisi* (possibly introduced), *Cottus beldingi*, *Cottus confusus*, *Cottus rhotheus*; So. Fk. John Day R. (above falls)—*Catostomus platyrhynchus*.

In the same timeframe, fish were sampled in the Silvies River during the feasibility evaluation of a water storage dam. The fish fauna was sampled and all species found are shown in Table 2.

Figure 48. Table 14: Fishes of the Silvies River Basin (Bond, 1971):

Common Name	Scientific Name	Source
black bullhead*	*Ictalurus melas*	(O.S.G.C., 1960, p. 110)
black crappie*	*Pomoxis nigromaculatus*	(U.S.D.I., Aug. 1957, p. 9)
Bluegill*	*Lepomis macrochirus*	(Thompson, 1968, p.2)
bridgelip sucker	*Catostomus columbianus*	(Bisson, 1969, Table 1)
brown bullhead*	*Ictalurus nebulosus*	(O.S.G.C., 1965)
Carp*	*Cyprinus carpio*	(U.S.D.I., 1957, p. 13)
channel catfish*	*Ictalurus punctatus*	(U.S.D.I., 1957, p. 13)
chiselmouth	*Acrocheilu alutaceus*	(Bisson, 1969, Table 1)
Kokanee*	*Oncorhynchus nerka*	(O.S.G.C., 1967, p. 56)
largemouth black bass*	*Micropterus salmoides*	(U.S.D.I., 1957, p. 13)
largescale sucker	*Catostomus macrocheilus*	(Bisson, 1969, Table 1)
longnose dace	*Rhinichthys cataractae*	(Bisson, 1969, Table 1)
mottled sculpin	*Cottus bairdi*	(Bisson, 1969, Table 1)
mountain whitefish	*Prosopium williamsoni*	(U.S.D.I., Aug. 1957, p. 9)
northern squawfish	*Ptychocheilus oregonensis*	(Bisson, 1969, Table 1)
pumpkinseed sunfish*	*Lepomis gibbosus*	(Thompson, 1968, p.2)
rainbow trout	*Salmo gairdneri*	(Bisson, 1969, Table 1)
redside shiner	*Richardsonius balteatus*	(Bisson, 1969, Table 1)
smallmouth bass*	*Micropterus dolomieui*	(O.S.G.C., 1968, p. 7)
speckled dace	*Rhinichthys osculus*	(Bisson, 1969, Table 1)
tui chub or roach	*Gila bicolor*	(Bisson, 1969, Table 1)
white crappie*	*Pomoxis annularis*	(Thompson, 1968, p.2)
yellow perch*	*Perca flavescens*	(U.S.D.I., 1957, p. 13)

* Introduced species

The Bond, 1971 sample locations include many of the tributaries of the Silvies River. The report lists species collected by region and sample site. The report summarizes the fish distribution as:

“Carp, tui chub, and occasionally the warm water game fish are present in Malheur Lake, region one.

Region two comprises the mouth of the Silvies River to the main channel of the river just southeast of Burns. Fishes which have been collected in this region include carp, chiselmouth, largescale sucker, northern squawfish and tui chub.

Region three is the main stem of the Silvies River upstream from Burns to the conjuncture of Emigrant Creek and the Silvies River as well as intervening tributaries. Fishes that have been collected there are bluegill, bridgelip sucker, bullhead catfish, carp, channel catfish, chiselmouth, crappie, large-mouth black bass, largescale sucker, northern squawfish, rainbow trout, redside shiner, tui chub, smallmouth bass and yellow perch.

Region four includes Emigrant Creek and tributaries and the Silvies River and tributaries upstream of Emigrant Creek to Silvies, Oregon. Fishes there include the bridgelip sucker, carp, chiselmouth, kokanee, largescale sucker, longnose dace, mottled sculpin, northern squawfish, rainbow trout, redside shiner and speckled dace.

Fishes that have been collected in region five, the Silvies River and tributaries north of Silvies, Oregon, include bridgelip sucker, chiselmouth, largescale sucker, northern squawfish, rainbow trout, redside shiner, and speckled dace.”

In 1984 and 1985 Oregon Department of Fish and Wildlife surveyed the Silvies River to develop information for the management of aquatic resources of the stream system. The data gathered was reported in 1991 (Hosford and Pribyl, 1991), including a list of species encountered during the two field seasons (Table 3).

Figure 49. Table 1 from Hasford and Pribyl (1991).

Table 1. Species cited by common name in the text. * indicates introduced species.

Common Name	Scientific Name
* Rainbow trout	*Oncorhynchus mykiss*
Redband trout	*Oncorhynchus* sp.
* Brook trout	*Salvelinus fontinalis*
* Smallmouth bass	*Micropterous dolomieui*
* Largemouth bass	*Micropterous salmoides*
* Bluegill	*Lepomis macrochirus*
* Pumpkinseed	*Lepomis gibbosus*
* White crappie	*Pomoxis annularis*
* Yellow perch	*Perca flavescens*
* Brown bullhead	*Ictalurus nebulosus*
Largescale sucker	*Catostomus macrocheilus*
Bridgelip sucker	*Catostomus columbianus*
* Common carp	*Cyprinus carpio*
Chiselmouth	*Acrocheilus alutaceus*
Speckled dace	*Rhinichthys asculus*
Longnose dace	*Rhinichthys cataractae*
Redside shiner	*Richardsonius balteatus*
Northern squawfish	*Ptychocheilus oregonensis*
Mottled sculpin	*Cottus bairdi*

Hosford and Pribyl (1991) indicates that smallmouth bass were introduced into the basin by Oregon Game Commission in 1956. Additional releases near Seneca and at the mouth of Stancliff Creek occurred in 1967. The report also acknowledges that rainbow trout were stocked in the river and hybrids between redband and rainbow trout were suspected. The report focused on game fish that included the native redband trout and introduced rainbow trout and smallmouth bass. They concluded that redband trout was the most abundant species in the upper tributaries and mainstem, trout numbers diminished downstream in the mainstem river. The evaluation by Hosford and Pribyl (1991) also conclude that tributaries are very important for spawning and rearing by rainbow trout.

In 1981 and 1982 the Blitzen River was sampled to determine the fish presence and population characteristics of the redband trout population in the Blitzen River system. The report (Hosford and Pribyl, 1985) has an excellent description of the history of water resource development and the history of fish use of Malheur Lake. The report includes the following table of species composition of fishes sampled in the Blitzen River at that time.

Figure 50. Table 1 from Hosford and Pribyl (1985) (Blitzen River Fish Abundance 1981-1982)

Table 1. Percentage species composition of fish found in the Blitzen River System.

Species	Malheur Refuge	Main stem Blitzen	Lower tributaries	Upper tributaries
Redband trout	13.2	42.2	77.2	86.7
Hatchery rainbow	3.1	0.0	0.0	0.0
Whitefish	4.0	8.1	1.6	0.0
Longnose dace	33.1	12.3	10.8	0.0
Mottled sculpin	39.3	37.4	15.4	13.3
Bridgelip sucker	3.7	0.0	0.0	0.0
Carp	2.1	0.0	0.0	0.0
Redside shiner	1.5	0.0	0.0	0.0

The work concluded that "carp are the greatest single factor in the loss of large redband trout in the Blitzen system…" The report recommended fish ladders be placed on dams on the refuge.

APPENDIX B – Priority Unscreened Diversion Inventory for Harney Basin

Figure 51. Table 15: Excerpt of the statewide Priority Unscreened Diversion Inventory (ODFW) showing the Harney Basin priority unscreened diversions.

Number	App #	Permit #	Certificate #	Transfer #	Water Right Type	POD #	Use	Maximum Rate of Diversion in CFS	Source	Tributary To:	Basin Name
31	0	0	0	E 1	SW	35	IRRIGATION	409.7914	SILVIES R	W FK SILVIES R	Malheur Lake
55 S	87463	54642	0		SW	1	SUPPLEMENTAL IRRIGATION	188.8939	A RESERVOIR	SILVIES RIVER	Malheur Lake
188 S	33340	26395	34599		SW	1	IRRIGATION	77.0013	SPROUL RESERVOIR	HAY CREEK	Malheur Lake
201 R	43162	4806	0		ST	1	SUPPLEMENTAL IRRIGATION	72.9106	BRIDGE CREEK	SILVIES RIVER	Malheur Lake
251 R	38082	3196	44467		ST	1	STORAGE	56.3072	HALL CREEK	SILVIES RIVER	Malheur Lake
342	0	0	0	E 1	SW	64	IRRIGATION	44.8300	SILVIES R	W FK SILVIES R	Malheur Lake
395 R	43162	4806	0		ST	1	SUPPLEMENTAL IRRIGATION	36.5756	BRIDGE CREEK	SILVIES RIVER	Malheur Lake
449	0	0	0		SW	2	POWER DEVELOPMENT	29.0000	SILVIES R	W FK SILVIES R	Malheur Lake
474 R	83532	12527	0		ST	1	RECREATION	26.5895	POISON CREEK/POISON RESERVOIR	HOUSE CREEK	Malheur Lake
520	0	0	0	E 1	SW	10	IRRIGATION	24.3900	SILVIES R	W FK SILVIES R	Malheur Lake
521	0	0	0	E 1	SW	10	IRRIGATION	24.3900	SILVIES R	W FK SILVIES R	Malheur Lake
522 R	2818	226	2065		ST	1	STORAGE	24.0629		SILVIES RIVER	Malheur Lake

560 S	4089	2366	3351		SW	1	IRRIGATION	21.0400	SILVIES RIVER	WEST FORK SILVIES RIVER	Malheur Lake
716	0	0	0	E 1	SW	63	IRRIGATION	13.7800	SILVIES R	W FK SILVIES R	Malheur Lake
909	0	0	0	E 1	SW	61	IRRIGATION	9.2100	SILVIES R	W FK SILVIES R	Malheur Lake
1019 S	4090	2367	9820		SW	1	IRRIGATION	7.5300	SILVIES RIVER	WEST FORK SILVIES RIVER	Malheur Lake
1110	0	0	0	E 1	SW	28	IRRIGATION	6.1250	SILVIES R	W FK SILVIES R	Malheur Lake
1199 S	1736	956	3324		SW	1	IRRIGATION	5.0000	EAST FORK SILVIES RIVER	MALHEUR LAKE	Malheur Lake
1241	0	0	0	E 1	SW	5	IRRIGATION	4.8500	SILVIES R	W FK SILVIES R	Malheur Lake
1245	0	0	0		SW	1	IRRIGATION	4.7900	E TROUT CR	SILVIES R	Malheur Lake
1246	0	0	0		SW	2	IRRIGATION	4.7900	TROUT CR	SILVIES R	Malheur Lake
1301	0	0	0	E 1	SW	13	IRRIGATION	4.3300	FLAT CR	SILVIES R	Malheur Lake
1348	0	0	0	E 1	SW	14	IRRIGATION	3.9400	TROUT CR	SILVIES R	Malheur Lake
1349	0	0	0	E 1	SW	15	IRRIGATION	3.9400	SILVIES R	W FK SILVIES R	Malheur Lake
1402	0	0	0		SW	1	IRRIGATION	3.5600	CAMP CR	SILVIES R	Malheur Lake
1438 S	1420	681	1052		SW	1	IRRIGATION	3.3600	BEAR CREEK	SILVIES RIVER	Malheur Lake
1515 E	108	4	840		SW	1	IRRIGATION	3.0100	BEAR CREEK	SILVIES RIVER	Malheur Lake
1577 S	3364	2095	75560		SW	1	IRRIGATION	2.9000	SILVIES RIVER	WEST FORK SILVIES RIVER	Malheur Lake
1583 S	2011	1033	1304		SW	1	IRRIGATION	2.8800	LITTLE SCOTTY CREEK	SCOTTY CREEK	Malheur Lake

1607	0	0	0		SW	2	IRRIGATION	2.8000	MOUNTAIN CR	SILVIES R	Malheur Lake
1615 E	4290	242	2920		SW	1	IRRIGATION	2.7400	BEAR CREEK	SILVIES RIVER	Malheur Lake
1642 S	38194	28501	44466		SW	2	IRRIGATION	2.6600	BUFFALO L RESERVOIR	HALL CREEK	Malheur Lake
1643 S	38194	28501	44466		SW	1	SUPPLEMENTA L IRRIGATION	2.6600	HALL CREEK	SILVIES RIVER	Malheur Lake
1721	0	0	0	E 1	SW	3	IRRIGATION	2.5000	CAMP CR	SILVIES R	Malheur Lake
1722	0	0	0	E 1	SW	4	IRRIGATION	2.5000	SILVIES R	W FK SILVIES R	Malheur Lake
1754	0	0	0	E 1	SW	8	IRRIGATION	2.4400	BRIDGE CR	SILVIES R	Malheur Lake
1769 R	3653	278	2062		ST	1	STORAGE	2.4063	JIMMY CREEK	SILVIES RIVER	Malheur Lake
1770 R	3293	258	1254		ST	1	STORAGE	2.4063	DAMON CREEK	SILVIES RIVER	Malheur Lake
1774	0	0	0	E 1	SW	9	IRRIGATION	2.4000	POISON CR	HOUSE CR	Malheur Lake
1798 S	5926	3663	2793		SW	1	IRRIGATION	2.3500	UNNAMED STREAM	SILVIES RIVER	Malheur Lake
1810	0	0	0	E 1	SW	6	IRRIGATION	2.3300	COTTONWOOD CR	SILVIES R	Malheur Lake
1811	0	0	0	E 1	SW	7	IRRIGATION	2.3300	SILVIES R	W FK SILVIES R	Malheur Lake
1889	0	0	0		SW	3	IRRIGATION	2.1900	TROUT CR	SILVIES R	Malheur Lake
1912 R	85466	13612	0		ST	1	MULTIPLE PURPOSE	2.1175	UNNAMED STREAM	SILVIES RIVER	Malheur Lake
1913 R	85466	13612	0		ST	1	MULTIPLE PURPOSE	2.1175	UNNAMED STREAM	SILVIES RIVER	Malheur Lake
1923	0	0	0		SW	1	IRRIGATION	2.0900	HALL CR	SILVIES R	Malheur Lake

1924	0	0	0		SW	2	IRRIGATION	2.0900	THORN CR	SILVIES R	Malheur Lake
1991 S	8867	5815	4792		SW	1	LIVESTOCK	2.0000	RIM ROCK SPRINGS	SILVIES RIVER	Malheur Lake
1992	0	0	0		SW	1	IRRIGATION	2.0000	FOLEY SL	SILVIES R	Malheur Lake
1993	0	0	0	T 9271	SW	1	IRRIGATION	2.0000	SILVIES RIVER	WEST FORK SILVIES RIVER	Malheur Lake
1994 S	742	347	884		SW	1	IRRIGATION AND DOMESTIC	2.0000	ROARING SPRING CREEK	EMIGRANT CREEK	Malheur Lake
1995 S	418	230	1632		SW	1	IRRIGATION	2.0000	JOHNSON RESERVOIR	THOMPSON GULCH	Malheur Lake
2056	0	0	0	T 8922	SW	2	IRRIGATION	1.9670	SILVIES RIVER	WEST FORK SILVIES RIVER	Malheur Lake
2068	0	0	0		SW	1	IRRIGATION	1.9500	SILVIES R	W FK SILVIES R	Malheur Lake
2079 R	86212	14193	0		ST	1	MULTIPLE PURPOSE	1.9250	FOLEY SLOUGH	EMBREE SLOUGH	Malheur Lake
2080 R	86212	14193	0		ST	1	MULTIPLE PURPOSE	1.9250	FOLEY SLOUGH	EMBREE SLOUGH	Malheur Lake
2081	0	0	0		SW	5	IRRIGATION	1.9200	PAINE CR	FLAT CR	Malheur Lake
2082	0	0	0		SW	3	IRRIGATION	1.9200	FLAT CR	SILVIES R	Malheur Lake
2083	0	0	0	T 8922	SW	1	IRRIGATION	1.9100	A DITCH	SILVIES RIVER	Malheur Lake
2092	0	0	0		SW	1	IRRIGATION	1.8800	BRIDGE CR	SILVIES R	Malheur Lake
2093 E	1748	115	1400		SW	1	IRRIGATION	1.8800	SILVIES RIVER	WEST FORK SILVIES RIVER	Malheur Lake
2101	0	0	0		SW	2	IRRIGATION	1.8400	COTTONWOOD CR	SILVIES R	Malheur Lake
2102	0	0	0		SW	1	IRRIGATION	1.8400	SILVIES R	W FK SILVIES R	Malheur Lake

2140	0	0	0		SW	1	IRRIGATION	1.7900	BRIDGE CR	SILVIES R	Malheur Lake
2152 S	743	348	1083		SW	1	IRRIGATION AND DOMESTIC	1.7700	EMIGRANT CREEK	SILVIES RIVER	Malheur Lake
2153	0	0	0	T 10892	SW	6	IRRIGATION	1.7700	JENKINS CREEK	LUCE CREEK	Malheur Lake
2154	0	0	0	T 10892	SW	9	IRRIGATION	1.7700	MOTHERS CREEK	WYMER CREEK	Malheur Lake
2155	0	0	0	T 10892	SW	8	IRRIGATION	1.7700	LUCE CREEK	WYMER CREEK	Malheur Lake
2180 S	20295	15832	34345		SW	2	IRRIGATION	1.7200	LITTLE SKULL CREEK	SKULL CREEK	Malheur Lake
2238	0	0	23511		SW	3	IRRIGATION, LIVESTOCK AND DOMESTIC	1.5625	ECHART CREEK	SKULL CREEK	Malheur Lake
2239	0	0	23511		SW	2	IRRIGATION, LIVESTOCK AND DOMESTIC	1.5625	LITTLE SKULL CREEK	SKULL CREEK	Malheur Lake
2240	0	0	23511		SW	1	IRRIGATION, LIVESTOCK AND DOMESTIC	1.5625	ECHART CREEK	SKULL CREEK	Malheur Lake
2885 S	5289	3233	1989		SW	1	IRRIGATION	0.7500	COTTONWOOD CREEK	SKULL CREEK	Malheur Lake
3402 R	33788	2388	78752		ST	1	LIVESTOCK	0.1083	UNNAMED STREAM/DEER CAMP RS	SKULL CREEK	Malheur Lake
3425	0	0	0	E 1	SW	21	IRRIGATION	0.0300	SILVIES R	W FK SILVIES R	Malheur Lake
3426 R	68570	11124	74551		ST	1	LIVESTOCK	0.0229	COTTONWOOD CR/MARES	SKULL CREEK	Malheur Lake
3429 S	65623	50340	79186		SW	5	LIVESTOCK	0.0200	RIMROCK SPR	SILVIES RIVER	Malheur Lake

3430 S	60865	48518	82005		SW	1	DOMESTIC	0.0200	A SPRING	EMIGRANT CREEK	Malheur Lake
3431 S	65634	49283	77093		SW	2	LIVESTOCK	0.0200	FL SPRING	MYRTLE CREEK	Malheur Lake
3432 S	65623	50340	79186		SW	4	LIVESTOCK	0.0200	SOUTH LIL SAGE HEN SPR	SILVIES RIVER	Malheur Lake
3433 S	65623	50340	79186		SW	6	LIVESTOCK	0.0200	LITTLE SAGE HEN CREEK	SILVIES RIVER	Malheur Lake
3434 S	65623	50340	79186		SW	1	LIVESTOCK	0.0200	3 E SPR	SILVIES RIVER	Malheur Lake
3435 S	65634	49283	77093		SW	1	LIVESTOCK	0.0200	MYRTLE SPRING	MYRTLE CREEK	Malheur Lake
3436 S	71104	52776	0		SW	1	LIVESTOCK	0.0200	A SPRING	MYRTLE CREEK	Malheur Lake
3437 S	65649	50343	77197		SW	4	LIVESTOCK	0.0200		ANTELOPE CREEK	Malheur Lake
3438 S	65649	50343	77197		SW	1	LIVESTOCK	0.0200	SALT SPRING	ANTELOPE CREEK	Malheur Lake
3439 S	65649	50343	77197		SW	5	LIVESTOCK	0.0200	COW SPR	ANTELOPE CREEK	Malheur Lake
3440 S	65649	50343	77197		SW	3	LIVESTOCK	0.0200	SCAB SPRING	ANTELOPE CREEK	Malheur Lake
3441 S	65649	50343	77197		SW	2	LIVESTOCK	0.0200	ADDY SPRING	ANTELOPE CREEK	Malheur Lake
3442 S	65649	50343	77197		SW	6	LIVESTOCK	0.0200	RIBES SPRING	ANTELOPE CREEK	Malheur Lake
3443 S	37007	27784	86070		SW	4	IRRIGATION	0.0200	MOTHERS CREEK	WYMER CREEK	Malheur Lake
3444 S	37007	27784	86070		SW	1	IRRIGATION	0.0200	MOTHERS CREEK	WYMER CREEK	Malheur Lake
3493 R	68571	11033	66451		ST	1	LIVESTOCK	0.0005	COTTONWOOD CREEK	SKULL CREEK	Malheur Lake

Appendix C - ODFW Fish Passage Priority List for Harney Basin

Count	ODFW Fish District	Owner	Barrier ID	Barrier Name	Barrier Type	Stream Name	Species in need of passage at barrier and biological status	T & E Score	Ave. Hab. Quant.	Habitat Quality	# NMF Species	Habitat Quality	Auto Up	Auto Down	Psg. Level	Score	2019 Group Rank
1	Southeast District	BLM	4016	Page Springs Gauging Weir	Dam	Donner und Blitzen River	Redband trout	0.5	70.0	100.0	1.0	6.0	2.0	0.0	3.0	425.0	Group 2
2	Southeast District	Unknown	32814	Unknown 1.4 miles upstreaam of 5-mile dam	Dam	Silvies River	Redband trout	0.5	359.0	130.0	1.0	2.0	2.0	0.0	4.0	273.0	Group 3
3	Southeast District	ODFW	18418	Yellow Jacket Dam	Dam	Yellowjacket Creek	Redband trout	0.5	3.8	40.0	1.0	4.0	0.0	0.0	5.0	195.0	Group 5
4	Southeast District	Unknown	32815	Old Mill Dam	Dam	Silvies River	Redband trout (historical)	0.0	10.6	55.0	1.0	3.0	1.0	0.0	4.0	167.0	Group 7
5	Southeast District	Unknown	4017	Fivemile Dam	Dam	Silvies River	Redband trout (historical)	0.0	360.6	130.0	1.0	1.0	1.0	1.0	5.0	150.0	Group 8
6	Southeast District	Ralph Eason	18175	Fred Scott Reservoir	Dam	Indian Ford Creek	Redband trout	0.5	15.7	55.0	1.0	1.0	0.0	0.0	5.0	90.0	Group 15
7	Southeast District	Unknown	12434	Silver Creek Dam	Dam	Silver Creek	Redband trout	0.5	62.8	85.0	1.0	1.0	0.0	1.0	4.0	88.0	Group 15
8	Southeast District	Unknown	26270	Unknown	Dam	Dairy Creek	Redband trout	0.5	5.7	40.0	1.0	1.0	0.0	0.0	5.0	75.0	Group 15
9	Southeast District	ODFW	18303	Chickahominy Reservoir	Dam	Chickahominy Creek	Redband trout	0.5	16.7	55.0	1.0	1.0	0.0	1.0	5.0	75.0	Group 15
10	Southeast District	Hammond Ranches	18258	Kern Reservoir Dam	Dam	Dry Krumbo Creek	Redband trout	0.5	6.5	40.0	1.0	1.0	0.0	0.0	5.0	75.0	Group 15
11	Southeast District	Hoyt and Sons	18112	Miller Reservoir (Harney)	Dam	Gould Creek	Redband trout	0.5	3.5	40.0	1.0	1.0	0.0	0.0	5.0	75.0	Group 15
12	Southeast District	Private	46464	Little Kiger Creek Diversion	Dam	Little Kiger Creek	Redband Trout	1	12	55	1	1	0	0	3	68.0	Group 15
13	Southeast District	Siskiyou Field Institute	18522	Alder Creek	Dam	Alder Creek	Redband trout	0.5	9.6	40.0	1.0	1.0	0.0	0.0	4.0	67.0	Group 15
14	Southeast District	Private	46465	Kiger Creek Diversion	Dam	Kiger Creek	Redband trout	0.5	2.1	25.0	1.0	1.0	0.0	0.0	3.0	50.0	Group 16
15	Southeast District	Sagehen Land Company/ Ketscher Cattle Co	18438	Moon Reservoir	Dam	Silver Creek	Redband trout (historical)	0.0	6.7	40.0	1.0	1.0	0.0	1.0	5.0	45.0	Group 16