Malheur River Subbasin Assessment and Management Plan

For Fish and Wildlife Mitigation

Appendix A, Part 2 – Aquatic Assessment

Malheur Watershed Council

And

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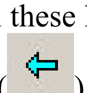
Appendix A, Part 2 –Assessment Aquatic

List of Figures

List of Tables

1 INTRODUCTION

The Malheur River Subbasin Assessment and Management Plan for Fish and Wildlife Mitigation is comprised of several documents. Because of the size of the documents the primary documents are further divided into sections for the purpose of saving as electronic files. This document, the Aquatic Assessment, provides the detail on aquatic species within the subbasin, current status, and limiting factors. Other sections of the report include the Management Plan (of which this is an appendix), which provides a summary of the assessment and inventory and describes the strategies needed to protect and restore fish and wildlife habitats within the subbasin. Two other sections of Appendix A are the Subbasin Overview, which provides background information on the general subbasin characteristics and water resources; and the Terrestrial Assessment, which provides the detail on terrestrial species within the subbasin, current status, and limiting factors. An additional supporting document, the Inventory Document (Appendix B), provides a summary of and an assessment of existing programs implemented in the subbasin to protect and restore fish and wildlife habitats. All references are included in a separate document. Finally, the Qualitative Habitat Assessment (QHA) spreadsheets are provided as separate documents for anyone who would like to look deeper into the mechanics of the QHA analysis, however, they are not required for the purposes of reviewing the overall plan.

Note to Reviewers: To facilitate the electronic review of this document we have used hyperlinks to all figures, tables, and other sections of the document. To easily see where these hyperlinks have been inserted please choose **Tools** > **Options** > and on the "**View**" tab choose "always" under "Field Shading". All of the live fields will then be highlighted like this. Clicking on these hyperlinks will take you to that item in the document. Use the Back Arrow on the toolbar () to return to your original location. The Back Arrow is on the Web toolbar. To open the Web toolbar, place your cursor anywhere over the toolbar in Word, and right-click the mouse. When the menu pops up, make sure that the Web toolbar is enabled.

2 FOCAL SPECIES CHARACTERIZATION AND STATUS

2.1 Native and Non-native Fish and Wildlife Species of Ecological Importance

Sixteen species of fish historically occurred, or have been suspected to have occurred, within the Malheur Subbasin (Table 1). A mix of salmonids and native nongame fish inhabited the Subbasin with each species dominating in its favored habitat niche. The North Fork and Upper Malheur Rivers that drain from Table Rock and the Strawberry Mountains, respectively, were probably the most important spawning and rearing tributaries in the Subbasin for most anadromous salmonids. Anadromous salmonids were blocked from the watershed by dams early in the 20th century, leaving redband trout and bull trout as the major focus of fisheries management (NWPPC 2000). Therefore, the Malheur Subbasin coalition have selected spring Chinook salmon, redband trout, and bull trout as aquatic focal species for the Malheur River Subbasin based on their cultural, biological, and esthetic value.

2.1.1 Pacific lamprey

Another anadromous species that may have been present historically in the Malheur River is the Pacific lamprey. It is known to have existed in the Owyhee and Snake Rivers and may have been taken as a food fish by Native Americans (Hanson et al. 1990). Construction of the dams on the Malheur River and Snake River would have eliminated this species from the Subbasin.

2.1.2 Mountain whitefish

Mountain whitefish are another cold water game fish that occur in sections of the upper North Fork and upper Malheur River, Crane Creek, and Big Creek where the channel is relatively large, deep pools are common, and water quality is good. The populations in the North Fork and Upper Malheur are considered distinct breeding populations because of the geographic isolation created by the construction of the dams.

2.1.3 Other fish species

Large numbers of steelhead and probably coho salmon have occurred historically (USFWS 1950, Fulton 1970a, Fulton 1970b, Thompson and Fortune 1967). Indigenous, non-game species include bridgelip sucker, largescale sucker, chiselmouth, redside shiner, longnose dace, specked dace, northern pikeminnow, mottled sculpin, and shorthead sculpin (Hanson et al. 1990, MOWC 1999).

Table 1: Historical fish species of the Malheur Subbasin

Common Name	Scientific Name	ODFW Management	Status	Location
Pacific Lamprey	Lampetra tridentate		Extinct	
Chinook Salmon	Oncorhynchus tshawytscha	Gamefish	Extinct	
Coho Salmon	Oncorhynchus kisutch	Gamefish	Extinct	
Steelhead	Oncorhynchus mykiss	Gamefish	Extinct	
Columbia River Redband Trout	Oncorhynchus mykiss	Gamefish	State Sensitive	Higher elevation areas of most major subbasins
Bull Trout	Salvelinus confluentus	Gamefish	Federal Threatened	Headwaters of North Fork and Logan Valley streams
Whitefish	Prosopium williamsoni	Gamefish		Lower sections of North Fork, Upper Malheur, and lower Malheur River
Northern Pike-minnow	Ptychocheilus oregonensis	Nongame		Lower sections of major subbasins
Chiselmouth	Acrocheilus alutaceus	Nongame		Lower malheur river
Redside Shiner	Richardsonius balteatus balteatus	Nongame		Lower sections of major subbasins
Speckled Dace	Rhinichthys osculus	Nongame		Lower sections of major subbasins
Long-nosed Dace	Rhinichthys cataractae	Nongame		Lower sections of major subbasins
Largescale Sucker	Catostomus macrocheilus	Nongame		Larger river and reservoirs
Bridgelip Sucker	Catostomus columbianus	Nongame		Lower sections of major subbasins
Shorthead Sculpin	Cottus confusus	Nongame		Headwater areas of perennial streams
Mottled Sculpin	Cottus bairdi	Nongame		Headwater areas of perennial streams

Source: ODFW, Ontario District Office 2001

2.2 Bull Trout (Salvelinus confluentus): Current Population Data and Status

The U.S. Fish and Wildlife Service listed bull trout in the Columbia River Basin (including the Malheur Subbasin) as threatened in June 1998. Under the listing Malheur Subbasin bull trout are considered members of the Columbia River Bull Trout Distinct Population Segment (DPS). This DPS is represented by relatively widespread, geographically isolated subpopulations throughout the entire Columbia River Basin within the United States and its tributaries, excluding bull trout found in the Jarbidge River, Nevada (FR 1998). The species was listed range wide in 1999 (FR 1999).

Two distinct local populations of bull trout have been identified in the Malheur River Subbasin by the Malheur Unit Bull Trout Recovery Team. These include the upper Malheur River bull trout population and the North Fork Malheur River population. The Malheur Bull Trout Recovery Team refers to these populations of bull trout as 2 local populations of one core population (Malheur River Subbasin). The core population, or the core area, represents the closest approximation of a biologically functioning unit.

The upper Malheur River population was isolated from all other populations of bull trout with the construction of Warm Springs Dam in 1919. The population of bull trout in the North Fork Malheur River was isolated from other populations of bull trout in 1926 with the construction of Agency Valley Dam. Both Warm Springs and Agency Valley Dams are upstream migratory barriers to fish as they have no fish passage facilities.

Bull Trout – North Fork Malheur River Local Population

The categorical status of bull trout in the North Fork Malheur River is "of special concern" (Buchanan et al. 1997, Ratliff et al. 1992). Buchanan et al. (1997) use five categorical levels to describe the status of bull trout that includes:

1) Low risk of extinction
2) Of special concern
3) Moderate risk of extinction
4) High risk of extinction
5) Probably extinct

The North Fork Malheur River bull trout population status is "of special concern". The recovery potential for the North Fork Malheur River bull trout population is considered to be "very good" (Buchannan et al. 1997). Habitat degradation, diversion losses, and past chemical treatment projects are listed as the main suppressing factors for the North Fork Malheur River bull trout population (Ratliff et al. 1992).

Bull Trout –Upper Malheur River Local Population

The upper Malheur River bull trout population status is at a "high risk of extinction". Buchannan et al. (1997) concludes that the recovery potential level for the upper Malheur River bull trout population at the given status will require major effort to restore. Habitat degradation, diversion losses, and the presence of sympatric brook trout populations are listed as the main suppressing factors for the upper Malheur River bull trout population (Ratliff et al. 1992).

2.2.1 Bull Trout: Abundance

The Oregon Department of Fish and Wildlife conducted a multiple pass removal method to estimate population in the North Fork Malheur River and tributaries in 1991 and 1992. The study concluded that 4,132 bull trout of at least age one is the estimated population for bull trout in the North Fork Malheur River in 1991 and 1992.

Quantitative estimates of bull trout abundance are necessary to determine the status of populations, to monitor changes in population size, and to evaluate the effectiveness of conservation strategies. Counting bull trout redds is an attractive technique to evaluate population abundance. Since only reproductive adults produce redds, redd counts should reflect the effective population size of a stock (Meffe and Carroll 1994). In addition, the potential impacts to the population from spawning ground surveys are relatively low compared to potential injuries that can occur when making population estimates based on multiple-pass removal or mark-recapture techniques using electrofishing (Hemmingsen et al. 1996). Thus, redd counts have been and continue to be the most commonly used method for monitoring bull trout abundance and are used in the North For Malheur River watershed to determine population trend and abundance of spawning bull trout. This estimate does not include the annual abundance of non-spawning and immature bull trout.

Beginning in 1999, surveyors noted and counted bull trout associated with redds. A total of 44 or 29% (44 bull trout/151 redds) of bull trout redds were observed with bull trout and the bull trout per redd ratio is 2 to 2.4 (Tinneswood and Perkins 2001). The adult spawning population data since 1996 is illustrated in Figure 1.

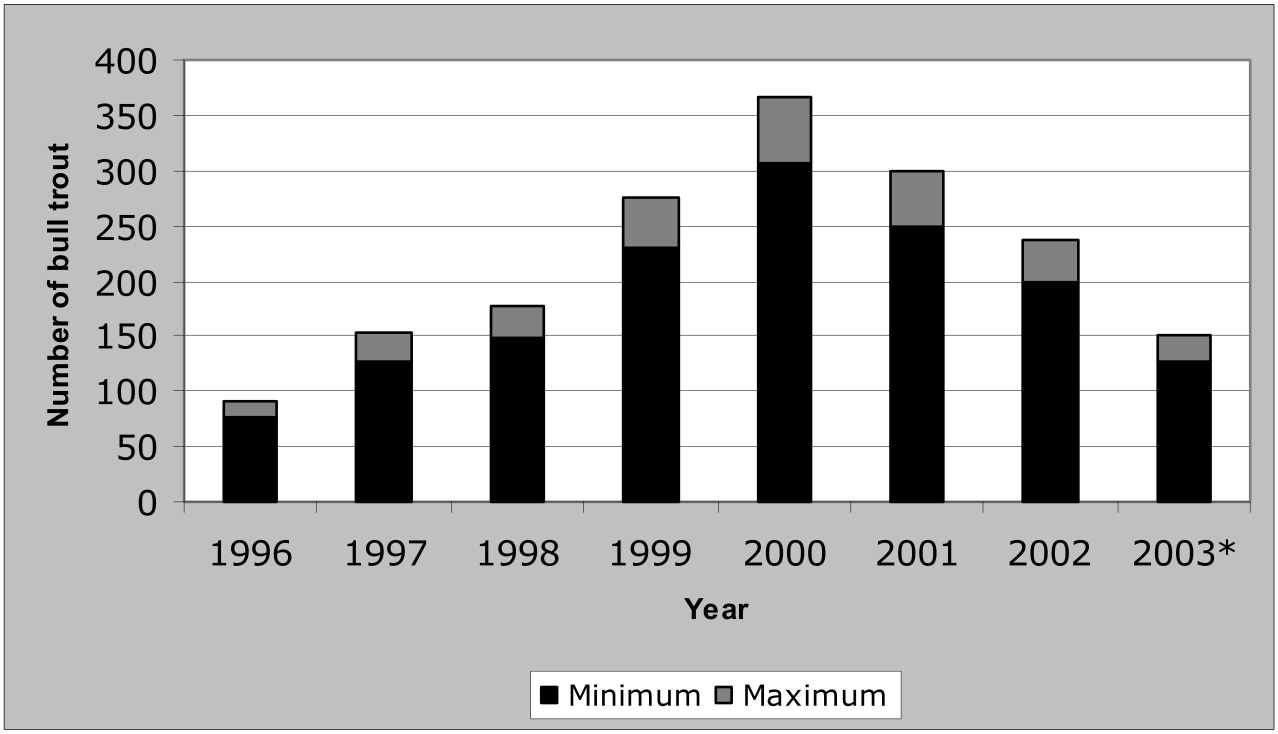


Figure 1: Estimated abundance of sexually mature bull trout in the North Fork Malheur River and associated headwater streams from 1996 to 2003. Minimum number of bull trout spawners were determined by assuming 2 fish per redd. Maximum number of bull trout spawners were estimated by calculating 2.4 bull trout per redd. (Data source: ODFW, Ontario District Office 2002. *- Draft data, ODFW, Ontario District 2003.)

Bull Trout –Upper Malheur River Local Population

The Oregon Department of Fish and Wildlife conducted a multiple pass removal method to estimate population in the Upper Malheur River tributaries in 1993 and 1994 that include the streams Big Creek, Lake Creek, and Meadow Fork of Big Creek. The study estimated the bull trout population to be 3,554 of at least age one fish for these tributaries. Densities ranged from 0.039 fish per lineal meter in Lake Creek to 0.474 fish per lineal meter in Meadow Fork of Big Creek (Buchanan et al. 1997).

Redd counts are used in the upper Malheur River watershed to determine population trends only. Due to the presence of brook trout, estimated abundance of spawning bull trout for the Upper Malheur local population can not be estimated at this time due to the inability to distinguish between bull trout and brook trout redds when not occupied.

2.2.2 Bull Trout: Capacity

The capacity of aquatic habitats to sustain native salmonid populations in the Malheur River Subbasin has decreased from the historical context. The capacity of the habitat can be expressed as either realized or unrealized habitat potential. The realized habitat potential of the system reflects the quality and quantity of habitat conditions currently occupied and utilized by a species. Habitat restoration and enhancement can increase the capacity of the Malhuer River Subbasin. The unrealized potential habitat of the Malheur River Subbasin are deficiencies of the quality and quantity of habitat conditions that have been occupied and utilized historically by this species but are no longer available due to anthropogenic causes. These deficiencies limit the species production and population due to the underutilization of historical habitat.

The Qualitative Habitat Assessment (QHA) is a good tool to summarize realized and unrealized potential habitat for the three selected focal species in the Malheur River Subbasin. Current conditions represent the realized potential of the Subbasin for a selected species while reference conditions represent the historic capacity of the system for the selected species. Disparities between the current and reference conditions are a deficiency in habitat quality and quantity. These deficiencies represent the unrealized potential of the Subbasin for the selected species. Furthermore, the Quality Habitat Assessment for the Malheur River Subbasin summarizes all known artificial barriers that also limit the capacity of the focal species in the Malheur River Subbasin.

Bull Trout

The realized habitat potential or current habitat utilized by bull trout in the Malheur Subbasin can be summarized by the current distribution of bull trout. Habitat losses identified in the QHA best summarize the unrealized potential for bull trout within the current distribution of the species. Various causes have also reduced the quantity of bull trout habitat. This reduction of quantity of habitat is also unrealized potential habitat for bull trout and is summarized in Table 2.

Table 2 Historical bull trout streams in the Malheur River Subbasin that are not currently occupied by the species.

Streams	Habitat Use
Little Malheur River	Migration/overwintering/foraging
Mainstem Malheur River from Namorf Dam to Drewsey	Migration/overwintering/foraging
Warm Springs Reservoir	Migration/overwintering/foraging
Crooked Creek	Spawning/rearing
Bosonberg Creek	Spawning/rearing
McCoy Creek	Spawning/rearing
Corral Basin	Spawning/rearing

2.2.3 Bull Trout: Productivity

A stable or increasing population is a key criterion for recovery under the requirements of the Endangered Species Act. Measures of the trend of a population (the tendency to increase, decrease, or remain stable) include population growth rate or productivity. Estimates of population growth rate (i.e., productivity over the entire life cycle) that indicate a population is consistently failing to replace itself indicate increased extinction risk. Therefore, the reproductive rate should indicate the population is replacing itself, or growing.

Since estimates of the total population size are rarely available, the productivity or population growth rate is usually estimated from temporal trends in indices of abundance at a particular life stage. For example, redd counts are often used as an index of a spawning adult population. The direction and magnitude of a trend in the index can be used as a surrogate for the growth rate of the entire population. For instance, a downward trend in an abundance indicator may signal the need for increased protection, regardless of the actual size of the population. A population which is below recovered abundance levels but moving toward recovery would be expected to exhibit an increasing trend in the indicator.

The population growth rate is an indicator of probability of extinction. This probability cannot be measured directly, but it can be estimated as the consequence of the population growth rate and the variability in that rate. For a population to be considered viable, its natural productivity should be sufficient for the population to replace itself from generation to generation. Evaluations of population status will also have to take into account uncertainty in estimates of population growth rate or productivity. For a population to contribute to recovery, its growth rate must indicate that the population is stable or increasing for a period of time.

Spawning surveys are used to determine the population trends and risk assessments for the two local populations in the Malheur River Subbasin. Redd counts can be made with relative ease and are an indirect measure of adult abundance. As a consequence, redd count information is typically used to evaluate trends in the size of local bull trout populations (Rieman et al. 1997).

2.2.4 Bull Trout: Life History Diversity

Bull trout exhibit either resident or migratory life-history strategies (Rieman and McIntyre 1993). Resident bull trout complete their entire life cycle in natal streams. Migratory bull trout spend one to four years in their natal stream then migrate out to either a lake (adfluvial form), river (fluvial form), or ocean (anadromous)(Cavender 1978, McPhail and Baxter 1996). Rieman and McIntyre (1993) found that migratory and resident life-history form may be found together and that either form may give rise to offspring that exhibit either resident or migratory behavior.

All life-history stages of bull trout have been closely associated with complex form of cover, including large woody debris, undercut banks, boulders, and pools (Fraley and Shepard 1989, Goetz 1989, Hoelscher and Bjounn. 1989, Sedell and Everest 1991, Pratt 1992, Thomas 1992, Rich 1996, Sexauer and James 1997, Watson and Hillman. 1997).

Bull trout are typically found in cold streams. Water temperatures in excess of 15^{o}C are believed to limit bull trout distribution (Fraley and Shepard 1989, Rieman and McIntyre 1995). Goetz

(1989) suggested optimum water temperatures for rearing bull trout to be about 7 or 8°C for rearing bull trout and 2 to 4°C for egg incubation. Nevertheless, individual bull trout have been collected in larger, warmer river systems throughout the Columbia River basin (Fraley and Shepard 1989, Rieman and McIntyre 1993, Rieman and McIntyre 1995, Buchanan et al. 1997). In Nevada, adult bull trout have been collected at sites with daily maximum stream temperatures up to 17.2°C in the West Fork of the Jarbidge River and 17.5°C in Dave Creek (USFWS 2002a). In Idaho, bull trout have been collected from the Little Lost River with stream temperatures up to 20°C. Lastly, bull trout have been collected in Oregon from the Malheur River with daily maximum stream temperatures exceeding 23°C (Schwabe et al. 2003a).

Bull trout reach sexually maturity from age 4 to 7. The size and age of a sexually mature bull trout is dependant upon life-history type and habitat limitations. Fecundity of smaller resident bull trout is less than their larger migratory counterpart (Fraley and Shepard. 1989, Goetz 1989). Furthermore, resident fish tend to mature at a smaller size than migratory bull trout. Resident adults range from 150 to 300 mm in total length and migratory adults commonly reach 600 mm or more (Pratt 1985, Goetz 1989). Bull trout may spawn multiple times during their life span and may spawn each year or in alternate years (Batt 1996). The frequency of multiple spawning and post spawn mortality is not well documented (Leathe and Graham 1982, Fraley and Shepard 1989, Pratt 1992, Rieman and McIntyre 1996) but post-spawn survival rates are believed to be high.

Bull trout spawn from late August to November when stream temperatures are declining to optimal temperatures (below 9°C). Typically, redds are often constructed in stream reaches fed by springs or near other sources of cold groundwater upwellings (Goetz 1989, Pratt 1992, Rieman and McIntyre 1996). Migratory bull trout migrate upstream to headwater spawning areas as early as April and have been reported to have migrated as far as 250 km upstream in Montana (Fraley and Shepard 1989, Swanberg 1997) and 109 km in Idaho (Flatter 1998).

The age of migration for immature bull trout is found to be variable. In the Metolius River Basin, bull trout under 100mm in length were generally only found in the vicinity of spawning areas and fish over 100mm were found downstream in larger channels and reservoirs (Ratliff and Howell 1992). Juvenile bull trout collected from the Umatilla River are between 100 to 200 mm long in the spring (Buchanan et al. 1997). Ratliff and Howell (1992) reported that age of juvenile downstream migration varied between age 1 to 3 with majority of out-migrates occurring at age 2. This pattern is similar to the findings of juvenile bull trout out-migrations in the Flathead River subbasin (Pratt 1992).

Bull trout are opportunistic feeders. Juvenile and resident bull trout prey on apatic insects, macro-zooplanktion, and small fish (Boag 1987, Goetz 1989, Donald and Alger 1993, Gunkel 2000). Migratory bull trout feed are various fish species (Leathe and Graham 1982, Fraley and Shepard 1989, Brown 1992, Donald and Alger 1993) that occupy larger, more productive stream reaches, which in turn results in greater growth rates than their resident counterpart.

2.2.5 Bull Trout: Carrying Capacity

The carrying capacity for the Malheur River subbasin has been altered from historical aspect. The carrying capacity has decreased for some native aquatic fish species, while others, though not documented, may have benefited from the relatively recent impacts to the Malheur River Subbasin. For the selected focal species, the current carrying capacity has decreased from the historical context.

Bull trout, redband trout, and chinook salmon are salmonids and all require relatively cool water. General limiting factors best described by throughout the Malheur River Subbasin are best described by Hanson et al (1990) and include nonpoint source pollution, riparian zone conditions, altered streamflow patterns, and unscreened diversions.

Non-point Source Pollution: Temperature, sedimentation, and turbidity are examples of non-point source pollutants. Sedimentation limits the production of salmonids by reducing available spawning habitat, egg survival and limits production of aquatic organisms. Turbidity is the amount of sediment suspended in the water column. Turbidity reduces the ability of sight feeders to obtain food by decreasing light penetration into the water column. Sources of sedimentation and turbidity include: return flow from irrigation diversions, poorly vegetated uplands and streambanks, road densities, and mining operations.

Riparian Zone Conditions: Healthy riparian vegetation effects water temperature, instream habitat, and provides increase channel stability resulting in lower width to depth ratios. Improvement of riparian conditions throughout the subbasin will increase fish production.

Altered Stream Flow Patterns: Water release from irrigation reservoirs have altered the historical hydrograph. In particular, the North Fork Malheur River, Malheur River, Bully Creek, and Willow Creek below Agency Valley Dam, Warm Springs Dam, Bully Creek Dam, and Willow Creek Dam respectively have altered historical stream flows. Historical low flow in the summer is currently a sustained high flow. Though historically low but constant in the winter, winter flows are now extremely low as the reservoirs store water for the next irrigation season. Extreme low winter flows limit fish production in these areas.

Unscreened Diversions: Unscreened diversions divert fish into irrigation ditches where fish may become stranded and die. Oregon law requires screens on all diversions that affect movement of game fish (ORS 498.300 and 509.615). In general, fish screens are required on all diversions of 30 cfs or greater at the expense of the diversion owner (ORS 498.311 and 509.615). For diversions of less then 30 cfs, the pace at which screens are required to be installed, as well as the details of cost sharing, are described in ORS 498.306.

Particular limiting factors that have affected the carrying capacity of the Malheur River bull trout population are habitat degradation and downstream losses to unscreened diversions (Bowers *et al.* 1993, Ratliff and Howell 1992, Buchanan et al. 1997). Passage barriers on the North Fork Malheur River at Agency Valley Dam prohibit entrained bull trout from migrating to critical bull trout spawning habitat (Schwabe et al. 2000). Agency Valley Dam and Warm Springs Dam have isolated the local populations of bull trout in the North Fork Malheur River and upper Malheur River and prevent genetic exchange. The introduction of brook trout in the upper Malheur River headwaters has been identified as a limiting factor to bull trout (Bower et al. 1993, Ratliff and Howell 1992, Buchanan et al. 1997). The cumulative effect of these limiting factors has reduced the carrying capacity for bull trout in the Malheur River Subbasin.

2.2.6 Bull Trout: Population Trend and Risk Assessment

Metapopulation theory is important to consider in bull trout recovery. A metapopulation is an interacting network of populations with varying frequencies of migration and gene flow among populations (Meffe and Carroll 1994). Multiple local populations distributed and interconnected throughout a watershed provide a mechanism for spreading risk from localized catastrophic disturbances. In part, distribution of local populations in such a manner is an indicator of a functioning core area. Based in part on guidance from Rieman and McIntyre (1993), bull trout core areas with fewer than five local populations are at increased risk, core areas that have five to ten local populations are at intermediate risk, and core areas with more than ten interconnected local populations are at diminished risk. Currently, two local populations have been identified by local area fish and wildlife managers in the Malheur River Subbasin. Based on existing information, the Malheur River bull trout core population is at increased risk from stochastic events.

The presence of the migratory life history form within the Malheur Recovery Unit was used as an indicator of the functional connectivity. If the migratory life form was absent, or if the migratory form is present but local populations lack connectivity, the core area was considered to be at increased risk. If the migratory life form persists in at least some local populations with partial ability to connect with other populations, the core area was judged to be at intermediate risk. Finally, if the migratory life form was present in all or nearly all local populations, and had the ability to connect with other local populations, the core area was considered to be at diminished risk. Irrigation developments have isolated the two identified local populations since 1919. Local populations within the Malheur River core area both have migratory bull trout present but no ability to connect, therefore, the Malheur core population / area is considered to be at increased risk.

Effective population size is a theoretical concept that allows us to predict potential future losses of genetic variation within a population due to small population sizes and genetic drift. For the purpose of recovery planning, effective population size is the number of adult bull trout that successfully spawn annually. Based on standardized theoretical equations (Crow and Kimura 1970), guidelines have been established for maintaining minimum effective population sizes for conservation purposes. Effective population sizes of greater than 50 adults are necessary to prevent inbreeding depression and a potential decrease in viability or reproductive fitness of a population (Franklin 1980). For bull trout, Reiman and Allendorf (2001) estimated that a minimum census number of fifty to one-hundred spawners per year are needed to minimize potential inbreeding effects within local populations.

To minimize the loss of genetic variation due to genetic drift and to maintain constant genetic variance within a population, an effective population size of at least 500 is recommended (Franklin 1980: Soule 1980; Lande 1988). Furthermore, a census population size between 500 and 1000 adults in a core area is needed to minimize the deleterious effects of genetic variation due to drift (Reiman and Allendorf 2001).

Redd counts in the North Fork Malheur River and spawning tributaries are used to track population trend data for adult bull trout. In general, an upward trend in redd numbers has been observed from 1992 to 2000. In 2000, estimated adult bull trout abundance in the North Fork

Malheur River peaked to above 300 individuals. Adult abundance in 2003 has declined to a five year low with under 200 individual adult bull trout. Redd surveys estimate the adult bull trout abundance for the North Fork Malheur River bull trout local population to be over 100 individuals from 1997 to 2003. The North Fork Malheur River local population is not considered at risk from inbreeding depression.

Due to the presence of brook trout, adult bull trout abundance and an evaluation of inbreeding risks has not been determined for the upper Malheur River local population.

Overall, the Malheur core population most likely contains less than 1000 spawning adults and is considered at risk from the deleterious effects of genetic drift.

2.2.7 Bull Trout: Unique Population Units

The bull trout population in the Malheur River subbasin has been identified as a single Gene Conservation Group by Oregon Department of Fish and Wildlife (Kostow 1995). The delineation of this Gene Conservation Group of bull trout is supported by past population genetic integrity research and analysis that was conducted throughout the range of the species. Based on this existing information, the United States Fish and Wildlife Service designated the Malheur River Recovery Unit that represents a unique population recovery unit of bull trout. The Malheur River Recovery Unit includes two local populations located in the headwaters of the North Fork Malheur River and the Upper Malheur River watersheds.

2.2.8 Bull Trout: Life History Characteristics of Unique Populations

North Fork Malheur River Local Population

In a two year study, 39 adult bull trout (>300 mm fork length) were collected and implanted with radio tags. Cycloid scale analysis was used to determine the age of bull trout. Age range of the adult bull trout that were radio tagged is four to seven years of age (Schwabe et al. 2003b). Bull trout were collected from Beulah Reservoir (n=35) and the North Fork Malheur River at river kilometer 69 near Crane Creek confluence (n=4). Results from the two year study suggest adult bull trout migration out of Beulah Reservoir occurred from mid-March to late May. In June, adult bull trout were fairly well distributed from Beulah Reservoir to RK 75. By early August, the majority of tagged bull trout had moved upstream of Crane Creek confluence at RK 69. Radio tagged fish have been documented to migrated up to 61 km in the North Fork Malheur River (Schwabe 2000). Adult bull trout migration into the spawning tributaries started in mid-July and peak migration into the spawning tributaries occurred in mid to late August. In 1999, adult bull trout resided in the spawning tributaries from 18 to 63 days, with an average of 46.2 days (Fenton pers. com. 2004). The peak in adult downstream migration from spawning tributaries occurred in late September and adult bull trout returned to the reservoir between late October and mid-December.

Spawning and rearing takes place in the mainstem and tributaries upstream of Crane Crossing in the North Fork Malheur River. Bull trout spawning surveys lead by Oregon Department of Fish and Wildlife were initiated in the North Fork Malheur headwaters in 1992 in streams with known or suspected bull trout population (Buchanan et al. 1997). Based on the data collected since

1992, bull trout spawning begins in late August and peaks in September. Redds have been observed as late as November (Perkins 1999). Spawning has been documented in: 1) the mainstem North Fork Malheur River upstream of the mouth of Deadhorse Creek, 2) Horseshoe Creek, 3) Swamp Creek, 4) Sheep Creek, 5) Elk Creek, 6) Crane Creek and 7) Little Crane Creek. Bull trout have been observed in Cow Creek during spawning surveys, but no redds have been observed (Perkins 1999).

Subadult rearing and adult foraging has been observed from the headwaters of the North Fork Malheur River down to Beulah Reservoir. In August 1997, snorkel surveys were conducted from the confluence of the Little Malheur and North Fork Malheur Rivers to the National Forest boundary by an interagency team of biologists (USFWS 2002). Bull trout rearing was observed down to the confluence of the Little Malheur River. Bull trout observed ranged from 50 to 400 millimeters in length with the majority in the 100 to 200 millimeter size range.

Sub-adult bull trout (fork length less than 250 mm) were trapped and tagged in the North Fork Malheur River. Trapping of subadult bull trout during 1998 and 1999 using a rotary screw trap showed subadult bull trout migrating downstream from the trap site at RK 69 away from known spawning and rearing tributaries of the North Fork Malheur River (Schwabe et al. 2000). Trap operation during this period was June to October with two downstream peaks observed, the largest in June and a small peak in September. In 2002 and 2003, a total of 28 subadult bull trout were implanted with radio tags. Radio telemetry on subadult bull trout suggest sporadic fish migration in May and June with both upstream and downstream movements observed. Nevertheless, a general migration upstream of subadult bull trout started in July and into August. Eventually, all subadult bull trout that were radio tagged migrated upstream of RK 69, the initial collection site. All subadult bull trout remained in the mainstem with no migration into known spawning areas. In September, downstream migration of radio tag subadult bull trout was evident.

Both fluvial and resident forms of bull trout occur in North Fork Malheur River local population. Adfluvial bull trout also occur in this local population but Beulah Reservoir is limited to overwintering habitat only. Rearing bull trout are known to occupy reservoir habitat year round, a trait not observed in the North Fork Malheur River bull trout population. Past studies suggest that bull trout overwinter in Beulah Reservoir but are suspected to migrate upstream into the North Fork Malheur River in late/early summer. No radio tagged bull trout have been observed in Beulah Reservoir from July through September. Using a 13.9^{o}C temperature tolerance for bull trout, no cold water refugia exists in Beulah Reservoir and associated inlets from July to September (USBR 2002). In 2002, Beulah Reservoir water storage levels went to run of river. An interagency team of biologists spot shocked the North Fork Malheur River and Bendire Creek, both perennial streams that flow into the reservoir. No bull trout were observed.

Upper Malheur River Local Population

Bull trout spawning and juvenile rearing occurs in the Upper Malheur River and tributaries upstream of the confluence of Big Creek. Timing of bull trout spawning in the Upper Malheur population is similar to what has been observed in the North Fork Malheur population with the peak occurring in mid-September. Streams where redds have been identified include Snowshoe Creek, Meadow For Big Creek, Lake Creek, Summit Creek, and Big Creek, although brook trout may account for some of the redds. Data collected in 1999 showed that 40 percent of the redds were counted prior to September 15th. These redds were assumed to be bull trout redds as they occurred in stream where most of the bull trout were also observed, although brook trout were present during these surveys (Perkins 1999).

In a two year study, 38 adult bull trout (>250 mm fork length) were collected and implanted with radio tags. Adult bull trout were collected from weir on the Upper Malheur River RK 304. Results from the study suggest that adult bull trout migration from the mainstem Malheur River to Big Creek and Lake Creek occurred from mid-May to the end of July. Adult bull trout migration did not occur past RK 3 on Lake Creek. Bull trout migrated into known spawning areas of Big Creek, Meadow Fork of Big Creek, and Snowshoe Creek in July and August. Adult bull trout resided in known spawning areas for 5 to 66 days, with an average of 35 days (Fenton pers. com. 2004). By the beginning of September, adult bull trout were observed migrating downstream. Downstream migration continued through March, though movements were relatively slow from December to March. A bull trout was observed at RK 287 near the confluence of the Upper Malheur River and Wolf Creek, approximately 31 river kilometers downstream from the initial site of capture (radio tag implant site) and up to 45 km downstream of documented spawning areas (Schwabe et al. 2001).

Subadult rearing and adult foraging occurs mainly from the Upper Malheur River tributaries downstream to approximately RK 297. Adult bull trout have been observed as far downstream as RK 287 during the winter months. It is possible, although not documented, that fish forage downstream to Warm Springs Reservoir during the winter.

Both fluvial and resident forms of bull trout occur in Upper Malheur River local population. Adfluvial life history forms of bull trout are not present in this local population since these fish have not been documented utilizing reservoir habitats.

2.2.9 Bull Trout: Genetic Integrity of Unique Populations

Initial genetic studies on bull trout throughout the Klamath and Columbia River basins conclude there is relatively little genetic variation within the populations of bull trout, but substantial genetic differences among populations (Leary and Allendorf 1991). Spruell and Allendorf (1997) concluded that Malheur bull trout belong in the "Snake River" group of populations, but are distinct from other Oregon populations within this group. In recent studies, Malheur bull trout are found to be more genetically similar to bull trout populations from the Boise (Idaho) and Jarbidge (Nevada) drainages than to other populations in Oregon, and these three populations form a cluster within the Snake River group (Spruell et al. 2003).

Further studies into the genetic makeup of bull trout are needed in the Malheur core area. Genetic information on local populations within the core area is necessary for a more complete understanding of bull trout interactions and population dynamics. The information will also assist recovery team members in the identification of additional local populations of bull trout located within the core area.

2.2.10 Bull Trout: Estimate of Historic Status

There is no straight forward approach in estimating predevelopment (latter half of 1800's) populations of bull trout.

The Malheur Recovery Unit estimated a combined recovery population estimate of 2,000 to 3,000 individuals distributed in the North Fork and Upper Malheur Rivers. The historical population was assumed healthy and would not be at risk from inbreeding or genetic drift. These risks summarized in section 3.2.3.1.6 suggest core population size must be between 500 and 1000 adults in a core area to minimize the deleterious effects of genetic variation due to drift (Reiman and Allendorf 2001).

The US Forest Service research known densities of bull trout observed in the Little Lost River, Idaho obtained by multiple-pass electrofishing surveys (Gamett 2002) and applied these estimates to those streams in the Malheur National Forest that have available habitat for bull trout. The Forest Service concluded that assuming bull trout matured at age 5 or 6, conservative estimates of the bull trout population of the Malheur River Subbasin consist of 5,557 and 11,114 adults respectively (High, pers. com. 2003).

2.3 Bull Trout Distribution

Bull trout are char native to the Pacific Northwest and western Canada. The historical range of bull trout includes major river basins in the Pacific Northwest at about 41 to 60 degrees North latitude, from the southern limits in the McCloud River in northern California and the Jarbidge River in Nevada to the headwaters of the Yukon River in the Northwest Territories, Canada (Cavender 1978; Bond 1992). To the west, bull trout range includes Puget Sound, various coastal rivers of British Columbia, Canada, and southeast Alaska (Bond 1992). Bull trout occur in portions of the Columbia River and tributaries within the basin, including its headwaters in Montana and Canada. Bull trout also occur in the Klamath River basin of south-central Oregon. East of the Continental Divide, bull trout are found in the headwaters of the Saskatchewan River in Alberta and Montana and in the MacKenzie River system in Alberta and British Columbia, Canada, (Cavender 1978; Brewin et al. 1997).

Although bull trout are presently widespread within their historical range in the coterminous United States, they have declined in overall distribution and abundance during the last century. For example, bull trout have been extirpated in the McCloud River basin, California, as well as locally in tributaries of other river basins. Declines resulted largely from habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, past fisheries management practices, and the introduction of nonnative species. These factors resulted in the reduction or elimination of migratory bull trout. Retaining migratory forms of bull trout in a population is important because these forms allow fish access to more resources (i.e., food and habitat), opportunities for genetic exchange, and the ability to recolonize habitats after local extirpations (e.g., by a watershed-wide disturbance affecting all bull trout in a resident population).

2.3.1 Bull Trout: Current Distribution/Spatial Diversity

Bull Trout

The current distribution of bull trout is summarized in Table 3. Bull trout primarily occur in the headwaters of the Malheur River Subbasin.

Table 3: Current distribution of bull trout in the Malheur River Subbasin. Table illustrates the current stream bull trout have been sampled from and the extent of use within these drainages.

Streams	Habitat Use
North Fork Malheur River from mouth to Agency Dam	Migration/overwintering/foraging
Beulah Reservoir	Migration/overwintering/foraging
North Fork Malheur River from Beulah Reservoir to confluence with Crane Creek	Migration/overwintering/foraging
Malheur River from Drewsey to Logan Valley	Migration/overwintering/foraging
Crane Creek	Migration/foraging
Cow Creek	Rearing
North Fork Malheur River from confluence with Crane Creek to the headwaters	Spawning/rearing
Little Crane Creek	Spawning/rearing

Streams	Habitat Use
Horseshoe Creek	Spawning/rearing
Flat Creek	Spawning/rearing
Swamp Creek	Spawning/rearing
Sheep Creek	Spawning/rearing
Elk Creek (including both north and south forks)	Spawning/rearing
Lake Creek	Spawning/rearing
Big Creek	Spawning/rearing
Meadow Fork Big Creek	Spawning/rearing
Snowshoe Creek	Spawning/rearing

Bull Trout –North Fork Malheur River Local Population

Current distribution of bull trout includes the North Fork Malheur River and upper Malheur River (upstream of Drewsey). Spawning and juvenile rearing takes place in selected headwater tributaries of both systems, as well as in the upper mainstem North Fork Malheur.

Bull trout in the North Fork Malheur River migrate to and overwinter in Beulah Reservoir. Entrainment below Agency Valley Dam has also been observed. Radio telemetry of entrained bull trout tend to stay within 2 river kilometers of the tailrace (Schwabe et al. 2000), though local residents have reported bull trout in the Malheur River around the vicinity of Juntura, Oregon. Although bull trout have been observed in the North Fork Malheur River below Agency Valley Dam, it is suspected that the entrained bull trout will not successfully spawn or rear due to the lack of spawning and rearing habitat and a highly altered seasonal hydrograph.

Migratory bull trout have also been observed in the lower one mile of the Little Malheur River (Schwabe et al. 2000). Adult bull trout mainly migrate into the upper reaches of South Fork Elk Creek, North Fork Elk Creek, Swamp Creek, Sheep Creek, Horseshoe Creek, Little Crane Creek, and Upper North Fork Malheur River. Reports of bull trout have been observed in Cow Creek and upper Crane Creek.

Bull Trout –Upper Malheur River Local Population

Bull trout occur in several headwater tributaries of the Upper Malheur River and occur as far downstream as Wolf Creek (RK 264). Bull trout use of the Malheur River below Wolf Creek to Warm Springs Reservoir is currently restricted seasonally probably due to elevated stream temperatures, lack of water, and lack of fish passage facilities at irrigation diversions (USFS 2000, Bowers et al. 1993, USFWS 2002). The Burns Paiute Tribe and ODFW have observed bull trout in Lake Creek, Big Creek, Meadow Fork Big Creek, and Snowshoe Creek (Burns Paiute Tribe, in press, Bowers et al. 1993, Buchanan 1997). The Tribe also collected a bull trout from Crooked Creek on September 10,1998 and recent observations of bull trout were noted from Summit Creek. Brook trout outnumber bull trout all headwater streams of the upper Malheur River except for Meadow Fork Big Creek where bull trout outnumber brook trout 15 to 1 (Burns Paiute Tribe, in press). Brook trout appear to be present in the lower 2 river kilometers of Meadow Fork Big Creek, with the upper 2 river kilometers dominated exclusively by bull trout.

2.3.2 Bull Trout: Historic Distribution

Information on the historic distribution of bull trout in the Malheur Subbasin is limited (Buchanan et al. 1997). However, bull trout would have had access to the Snake River prior to dam construction. Stream temperatures in the lower Malheur River would have limited bull trout spawning and juvenile rearing, but the area would have been used for migration corridors and overwintering habitat (Hanson et al. 1990). Furthermore, the genetic similarities between the Malheur local populations of bull trout to the populations of bull trout in the Boise and Jarbidge drainage imply that the mainstem North Fork Malheur River and Upper Malheur River were historically utilized as migratory habitat.

Data collected within the last 50 years document bull trout in areas outside the their current distribution. This data leads local resource land and fisheries managers to suspect historical or potential habitat for bull trout in several streams in the Malheur River Subbasin. The historical distribution of bull trout includes the streams identified in Attachment 2 - General Assessment reach characteristics and focal species use by reach.

Bull trout were last reported in the Little Malheur River on the Malheur National Forest near FSR 16 crossing in the late 1960's (Goetz 1989, Hanson et al. 1990). Fluvial bull trout were observed to migrate into the lower reach of the Little Malheur River from Beulah Reservoir, then return to the N.F. Malheur River and continue to spawning areas in the upper N.F. Malheur River and tributaries during a radio-telemetry study in the late 1990's (Schwabe et al. 2000). Bull trout were last reported in Crooked Creek in September 1998 by the Burns Paiute Tribe Fish and Wildlife Department upstream of FSR 1630-333 crossing. The bull trout collected during a fish distribution survey of Crooked Creek, approximately at RK 2, measured 240 mm fork length. Lastly, bull trout were last reported in Bosonberg Creek by past creel surveys conducted in the 1950's and 60's (Bowers et al. 1993).

Many of the headwater streams were chemically treated to eradicate bull trout in the Upper Malheur River in 1955. Streams include Lake Creek, McCoy Creek, Crooked Creek, Big Creek, Bosonberg Creek and Summit Creek. Considerable numbers of bull trout were reported killed from this project (Bowers et al. 1993).

2.3.3 Bull Trout: Identification of Differences in Distribution Due to Human Disturbance

Habitat degradation, diversion losses, introduction of brook trout, and past chemical treatment project are current and past human activities that have impacted bull trout distribution (Ratliff and Howell 1992). Warm Springs Dam and Agency Valley Dam have impacted the winter distribution of bull trout due to the lack of passage facilities.

2.4 Redband Trout (Oncorhynchus mykiss): Current Population Data and Status

Rainbow trout found primarily east of the Cascade Mountains in the U.S. are often called redband (NRCS 2000). The redband trout was considered a candidate species for listing under the federal Endangered Species Act (ESA) until March 20, 2000 when a final decision was made to not list redband (USFWS 2000). It is listed as a Sensitive Species under Oregon's Endangered Species Act. The health of the redband population in the Malheur River watershed is currently unknown and an interagency team has initially begun research on life history characteristics (Schwabe et al. 2000).

2.4.1 Redband Trout: Abundance

Pribyl and Hosford (1985) sampled the Upper Malheur and the North fork Malheur rivers in the early part of the 1980's. Their findings were that native rainbow (redband) trout were the third most abundant species of fish (longnose dace and whitefish being the most abundant) in the Upper Malheur river above Warm Springs Reservoir. The Burns Paiute Tribe conducted snorkel surveys in the Upper Malheur River in areas where cool water inputs were identified. The Tribe noted redband trout were second in abundance at the lower two site, and most abundant at the upper site (Schwabe et al. 2003b). In addition, Pribyl and Hosford (1985) noted that native rainbow (redband) trout were the most abundant species of fish found in the North Fork Malheur River above Beulah Reservoir.

Information on redband is more abundant for the Upper Malheur River watershed above Warm Springs Reservoir than for any other watersheds in the Malheur River Subbasin. The US Forest Service, Bureau to Land Management, ODFW, and the Burns Paiute Tribe have collected years of data in the watershed. Lake Creek and Meadowfork Creek, both in the headwaters of the Upper Malheur River, were surveyed with a presence absence study in 2003 (Burns Paiute Tribe in press). The findings in these studies were that redband trout were the least abundant species of salmonid behind brook trout and bull trout in both Lake Creek and Meadowfork Creek (Burns Paiute Tribe, in press). The agencies have also worked together in the collection of fisheries data on numerous perennial streams in the watershed. The density of redband trout has been noted as high as 1.18 fish/m^2, with an average density of 0.40 fish/m^2 (Table 4).

Table 4: Population densities of redband trout in the tributaries of the Upper Malheur River, 1999-2001.

Date	Watershed	Stream	Source	Population Density (fish/m2)	Char Present
1999	Upper Malheur	Crooked	Schwabe et al 2002a	0.5	Brook Trout
1999	Wolf Creek	Calamity 2199	High 2004	0.43	no
1999	Wolf Creek	Calamity 2099	High 2004	0.24	no
1999	Wolf Creek	Calamity 1999	High 2004	0.35	no
1999	Wolf Creek	Calamity 1899	High 2004	0.44	no

Date	Watershed	Stream	Source	Population Density (fish/m2)	Char Present
2000	Upper Malheur	Bosonberg	Schwabe et al 2001	0.17	Brook Trout
2001	Wolf Creek	Beaverdam	High 2004	0.48	no
2001	Wolf Creek	Brophy	High 2004	0.9	no
2001	Wolf Creek	Calamity 1701	High 2004	0.24	no
2001	Wolf Creek	Calamity 1801	High 2004	0.63	no
2001	Wolf Creek	Calamity 1901	High 2004	0.47	no
2001	Wolf Creek	East Fork Wolf 1301	High 2004	0.66	no
2001	Wolf Creek	East Fork Wolf 1401	High 2004	1.01	no
2001	Wolf Creek	East Fork Wolf 3401	High 2004	0.75	no
2001	Wolf Creek	Gabe 2301	High 2004	0.13	no
2001	Wolf Creek	Gabe 3501	High 2004	0.02	no
2001	Wolf Creek	Gunbarrel	High 2004	0.39	no
2001	Wolf Creek	Middle Wolf 0801	High 2004	0.4	no
2001	Wolf Creek	Middle Wolf 0901	High 2004	0.33	no
2001	Wolf Creek	Schurtz 1501	High 2004	0.51	no
2001	Wolf Creek	Schurtz 1601	High 2004	0.71	no
2001	Wolf Creek	West Fork Wolf 1101	High 2004	0.47	no
2001	Wolf Creek	West Fork Wolf 1201	High 2004	1.18	no
2001	Wolf Creek	West Fork Wolf 3301	High 2004	0.29	no
2001	Wolf Creek	Wolf	High 2004	0.34	no
2001	Pine Creek	Pine 2501	High 2004	0.25	no
2001	Pine Creek	Pine 2601	High 2004	0.08	no
2001	Pine Creek	Pine 2701	High 2004	0.05	no
2001	Pine Creek	Pine 2801	High 2004	0.16	no
2001	Pine Creek	West Fork Pine	High 2004	0.26	no
2001	Muddy Creek	BigMuddy	High 2004	0	no
2001	Upper Malheur	McCoy	Schwabe et al 2003a	0.08	Brook Trout
2001	Upper Malheur	Summit	Schwabe et al 2003a	0.35	Brook Trout

The Burns Paiute Tribe conducted a presence absence survey on the Malheur River from RM 79 to 88 in August of 2002(Schwabe et al. 2003b). In this survey there were 15 rainbow trout collected and were found to be the second least abundant fish species in this section of river.

2.4.2 Redband Trout: Capacity

The capacity of aquatic habitats to sustain native salmonid populations in the Malheur River Subbasin has decreased from the historical context. The capacity of the habitat can be expressed as either realized or unrealized habitat potential. The realized habitat potential of the system reflects the quality and quantity of habitat conditions currently occupied and utilized by a species. Habitat restoration and enhancement can increase the capacity of the Malhuer River Subbasin. The unrealized potential habitat of the Malheur River Subbasin are deficiencies of the quality and quantity of habitat conditions that have been occupied and utilized historically by this species but are no longer available due to anthropogenic causes. These deficiencies limit the species production and population due to the underutilization of historical habitat.

The Qualitative Habitat Assessment (QHA) is a good tool to summarize realized and unrealized potential habitat for the three selected focal species in the Malheur River Subbasin. Current conditions represent the realized potential of the Subbasin for a selected species while reference conditions represent the historic capacity of the system for the selected species. Disparities between the current and reference conditions are a deficiency in habitat quality and quantity. These deficiencies represent the unrealized potential of the Subbasin for the selected species. Furthermore, the Qualitative Habitat Assessment for the Malheur River Subbasin summarizes all known artificial barriers that also limit the capacity of the focal species in the Malheur River Subbasin.

The realized potential for redband trout in the Malheur Subbasin can be summarized by the current distribution. Again, habitat losses summarized in the QHA best summarize the unrealized potential for redband trout within the current distribution of bull trout. Various causes have also reduced the quantity of redband trout habitat. This reduction of quantity of habitat is unrealized potential habitat for redband trout and is summarized in Table 5.

Table 5: Historic habitat not currently utilized by redband trout in the Malheur River Subbasin.

Streams	Historical Habitat Use	Comment
Mainstem Malheur River, Mouth to Namorf	Rearing/migration	Water Quality
Mainstem Malheur River, Warm Springs Reservoir to Griffin Creek	Migration/rearing/spawning	Dewatered during irrigation season
Lower Otis Creek	Migration,/rearing	
Lower Cottonwood Creek	Migration, rearing	
Upper Bosonberg Creek	Spawning/rearing	Blocked by Railroad grade
Willow Creek, mouth to near Brogan	Migration, rearing	Low flows, dewatered during irrigation season
Willow Creek, near Brogan to Malheur Reservoir	Migration, rearing	Channelization, water quality
Bully Creek, Mouth to Bully Creek Reservioir	Migration/overwintering	Channelization, water quality
Bully Creek, Resevoir to South Fork Indian Creek	Migration, rearing	
Cottonwood Creek	Spawning/rearing	

2.4.3 Redband Trout: Productivity

The productivity of trout in the Malheur Basin can be measured by the trend of the population growth rate (USFWS 2002). The estimate of the number of redband trout in the Malheur Subasin is difficult to attain since population surveys have not been conducted on the subbasin scale. Therefore population trends cannot be determined due to the limitation of data.

2.4.4 Redband Trout: Life History Diversity

O. mykiss are taxonomically grouped in the family Salmonidea and are considered to exhibit more complex life history traits than other species grouped within this family. *O. mykiss* may exhibit anadromy that includes migration into and rearing in marine habitats. This migratory form of *O. mykiss* is commonly known as steelhead. Non-anadromous forms of O. mykiss are usually referred to as either “rainbow” or “redband” trout. Non-anadromous forms of *O. mykiss* reside their whole life cycle in freshwater and exhibit either resident, fluvial, and adfluvial life history traits. The relationship between anadromous and non-anadromous life history forms is poorly understood.

Steelhead typically spend the first two years of life in freshwater habitat before migrating out to the ocean. Steelhead will rear in the ocean for two to three years until they mature as adults and then return to natal stream to spawn. This level of maturity varies. Steelhead that re-enter freshwater habitat with immature gonads are termed “stream maturing” (commonly known as summer steelhead) and those that enter freshwater with mature gonads are “ocean maturing” (commonly known as winter steelhead). Summer steelhead require several months to fully sexually mature and spawn while winter steelhead typically are ready to spawn once they enter freshwater. Steelhead typically spawn between December through June. Age at first spawn is typically at age four or five. Steelhead, as well as redband trout, are iteroparous, meaning that they have the ability to reproduce more than once during their life cycle. (FR 1996).

Resident *O. mykiss* forms are simply known as “rainbow” or “redband” trout. Two major subgroups occur in the western United States. The coastal group (commonly referred to as rainbow trout) and inland group (commonly referred to as redband trout). Redband are found east of the cascade crest (FR 1996) that includes those found in the Malheur River Subbasin. These two groupings apply to both anadromous and nonadromous forms of *O. mykiss*.

Most redband trout reach spawning age at three or four years of age, but have been noted to sexually mature as early as age two and as late as age six (Kunkel 1976). “Riffle and pool tail-out habitats with well aerated gravels free of sediment are ideal spawning habitats.” (NRCS 2000). Muhlfeld 2002 found that 80% of the redband trout redds studied in a third order stream in Montana were located in pool tailouts and 76% of all redds were comprised of small gravel (2-6mm). Water flow through the gravel of a redd is essential for the oxygenation of the eggs. Redband trout spawning activities are influenced by temperature and stream flow. “Water temperature and stream discharge apparently influenced the timing and spawning by redband trout in Basin Creek during the spring of 1998. Redband trout began spawning once maximum daily temperatures consistently exceeded 7.0°C" (Muhlfeld 2002). Redband typically spawn in SE Oregon in April and May (Kunkel 1976).

Redband trout require different habitat during different seasons of the year. Redband trout like cool temperatures in clean and clear waters. During the summer months, when water temperatures in the Malheur River tend to be warmer, redband trout need deep pools where the temperatures may be somewhat cooler. Muhlfeld and Bennett (2000b) found that "juvenile and adult fish generally maintained deep positions relatively close to the streambed".

During the fall and winter months, when the air temperature of the headwaters of the Malheur can become well below freezing, redband trout require deep pool refugia. "The lack of extensive movement and small home ranges indicate that adult redband trout found suitable overwintering habitat in deep pools with extensive amounts of cover within a third order stream"(Muhlfeld and Bennett 2000a).

Redband trout require high levels of habitat complexity. "Good trout stream habitat is complex, consisting of an array of riffles and pools, submerged wood, boulders, undercut banks, and aquatic vegetation" (NRCS 2000). Trout need cover for protection from predators. Deep pools, vegetation or submerged wood are a few examples of good cover habitat for redband trout. The importance of mainstem and reservoir habitat to resident populations of redband trout residing in tributaries is not well understood (Hanson et al. 1990).

Redbands tend to be opportunistic feeders and will readily eat available forage. Redband trout rely on a variety of food items ranging from plankton to crayfish. The diet of redband trout is dependant on the surrounding habitat. Trout occupying streams with dense riparian habitat feed heavily on terrestrial organisms while those occupying riffle habitats with large substrates tend to feed heavily on aquatic organisms. In lake and reservoir habitats, invertebreates such as plankton , crustaceans, snails, and leaches are readily fed upon. It is common for larger redband trout to become pisciverous (NRCS 2000).

2.4.5 Carrying Capacity

The carrying capacity for the Malheur River subbasin has been altered from historical aspect. The carrying capacity has decreased for some native aquatic fish species, while others, though not documented, may have benefited from the relatively recent impacts to the Malheur River Subbasin. For the selected focal species, the current carrying capacity has decreased from the historical context.

Bull trout, redband trout, and chinook salmon are salmonids and all require relatively cool water. General limiting factors throughout the Malheur River Subbasin are best described by Hanson et al. (1990) and include nonpoint source pollution, riparian zone conditions, altered streamflow patterns, and unscreened diversions.

Non-point Source Pollution: Temperature, sedimentation, and turbidity are examples of non-point source pollutants. Sedimentation limits the production of salmonids by reducing available spawning habitat, egg survival and limits production of aquatic organisms. Turbidity is the amount of sediment suspended in the water column. Turbidity reduces the ability of sight feeders to obtain food by decreasing light penetration into the water column. Sources of sedimentation and turbidity include: return flow from irrigation diversions, poorly vegetated uplands and streambanks, roads (correlated with road densities), and mining operations.

Riparian Zone Conditions: Healthy riparian vegetation effects water temperature, instream habitat, and provides increased channel stability resulting in lower width to depth ratios. Improvement of riparian conditions throughout the subbasin will increase fish production.

Altered Stream Flow Patterns: Water releases from irrigation reservoirs have altered the historical hydrograph. In particular, the North Fork Malheur River, Malheur River, Bully Creek, and Willow Creek below Agency Valley Dam, Warm Springs Dam, Bully Creek Dam, and Willow Creek Dam respectively have altered historical stream flows. The historic summertime low flow has currently been replaced by a sustained high flow. Though historically low but constant in the winter, winter flows are now extremely low as the reservoirs store water for the next irrigation season. Extreme low winter flows limits fish production in these areas.

Unscreened Diversions: Unscreened diversions divert fish into irrigation ditches where fish may become stranded and die. Oregon law requires screens on all diversions that affect movement of game fish (ORS 498.300 and 509.615). In general, fish screens are required on all diversions of 30 cfs or greater at the expense of the diversion owner (ORS 498.311 and 509.615). For diversions of less then 30 cfs, the pace at which screens are required to be installed, as well as the details of cost sharing, are described in ORS 498.306.

Particular limiting factors that have affected the carrying capacity of the redband trout population in the lower Malheur River (mouth to RM 69), Bully Creek (mouth to Bully Creek Dam), and Willow Creek (mouth to near Brogan) are low winter flows, high turbid summer flows, high water temperature, high levels of nonpoint agricultural pollutants, and degraded aquatic habitat due to channelization (Hanson et al. 1990). Willow Creek, from mouth to near Brogan, the natural channel has been eliminated and the present creek is in a deep cut that serves as drain and irrigation canal (Hanson et al. 1990).

Limiting factors for redband trout in the Malheur River (RM 69 to 123), Willow Creek (near Brogan (RM 41 to RM 30), and North Fork Malheur (RM 0 to 18) are very low winter flows and high turbid summer flows associated with the water releases from the respective dams. Habitat concerns on the Malheur River approximately at RM 138 and below include low summer flows, unscreened irrigation diversions, streambank erosion, and lack of riparian vegetation (Hanson et al. 1990).

Limiting factors on the South Fork Malheur River is elevated stream temperatures, though some habitat is suitable for salmonid rearing between RM 17 and 18, where springs enter the river.

In regards to the subbasin, main limiting factors include habitat degradation and downstream losses to unscreened diversions. Unscreened diversions pose a threat to all native fish species. Culvert barriers also contribute to loss habitat and genetic isolation, especially in headwaters streams where spawning is more likely. Hybridization from non-native *O. mykiss* may pose a threat to native *O. mykiss* populations. Benke (1982) found that hybridization between non-native and native trout has occurred in the Malheur Subbasin but natural selection has favored the genotype of the native *O. mykiss*. Genetic data throughout the subbasin is currently limited.

2.4.6 Redband Trout: Population Trend and Risk Assessment

The estimate of the number of redband trout in the Malheur River Subbasin is difficult to attain since limited population studies have been conducted on the entire basin. Therefore it is hard to determine if the population is increasing, decreasing, or remaining the same. Due to the construction of Agency Valley Dam, Warm Springs Dam, Bully Creek Dam, and Willow Creek Dam, redband trout population have been isolated in the Upper North Fork Malheur River, Upper Malheur River, Bully Creek, and Willow Creek respectively. Though connectivity has been disrupted, risk assessments cannot be determined at this time due to the limited population data on redband trout.

2.4.7 Redband Trout: Unique Population Units

Several populations of redband trout occur in tributaries that do not have perennial flows in their lower reaches, thus these populations are isolated for most of the year (Hanson et al. 1990). ODFW considers these populations to be distinct breeding populations. It is probable that distinct populations of redband trout also occur in other tributaries with perennial flows, but genetic analysis has not been conducted.

Redband trout populations in the Upper North Fork Malheur River, Upper Malheur River, Upper Cottonwood Creek, Upper Willow Creek, and Upper Bully Creek may be considered distinct breeding populations due to habitat isolation caused by dam construction.

2.4.8 Redband Trout: Life History Characteristics of Unique Populations

Very little is known about the life history of redband trout in the Malheur River Subbasin. Though the temperature preference for trout is between 40^{o}-70^{o}F, redband can tolerate temperatures of 80^{o}F given streams are capable of cooling in the evening (Hanson et al. 1990). Genetic isolation from the coastal group of O. mykiss known as rainbow trout is attributed to the ability of the redband trout to resist high temperatures and harsh environments (Behnke 1982). Grover and Hodgson (1999) determined that redband densities in the Crooked River Subbasin in Oregon are not limited by temperature alone, rather such a relationship is more complex and is likely that a suite of factors act on trout densities.

The Burns Paiute Tribe has collected numerous redband trout (>350 mm fork length) from the upper Malheur River (RM 189) in the downstream weir trapbox in 2000 and 2001. Due to the condition of these fish, they were considered post spawn redband trout and the downstream migration of these fish suggest a fluvial life history form present in the Upper Malheur River (Burns Paiute Tribe, in press). The extent of redband trout migration throughout the subbasin is unknown. Resident redband trout are the most relatively abundant salmonid in some reaches of the headwater tributaries that do not sustain resident char populations (Burns Paiute Tribe, in press).

2.4.9 Redband Trout: Genetic Integrity of Unique Populations

Behnke (1982) conducted a taxonomic evaluation on redband trout on 8 drainages in the Malheur River Subbasin. Behnke (1982) found that there was an "overwhelming predominance of the native trout genotype in the Malheur drainage". Of the samples analyzed, Behnke concluded that "pure" redband trout were found in Squaw Creek (T21S, r40E, Sec.24), Hog Creek (T20S R 40E), West Cottonwood Creek (T19S, R30E, Sec, 12), and South Fork Indian Creek (T18S R39E). Slight hybridization detected in the redband trout population in the Little Malheur River (T17S, R36E, Sec 1) and South Fork Cottonwood Creek (T22S R39E and T22S R41E). Samples collected from Calf Creek (T20S R38E Sec 24) were judged to be the most hybridized with coastal rainbow stocks. Although the Calf Creek population phenotypic analysis was evident of hybridization, it is still predominantly of the native redband trout genotype. Slight introgression of non-native genes has occurred in some populations but they have successfully resisted "genetic swamping" due to natural selection has highly favored the native genotype. Behnke speculated that hybridized and non-native O. mykiss are likely to die off in the excessively warm water environments present in the Malheur River Subbasin during the summer months.

A genetic study on redband trout was conducted in the North Fork Malheur River above Agency Valley Dam in 1999 (Schwabe et al. 2001). In this study, 166 samples from redband trout were collected from Beulah Reservoir, Bear Creek, Little Malheur River, Crane Creek, and the upper part of the North Fork Malheur River. From the DNA extracted, it was determined that the differentiation among the five sites was low (F_{st}=0.004). Coupled with the work of Behnke (1982), the redband genotype is predominate in the North Fork Malheur River watershed and there is very little spawning interaction between the native redband trout and the stocked hatchery rainbow trout.

Past genetic studies have found that resident and anadromous life forms of redband trout collected in the same geographical area are more similar to each other than either is to the same form from a different geographic area. Furthermore, anadromous and non-anadromous *O. mykiss* are genetically indistinguishable and are not reproductively isolated. It appears that anadromous and non anadromous *O. mykiss* from the same geographic area may share a common gene pool, at least over evolutionary time periods. (FR 1996). "Most steelhead that originally ascended the Columbia River must have been redband steelhead. Redband trout are found in the headwaters of most major river systems in the area upstream of the Hells Canyon Complex" (Chandler and Chapman 2001). It is unknown if non-anadromous *O. mykiss* that have been blocked and isolated above barrier dams still have the ability to produce anadromous *O. mykiss* life history forms. With the construction of the dams that have halted the migration of anadromous fish, it is unknown if steelhead genes have been eradicated from the Malheur River Subbasin or if the anadromous gene is still present in the current redband trout population. In the Deschutes River, Oregon, otolith microchemistry found that adult steelhead were offspring of anadromous steelhead females and resident rainbow trout were offspring of female resident rainbow (Zimmerman and Reeves 2000).

2.4.10 Redband Trout: Estimate of Historic Status

"Rainbow (redband) trout will forage far from their established territories when food is limited" (NRCS 2000). Since redband trout are able to migrate when conditions are not favorable, it is possible to assume that historically all the rivers and streams in the Malheur drainage basin could have sustained redband trout. When unnatural circumstances such as logging and road building were incorporated into the watershed, the connectivity of many populations was lost. The historic distribution of redband discussed in section 3 of this report was assembled using the expert opinions of the aquatic technical team, and can be considered as the most probable estimate of historic distribution.

2.5 Redband Trout Distribution

Rainbow trout found primarily east of the Cascade Mountains in the U.S. are often called redbands. The historic range of rainbow trout extends from Alaska to Mexico and includes British Columbia, Washington, Oregon, California, Idaho, and Nevada. Rainbow trout are currently found throughout much of the United States (NRCS 2000).

2.5.1 Redband Trout: Current Distribution/spatial Diversity

Redband trout are the most prevalent indigenous salmonid in the Subbasin, having been identified by ODFW in 76 streams in the Malheur River Subbasin (Hanson et al. 1990). They are found in tributaries of the South Fork Malheur and the Malheur River below Warm Springs Reservoir, the mainstem and North Fork and their tributaries and above Bully Creek reservoir and its tributaries. The strongholds for redband trout are similar to that of bull trout – the North Fork and Upper Malheur River upstream of the reservoirs. Downstream of the reservoirs and in smaller tributaries, habitat is considered marginal for spawning and rearing due to low flows, poor water quality, and blockages due to irrigation structures (Hanson et al. 1990, Wayne Bowers, ODFW, pers. comm. 2001). Tributaries redband trout inhabit in the Malheur River Subbasin are shown in Table 6.

Table 6: List of tributaries where redband trout are currently found. Fish presence in these tributaries can either be migratory, rearing, and/or spawning or a combination thereof.

Main Water Body	Associated Tributaries with Redband Trout Present
North Fork Malheur River	Horseshoe Creek; Deadhorse Creek; Swamp Creek; Cow Creek; Little Cow Creek; Sheep Creek; Short Creek; North and South Fork Elk Creeks; Little Crane Creek; Crane Creek; Buttermilk Creek; Fopian Creek; Kate Creek; Bear Creek.
Little Malheur River	Rock Creek; South Bullrun Creek; Lunch Creek; Larch Creek; Canteen Creek; Camp Creek; Hunter Creek.
Upper Malheur River	Meadow Fork Creek; Big Creek; Snowshoe Creek; Lake Creek; McCoy Creek; Corral Basin Creek; Bosonberg Creek; Little Logan Creek; Summit Creek; Larch Creek; Crooked Creek; Dollar Basin Creek; Bluebucket Creek; Pine Creek; Griffin Creek; Otis Creek; Cottonwood Creek; Stinkingwater Creek; Pine Creek; Little Pine Creek; Wolf Creek; Little Wolf Creek; Magpie Creek; Calamity Creek; Gunbarrel Creek.
South Fork Malheur River	Coleman Creek; Crane Creek; Little Crane Creek; Alder Creek; Camp Creek, Swamp Creek; East Swamp Creek; Granite Creek; Big Granite Creek.
Mainstem Malheur River	Calf Creek; Canyon Creek; Hunter Creek; Pole Creek; Black Canyon; Gold Creek; Hog Creek; North Fork Squaw Creek; Cottonwood Creek.
Bully Creek	Rall Canyon Creek; Clover Creek; South Fork Indian Creek; West Fork Cottonwood Creek; Cottonwood Creek; Reds Creek.
Willow Creek	Bridge Creek; South Willow Creek; Basin Creek.

Redband trout currently do not occupy habitats in the Malheur River from RM 0 to 69, Willow Creek from RM 0 to RM 30, and Bully Creek from RM 0 to 14 (Hanson et al. 1990).

Historically this habitat was primarily utilized for migration and provided marginal habitat for rearing.

Redband trout are widely distributed within the Malheur River Subbasin. Though the data is limited, current and historical distribution of redband trout is relatively static. Though management and land use activities have affected the seasonal use of habitat within some reaches of the Malheur Subbasin, redband trout continue to utilize a good percentage of habitats historically available to the species.

2.5.2 Redband Trout: Historic Distribution

Information on the historic distribution of redband trout in the Malheur River Subbasin is also limited. However, redband trout would have had access to the Snake River prior to dam construction. Due to the historic runs of anadromous life history forms of redband trout, known as steelhead, the lower habitats of the subbasin would have at least be considered migratory corridors for the species. It is presumed by local fish and land managers that fluvial redband trout currently utilize habitats in the lower Malheur River Subbasin for winter rearing and migration, but has not been officially documented. Redband trout historically were found in the tributaries of the North Fork, Upper Malheur and the South Fork of the Malheur; in the tributaries of Willow Creek; and in the tributaries of Bully Creek (Hanson et al. 1990).

2.5.3 Redband Trout: Identification of Differences in Distribution Due to Human Disturbance

Redband

Dam construction without fish passage capabilities has isolated habitat and populations of redband trout. Due to the construction of Agency Valley, Warm Springs, Bully Creek, and Willow Creek Dams, redband trout population have been isolated in the Upper North Fork Malheur River, Upper Malheur River, Bully Creek, and Willow Creek respectively. Furthermore, the construction of the irrigation reservoirs and Brownlee Reservoir in 1958 extirpated anadromous *O. mykiss* life history forms from the subbasin. It is unknown if the steelhead genes are still present in the redband trout populations that currently exist in the Malheur River Basin. The loss of anadromous fish has indirectly disrupted the historical fish communities of the Malheur River Subbasin. Human changes that have impacted redband include (Hanson et al., 1990; Bowers et al. 1979):

- Dam construction - many Dams along the Malheur River have no upstream fish passage.
- Livestock grazing – grazing has altered riparian and upland plant communities, and resulted in mechanical damage to streambeds and banks.
- Irrigation - during low water years irrigation contributes to dewatering of streams.
- Stream Channel Manipulation - various activities (e.g., road building, narrowing of flood plains for agriculture) have resulted in increased bank erosion and lowered water tables.

- Timber harvest – has contributed to increased water temperature due to lack of shade; destabilization of hillsides that result in increased sediment production; and alteration of flow pathways from subsurface to surface.

2.6 Chinook Salmon (*Oncorhynchus tshawytscha*): Current Population Data and Status

Chinook salmon, as well as all other runs of anadromous fish species native to the Malheur River Subbasin, are extinct. Construction of Warm Springs Dam on the Malheur River in 1919 and Agency Valley Dam on the North Fork Malheur River in 1935 blocked migration to the headwaters of these streams. The upper reaches of both these streams have miles of excellent spawning gravels and rearing area for anadromous species, but generally lack pool area (Pribyl and Hosford 1985). Construction of Brownlee Dam on the Snake River in 1958 blocked anadromous fish from reaching the Malheur River (NWPPC 2000).

2.6.1 Chinook Salmon: Abundance

The native population of chinook salmon have been extirpated from the Malheur River subbasin.

2.6.2 Chinook Salmon: Capacity

The capacity of aquatic habitats to sustain native salmonid populations in the Malheur River Subbasin has decreased from the historical context. The capacity of the habitat can be expressed as either realized or unrealized habitat potential. The realized habitat potential of the system reflects the quality and quantity of habitat conditions currently occupied and utilized by a species. Habitat restoration and enhancement can increase the capacity of the Malheur River Subbasin. The unrealized potential habitat of the Malheur River Subbasin are deficiencies of the quality and quantity of habitat conditions that have been occupied and utilized historically by this species but are no longer available due to anthropogenic causes. These deficiencies limit the species production and population due to the underutilization of historical habitat.

The Qualitative Habitat Assessment is a good tool to summarize realized and unrealized potential habitat for the three selected focal species in the Malheur River Subbasin. Current conditions represent the realized potential of the Subbasin for a selected species while reference conditions represent the historic capacity of the system for the selected species. Disparities between the current and reference conditions are a deficiency in habitat quality and quantity. These deficiencies represent the unrealized potential of the Subbasin for the selected species. Furthermore, the Quality Habitat Assessment for the Malheur River Subbasin summarizes all known artificial barriers that also limit the capacity of the focal species in the Malheur River Subbasin.

Historical distribution of chinook salmon best describes the species potential habitat. Due to the extinction of chinook salmon, all habitat historically utilized by chinook salmon in the Malheur River Subbasin is unrealized potential habitat for the species. Past studies and early journals of the historical distribution of chinook salmon in the Malheur River Subbasin is discussed in section 3.

2.6.3 Chinook Salmon: Productivity

Extirpated population.

2.6.4 Chinook Salmon: Life History Diversity

Adult spring chinook entered the Columbia River during the early spring months. Migration through the Snake River occurred from late April through July. Spawning occurred from late July through September. The majority of adult spawners were age three to five year old fish.

Spawning typically occurred in the upper reaches of the larger and medium-sized tributary streams. Spawning in some of the smaller tributaries where suitable conditions permitted provided additional habitat.

Emergence of spring chinook fry from the gravel varied upon location but general occurred from about March to May. Chinook salmon eggs will hatch depending upon water temperatures, between 90 and 150 days after deposition. Stream flow, gravel quality, and silt load all significantly influence the survival of developing chinook salmon eggs. Outmigration of juvenile chinook salmon from natal streams varied. For some, outmigration occurred the first fall while others were delayed and outmigrated in the second spring. Typically, outmigration usually occurs in the second spring of life when the smolts are approximately age 1+. Size at outmigration is typically between 4 to 6 inches in length. Spring freshets caused by snowmelt initiated outmigration of chinook smolts. Typical peaks in the hydrograph of the Malheur River occur from March through May. Smolt migration of spring chinook into and through the Snake River en route to the ocean occurred from April through June (Haas 1965).

2.6.5 Chinook Salmon: Carrying Capacity

The carrying capacity for the Malheur River subbasin has been altered from historical conditions. The carrying capacity has decreased for some native aquatic fish species, while others, though not documented, may have benefited from the relatively recent impacts to the Malheur River Subbasin. For the selected focal species, the current carrying capacity has decreased from the historical context.

Bull trout, redband trout, and chinook salmon are salmonids and all require relatively cool water. General limiting factors throughout the Malheur River Subbasin are best described by Hanson et al (1990) and include: nonpoint source pollution, riparian zone conditions, altered streamflow patterns, and unscreened diversions.

Non-point Source Pollution: Temperature, sedimentation, and turbidity are examples of non-point source pollutants. Sedimentation limits the production of salmonids by reducing available spawning habitat, egg survival and limits production of aquatic organisms. Turbidity is the amount of sediment suspended in the water column. Turbidity reduces the ability of sight feeders to obtain food by decreasing light penetration into the water column. Sources of sedimentation and turbidity include: return flow from irrigation diversions, poorly vegetated uplands and streambanks, road densities, and mining operations.

Riparian Zone Conditions: Healthy riparian vegetation effects water temperature, instream habitat, and provides increase channel stability resulting in lower width to depth ratios. Improvement of riparian conditions throughout the subbasin will increase fish production.

Altered Stream Flow Patterns: Water release from irrigation reservoirs has altered the historical hydrograph. In particular, the North Fork Malheur River, Malheur River, Bully Creek, and Willow Creek below Agency Valley Dam, Warm Springs Dam, Bully Creek Dam, and Willow Creek Dam respectively have altered historical stream flows. The historic summertime low flow has currently been replaced by a sustained high flow.. Though historically low but constant in the winter, winter flows are now extremely low as the reservoirs store water for the next irrigation season. Extreme low winter flows limits fish production in these areas.

Unscreened Diversions: Unscreened diversions divert fish into irrigation ditches where fish may become stranded and die. Oregon law requires screens on all diversions that affect movement of game fish (ORS 498.300 and 509.615). In general, fish screens are required on all diversions of 30 cfs or greater at the expense of the diversion owner (ORS 498.311 and 509.615). For diversions of less then 30 cfs, the pace at which screens are required to be installed, as well as the details of cost sharing, are described in ORS 498.306.

Obvious limiting factors on spawning and rearing areas for spring chinook salmon in the Columbia River Basin are: (1) reduction of stream flow and blockage by irrigation projects and push-up dams, (2) blockage by hydroelectric projects; (3) inundation of spawning areas by impoundments; and (4) destruction of spawning and rearing areas by siltation, debris, or pollution from sewage, farming, logging, and mining (Fulton 1968). Blockage by irrigation and hydroelectric projects limit the production of chinook salmon in the Malheur River Subbasin. Though low flow, excessive water temperatures, unscreened ditches, and siltation made some historical spawning and rearing areas unsuitable, upstream areas still appear excellent for spawning (Thompson and Haas 1960; Fulton 1968).

Even before the Snake River dams were built, anadromous fish had been largely eliminated from the Subbasin. In 1950, USFWS biologist Zell Parkhurst wrote:

> *The numerous dams and diversion obstruct the passage of fish and utilize the flow of the Malheur river system for irrigation to such an extent that this river system is no longer of any possible value to salmon. Where formerly large runs of Chinook salmon and steelhead trout utilized the extensive spawning areas there have been so few of these fish for so many years that the capture or even the appearance of a single one is a most unusual and rare occurrence"(USFWS 1950).*

Furthermore, the anadromous population of the Malheur River in the early 1940's was considered to be small due to a low water supply in late summer and some small dams have been placed across the stream (Stanford 1942).

2.6.6 Chinook Salmon: Population Trend and Risk Assessment

Extirpated population.

2.6.7 Chinook Salmon: Unique Population Units

The native population in the Malheur River Subbasin is extinct. No data is available on the native anadromous stocks in this Subbasin.

2.6.8 Chinook Salmon: Life History Characteristics of Unique Populations

The native population in the Malheur River Subbasin is extinct. No data is available on the native anadromous stocks in this Subbasin.

2.6.9 Chinook Salmon: Genetic Integrity of Unique Populations

Chinook salmon populations in the Columbia and Snake Rivers appear to be separated into two large genetic groups: those producing ocean-type out migrants and those producing stream-type out migrants. The first group includes populations in lower Columbia River tributaries, with both spring-run and fall-run (``tule'') life histories. These ocean-type populations exhibit a range of juvenile life history patterns that appear to depend on local environmental conditions. Ocean-type chinook salmon populations east of the Cascade Range Crest include both summer-and fall-run (``bright'') populations, and are genetically distinct from lower Columbia River ocean-type populations. Fall-run populations in the Snake River, Deschutes River, and Marion Drain (Yakima River) form a distinct subgroup.

The second major group of chinook salmon in the Columbia and Snake River drainage consists of spring- or summer-run fish. Based on analysis of genetic clusters, three relatively distinct subgroups appeared within these stream-type populations. One subgroup includes spring-run populations in the Klickitat, John Day, Deschutes, and Yakima Rivers of the mid-Columbia River. A second subgroup includes upper Columbia River spring-run chinook salmon in the Wenatchee and Methow Rivers, but also includes spring-run fish in the Grande Ronde River and Carson Hatchery. This is likely due to the releases of exotic Carson hatchery stock in these basins, rather than to natural genetic similarities. A third subgroup consists of Snake River spring- and summer-run populations in the Imnaha and Salmon Rivers, as well as those in the Rapid River and Lookingglass Hatcheries. The Klickitat River spring-run population appears to be genetically intermediate between upper and lower Columbia River groups.

Wild adult spring and summer chinook salmon were collected at Oxbow and Hells Canyon dams from 1964 to 1969 and were utilized as a stock fish for the Rapid River Hatchery program (Abbott and Stute 2001). No intentional mixing of other hatchery or wild stocks has influenced the genetic integrity of the Rapid River Hatchery Stock. Nevertheless, the inability of hatchery personnel to distinguish between wild and hatchery returns has resulted in introgression between the wild Rapid River stock and the hatchery Rapid River Stock. These two stocks are now genetically indistinguishable (Moran 1998). The Rapid river Hatchery stock would be well suited for use in reintroduction into Snake River Basin above Brownlee Dam (Armour 1990, Chapman 2001).

2.6.10 Chinook Salmon: Estimate of Historic Status

There is no straight forward approach in estimating predevelopment (latter half of 1800's) runs of anadromous fish returns to the Snake River Basin. Any such approach is subject to significant disparagement. For planning document purposes, four approaches have been conducted to estimate historical chinook salmon runs to the Columbia River Basin and will be included in this document.

Chapman (1986) estimated peak salmon runs for a period of 40 years from 1880 to 1920. Chapman used peak harvest data and estimated escapement rates to figure peak run size. Chapman estimated annual peak run of chinook salmon returning to the Columbia River Basin to be 3.75 to 4.34 million. Further breakdown includes: 0.50 to 0.59 spring chinook, 2.00 to 2.50 million summer chinook, and 1.25 million fall chinook.

The Northwest Power and Conservation Council (NWPPC 1986) estimated peak salmon runs based on peak harvest data of the late 1800's and estimated escapement rates to figure peak run size. The NWPPC estimated annual peak run of chinook salmon returning to the Columbia River Basin to be 4.78 to 9.20 million.

The Pacific Fishery Management Council (PFMC 1979) estimated peak salmon runs based on freshwater habitat. The PFMC estimated annual peak run of chinook salmon returning to the Snake River Basin to be 1.40 million.

Chapman and Chandler (2003) considered all three previously discussed estimates for the Columbia River Basin to estimate predevelopment chinook salmon returns to the Snake River above Brownlee Reservoir. Chandler estimated total runs size to be 932,800 to 1,460,000. Further breakdown includes; 760,000 to 1,190,000 spring/summer chinook and 172,800 to 270,000 million fall chinook.

The number of chinook salmon produced by the Malheur River Subbasin is undetermined, but is suspected to have supported "large" runs of salmon (Fulton 1968, 1970) and was considered to be one of the areas most valued salmon breeding streams (Van Dusen 1903). Annual fish camps near the current town of Drewsey, Oregon on the Malheur River was a critical destination for the Northern Paiute (Wadadika) to harvest spring chinook (Whiting 1950).

2.7 Chinook Salmon Distribution

Historically, chinook salmon ranged as far south as the Ventura River, California, and their northern extent reached the Russian Far East. In North America, chinook salmon range from Kotzebue Sound, Alaska, to Santa Barbara, California. Spawning and rearing chinook are found in most of the rivers in this region, with significant runs in the Columbia River, Rogue River, and Puget Sound. As with the bull trout, chinook salmon have declined in overall distribution and abundance during the last century. Declines resulted largely from habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, and past fisheries management practices. These declines have resulted in the listing of numerous stocks of chinook salmon as a threatened or endangered species throughout the western states.

2.7.1 Chinook Salmon: Current Distribution/spatial Diversity

The native population of chinook salmon have been extirpated from the Malheur River subbasin. The estimated miles of lost habitat in the Malheur Subbasin is 205[1] linear miles (NWPPC 1986).

2.7.2 Chinook Salmon: Historic Distribution

Most of the Malheur River was used by anadromous species (Fulton 1970). Before construction of Warm Springs Reservoir in 1919 and Beulah Reservior in 1935, the Malheur River supported runs of spring chinook salmon, steelhead (Haas 1965, Fulton 1970), and probably coho salmon (Thompson and Haas 1960, Pribyl and Hosford 1985, Thompson and Fortune 1967). According to Pribyl and Hosford (1985) "long-time residents of the area can remember spearing salmon in the Logan Valley area of the Upper Malheur and also in the mainstem Malheur near Ontario. Hand forged spears and gaff hooks, used to catch salmon, can still be found at the ranches below Beulah Reservoir on the North Fork Malheur". Logan Valley was ethnographically documented as an important locality for fishing, hunting and gathering by Native American Tribes as well as a trade center (Couture 1978). In July of 1926, the Oregon Fish Commission's Master Fish Warden toured the Malheur Subbasin and noted:

> "About thirty-five miles out of Crane, we crossed Camp Creek, a tributary of the south fork of the Malheur River. Upon investigation there, we found that the stream seemed to be alive with young Chinook salmon and a few steelheads" (Ballagh 1926).

Potential spawning of anadromous fish include but are not limited to the upper Malheur River, North Fork Malheur River, South Fork Malheur River, Willow Creek, Cottonwood Creek, and Bully Creek Historical information on the distribution of chinook salmon in the Malheur River is limited. Information on the historical distribution of anadromous fish runs in the Malheur River is referenced in a few journals written by early explorers and military personnel (Williams 1865, Ogden 1950). These early journals are subject to interpretation as stream names have changed

[1] The aquatic technical team estimates that there are 280 miles of lost habitat in the entire subbasin, including tributaries.

since the early expeditions in the early 1800's. A difficulty in the determination of historical distribution of chinook salmon in particular streams is debated among professional managers and local residents. Many can concur that the upper Malheur River and North Fork Malheur drainages most likely sustained anadromous fish in the Subbasin. The Upper Malheur River, North Fork Malheur River and associated headwaters are presumed to have produced significant numbers of anadromous fish and currently has adequate habitat for anadroumous fish and has been recommended for reintroduction (Buckman 1990, Thompson and Haas 1960).

2.7.3 Chinook Salmon: Identification of Differences in Distribution Due to Human Disturbance

Human disturbance has severely effected chinook salmon populations in the Malheur River Subbasin. Numerous diversion dams and habitat degradation has effected the survival of chinook salmon in the late and early 1900's. The construction of Warm Springs Dam in 1919 and Agency Valley Dam 1926 block the most productive spawning areas for chinook salmon. Lastly, the construction of Brownlee on the Snake River ultimately blocks chinook salmon, as well as all other anadromous fish species, from migrating to the Malheur River. Construction of Ice harbor in 1962, Lower Monumental in 1969, Little Goose in 1970, Lower Granite in 1975, Hells Canyon in 1967, and Oxbow in 1961 have increased the population loss to the Snake River chinook salmon (Chandler *et al* 2001) further complicating reintroduction efforts above Brownlee Reservoir. Though reintroduction is possible, significant changes in the operation and design of these facilities will be required.

2.8 Description of Aquatic Introductions, Artificial Production and Captive Breeding programs

2.8.1 Aquatic Introductions: Current Situation

Non-native, warm water species generally occur in the lower Subbasin and include largemouth and smallmouth bass, black and white crappie, bluegill, warmouth, pumpkinseed, channel catfish, brown bullhead, yellow perch, and flathead catfish (Table 7) (Hanson *et al.* 1990, MOWC 1999). Non-native, cold water species present include brook trout and hatchery rainbow trout. Brook trout are mainly distributed in the upper Malheur River above Warm Springs Reservoir and associated tributaries. Illegal introduction of white crappie was detected in Beulah Reservoir by the US Geological Survey and Burns Paiute Tribe Fish and Wildlife Department (Schwabe et al. 2003, 2004).

Past projects in the Malheur Basin have included the poisoning of the Malheur waters and the restocking of hatchery rainbow trout. In 1955, the whole Upper Malheur drainage above Warm Springs Reservoir was chemically treated with rotenone. That same year, Beulah Reservoir, 23 miles of the North Fork Malheur, 19 miles of the Little Malheur, and several major tributaries were also chemically treated with rotenone. An unknown race of rainbow trout was used to stock both systems. In 1961, Beulah Reservoir and the upper North Fork Malheur were again chemically treated with rotenone and stocked with an unknown race of rainbow trout (Pribyl and Hosford 1985).

Table 7: List of introduced fish species found in the Malheur River Subbasin.

Common Name	Scientific Name	ODFW mgt.	Status	Location
Hatchery Rainbow Trout	Oncorhynchus mykiss	Gamefish	Introduced	Malheur, Pole Creek, Beulah, Warm Springs, Murphy, Cottonwood reservoirs, 9 small BLM stock ponds, and Malheur River from Gold Cr to Warm Springs Dam
Brook Trout	Salvelinus fontinalis	Gamefish	Introduced	Logan Valley streams
Largemouth Bass	Micropterus salmoides	Gamefish	Introduced	Warm Springs Res, Bully Creek Res.
Smallmouth Bass	Micropterus dolomieu	Gamefish	Introduced	Warm Springs Res, Bully Creek Res.
White Crappie	Pomoxis annularis	Gamefish	Introduced	Beulah Reservoir, Warm Springs Res, Bully Creek Res.
Black Crappie	Promoxis nigromaculatus	Gamefish	Introduced	

Bluegill	Lempomis macrochirus	Gamefish	Introduced	Warm Springs Res, Bully Creek Res.
Yellow Perch	Perca flavescens	Gamefish	Introduced	Warm Springs Res, Bully Creek Res.
Channel Catfish	Ictalurus punctatus	Gamefish	Introduced	Warm Springs Res, Bully Creek Res., and lower Malheur River
Brown Bullhead	Ameiurus nebulosus	Gamefish	Introduced	Warm Springs Res, Bully Creek Res.
Common Carp	Cyprinus carpio	Nongame	Introduced	Lower Malheur River
Oriental Weatherfish	Misgurnus anguillicaudatus	Nongame	Introduced	Irrigation and drain ditches in lower Subbasin
Warmouth	Lepomis gulosus	Gamefish	Introduced	
Pumpkinseed	Lepomis gibbosus	Game fish	Introduced	
Flathead Catfish	Pylodictis olivaris		Introduced	

Source: ODFW, Ontario District Office 2001

2.8.2 Aquatic Introductions: Historic Situation

Bull trout were held in low regard by anglers and fishery managers due to its supposedly poor fighting qualities and piscivorous habit (Bond, 1992). Brook trout may have been introduced to the Malheur Subbasin because they were more appealing to local anglers. Detailed stocking records from ODFW date back to 1950, with no indication of stocking brook trout in the Malheur River Subbasin. Stocking records prior to 1950 are incomplete and may explain why there is no record of brook trout introduction into the Malheur River Subbasin. According to anecdotal information, brook trout fry were stocked by pack train in the 1930s by sheepherder volunteers in exchange for free hunting and fishing licenses (Bowers et. al., 1993).

Redband

Hatchery rainbow trout were stocked in the mainstem Malheur downstream of Warm Springs Dam between Riverside and Gold Creek. They were also stocked in a number of irrigation reservoirs and small BLM stock ponds. They have not been stocked in the North Fork or Upper Malheur upstream of the reservoirs since 1993 (Bowers 2001).

2.8.3 Aquatic Introductions: Affect of Straying/Ecologic Consequences

Brook trout occur in the upper Mainstem Malheur River. Hybridization and displacement of bull trout by non-native brook trout is a major concern (USFS 2000, Hanson *et al*. 1990). The presence of sympatric bull and brook trout populations has been considered one of the greatest threats to native bull trout. Brook trout have not been observed in the North Fork Malheur River and are limited to the headwaters of the upper Malheur River. An intensive study of feeding behavior and diet of bull trout and brook trout was recently conducted at two study sites, including one site located in the Malheur Subbasin (Meadow Fork of Big Creek) (Gunckel 2000). The study found that due to similar habitat use, feeding behavior and diet of the two species, and aggressive interactions between the species, that when habitat and prey resources are scarce, direct interference competition is likely and the dominant behavior of brook trout may potentially displace bull trout (Gunckel 2000).

Redband

Redband trout have adapted to the harsh conditions that the Malheur River sometimes provides including high water temperature. When hatchery rainbow trout genes are passed on to the next generation with a redband parent, it may reduce the offspring's ability to survive during harsh conditions.

2.8.4 Artificial Production: Current

Currently, no artificial production facilities for fish are in operation in the Malheur River Subbasin. However, stocking of hatchery rainbow trout to augment the native redband fishery has occurred on an annual basis in the Subbasin since the 1950s (Hanson et al. 1990). Fingerling hatchery rainbow trout continue to be stocked in sections of the mainstem between Riverside and Gold Creek on an annual basis. Fingerling rainbow trout are still stocked in larger irrigation storage reservoirs and a few suitable small BLM stockwater ponds. They have not been stocked in the North Fork or Upper Malheur upstream of the reservoirs since 1993 (Bowers 2001). Surveys to date indicate that most legal sized hatchery fish were removed by fishers or die off rapidly.

2.8.5 Artificial Production: Historic

The headwaters of the Malheur drainage were stocked with hatchery trout, including sections of the Mainstem, North Fork, and Little Malheur Rivers on National Forest land near Forest Service Road 16. A total of about 6,000 yearling rainbow trout were stocked annually at 11 sites. Starting in 1994, ODFW ceased fish stocking in the North Fork and Upper Malheur Rivers upstream of Beulah and Warm Springs Reservoirs to reduce competition and incidental hooking mortality on bull trout.

Ballagh (1926) noted in his investigation of rivers that a hatchery was located in Canyon City, Oregon that is approximately 15 miles from the headwaters of the Malheur River. Artificial production of brook trout may have been reared at this facility and used to stock the upper Malheur River Subbasin in the early 1900s.

2.8.6 Artificial Production: Affect of Straying/ecologic Consequences

Benke (1982) examined redband trout from small tributaries and the mainstem Malheur and Bully Creek and found very little evidence for introgression of hatchery trout characteristics. Benke attributed this to natural selection strongly favoring the native genotype. However, according to Hanson et al. (1990), additional genetic and life history work is needed to explain relationships between populations of redband trout in the Malheur Subbasin, their relationship with the rainbow group, and possible interactions with hatchery rainbow trout.

Redband trout have adapted to the harsh conditions that the Malheur River sometimes provides such as high water temperature. When hatchery rainbow trout genes are passed on to the next generation with a redband parent, it may reduce the offspring's ability to survive during harsh conditions.

2.8.7 Relationship Between Naturally and Artificially-Produced Populations

Benke (1982) examined redband trout from small tributaries and the mainstem Malheur and Bully Creek and found very little evidence for introgression of hatchery trout characteristics. He attributed this to natural selection strongly favoring the native genotype. However, according to Hanson *et al.* (1990), additional genetic and life history work is needed to explain relationships between populations of redband trout in the Malheur Subbasin, their relationship with the rainbow group, and possible interactions with hatchery rainbow trout.

Hatchery stocked rainbow trout compete for food and habitat space with native redband trout. Redband trout have adapted to the harsh conditions that the Malheur River sometimes provides such as high water temperature. When hatchery rainbow trout genes are passed on to the next generation with a redband parent, it may reduce the offspring's ability to survive during harsh conditions.

2.9 Harvest in the Subbasin

Current Harvest Opportunities

No artificial production facilities for fish occur within the Malheur Subbasin. However, stocking of hatchery rainbow trout to augment native redband fisheries has occurred on an annual basis in the Subbasin since the 1950s (Hanson et al. 1990). Brook trout were stocked early in the 20th century, probably from a hatchery that apparently was located near Canyon Creek (Bowers 2001; Ballagh 1926). The headwaters of the Malheur drainage were stocked with hatchery trout, including sections of the Mainstem, North Fork, and Little Malheur Rivers on National Forest land near Forest Service Road 16. A total of about 6,000 yearling rainbow trout were stocked annually at 11 sites. Starting in 1994, ODFW ceased fish stocking in the North Fork and Upper Malheur Rivers upstream of Beulah and Warm Springs Reservoirs to reduce competition and incidental hooking mortality on bull trout. Fingerling trout continue to be stocked in sections of the mainstem between Riverside and Gold Creek on an annual basis. Fingerling rainbow trout are still stocked in larger irrigation storage reservoirs and a few suitable small BLM stockwater ponds. Surveys to date indicate that most legal sized hatchery fish were removed by fishers or died off fairly rapidly.

Benke (1982 in Hanson et al. 1990) examined redband trout from small tributaries and the mainstem Malheur and Bully Creek and found very little evidence for introgression of hatchery trout characteristics. He attributed this to natural selection strongly favoring the native genotype. However, according to Hanson et al. (1990), additional genetic and life history work is needed to explain relationships between populations of redband trout in the Malheur Subbasin, their relationship with the rainbow group, and possible interactions with hatchery rainbow trout.

Bull trout in the Malheur River Subbasin were listed as a threatened species in 1998 (FR 1998). Several angling regulations were changed for the protection of bull trout. Sport harvest of bull trout has been prohibited since March 31, 1991 (Bowers *et al.* 1993). In 1999, angling regulations changed to artificial lure and fly only in the North Fork Malheur River above Beulah Reservoir and the Upper Malheur River above Warm Springs Reservoir to protect bull trout from incidental angling mortality. Bag and size limits of brook trout were eliminated to encourage sport harvest.

Lost Harvest Opportunities

Tribal harvest of fish species has been severely impacted by the construction of irrigation and hydropower facilities throughout the Columbia River Basin. The Wadadika, descendants of the Northern Paiute, were centered around the Malheur and Harney Lakes in the Great Basin of southeast Oregon. In early May, the Wadadika's annual economic cycle began. This included root gathering and preparation by the women while the men traveled to the Malheur River near present day Drewsey, Oregon to prepare and install fish traps for the upcoming Spring Salmon run. At the end of the Spring Salmon run, families would than disperse to hunt (deer, sagehens, ground hogs, antelope, rabbits), collect seeds, roots, berries and crickets then move back to the winter camps around Harney and Malheur Lakes by November (Whiting 1950). The "Salmon Eaters" , a Paiute group that occupied the lower Malheur River, undoubtedly had access to more salmon and steelhead, but details of their subsistence are lacking (NWPPC 1986).

Information regarding the annual harvest of fish by Native Americans is limited. A few estimates have been developed to estimate the magnitude of aboriginal catch in the Columbia Basin before 1850 (NWPPC 1986). The Craig and Hacker Estimate postulated that an average of one pound of salmon per day or 365 pounds per person was consumed annually. The Hewes Estimate postulated that Northern Paiute each consumed an average of 50 lbs. annually. Further adjustment of the Hewes Estimate postulated that Northern Paiute each consumed an average of 143 lbs. annually (NWPPC 1986).

Presently, the anadromous fishery is also considered to be a significant lost resource. Ballagh (1926) reported:

> *"There is a riffle in the [Malheur] River about 300 feet below this dam [Nevada Dam], and it seems that this is the main place where the people come to fish with gigs, spears, hooks – any way to get the fish. I was told that there were as many as one hundred a day there trying to catch salmon as they ascended the river. Lots of cars come in from Idaho for the purpose of taking fish, and if not successful the first time, they would come again. Mr. McClees informed me that there were several parties who made four and five trips from Idaho for this purpose."*

The construction of Warm Springs Dam in 1919 and Agency Valley Dam in 1935 may have had a significant impact on salmon runs and associated fishery by blocking the more productive spawning habitat in the Malheur River Subbasin. Due to the good quality of habitat available in the upper reaches of the Subbasin, investigations into the reintroduction of salmon (Thompson and haas 1960, Buckman 1990) and the development of anadromous fish hatcheries (Ballagh 1926) has been recommended.

3 AQUATIC ASSESSMENT

The purpose of this section of the report is to identify the limiting habitat factors affecting the three aquatic focal species (i.e., redband trout, bull trout, and Spring Chinook salmon), and to prioritize future enhancement and protection activities, both at the watershed and subbasin scales. This information will form the basis of the aquatic habitat recovery plan presented in the Malheur Basin Management Plan.

As noted by the Independent Scientific Advisory Board (ISAB), the challenge faced by fisheries managers in developing recovery plans is how to assemble and analyze incomplete habitat data in such a way that meaningful decisions can be made on the condition and abundance of the focal species (Bilby et al., 2003). The ISAB identified a hierarchy of general approaches, each level of which is more rigorous (and technically defensible) then the previous approach. The first approach that has been widely applied is expert opinion. However, expert opinion is highly subjective, and the underlying assumptions are often not valid or explicitly stated. The second approach is the use of so called expert systems, which allow the opinions of multiple scientists to be combined in a transparent and objective way. The third and most rigorous approach is the use of empirical models that quantitatively relate habitat attributes to population occurrence and abundance. Clearly this third approach would be the preferred alternative in developing recovery strategies for the Malheur, however, our current understanding of habitat conditions, and relationship to species abundance are not at a level that would allow the development of an empirical model approach.

Limiting factors analysis and protection/enhancement prioritization was accomplished for the Malheur subbasin using the Qualitative Habitat Assessment (QHA) model, developed by Mobrand Biometrics, Inc., for the NWPCC. The QHA model is an expert system which allows the systematic compilation and analysis of habitat data that affects the three aquatic focal species selected for the Malheur Subbasin. The following section of the report provides a brief overview of the QHA methodology, while subsequent sections describe the model results.

3.1 Overview of QHA methodology

The version of QHA used for this assessment was the Oregon TOAST version 1.01, dated 10/24/2003. The overview of the methodology presented here is taken from the "QHA User's Guide for Subbasin Planning in Oregon, October 21, 2003" (McConnaha et al., 2003).

The QHA provides a structured, "qualitative" approach to analyzing the relationship between a given fish species and its habitat. It does this through a systematic assessment of the condition of several aquatic habitat attributes (sediment, water temperature, etc.) that are thought to be key to biological production and sustainability. Attributes are assessed for each of several stream reaches within the subbasin. Habitat attribute conditions are then considered in terms of their influence on a given species and life stage. QHA relies on the expert knowledge of natural resource professionals with experience in a given local area to bring together all available information (Figure 2) to describe physical conditions in each reach, and to create an hypothesis about how the habitat would be used by a given fish species. The hypothesis is the "lens" through which physical conditions in the stream are viewed. The hypothesis consists of weights that are assigned to life stages and habitat attributes, as well as a description of how reaches are used by different life stages. These result in a composite weight that is applied to a physical habitat score in each reach. This score is the difference between a rating of physical habitat in a reach under the current condition and a theoretical "reference" condition. The final result is an indication of the relative restoration and protection value for each reach and habitat attribute.

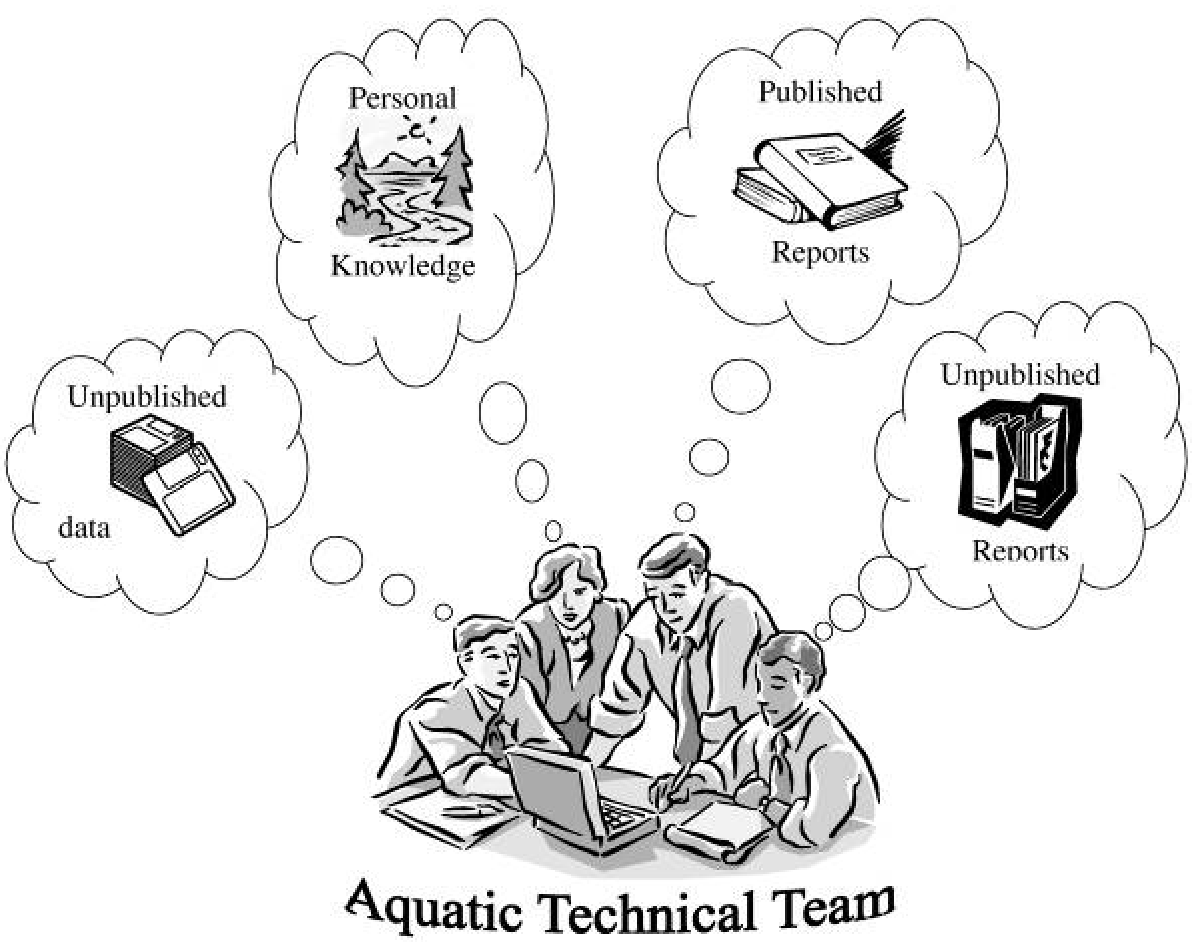


Figure 2. Schematic of data gathering in the QHA process.

QHA should not be viewed as a sophisticated analytical model. QHA simply supplies a framework for reporting information and analyzing the relationships between a species and its environment. It is up to knowledgeable scientists, managers, and planners to interpret results and make actual decisions regarding these relationships and the actions that might be taken to protect or strengthen these relationships.

To review, the intermediate products from the QHA process are:

1. Division of the streams in the watershed into the largest possible units having reasonably homogenous habitat characteristics (i.e., stream reaches) – See Section 3.2 below,

2. Characterization of current and historical habitat conditions by stream reach using local experts to synthesize existing information (Figure 2) – See Section 3.3 below,

3. Development of aquatic species hypotheses that describe our understanding of how the focal species use stream habitat, and which habitats are most important to different life stages – See Section 3.4 below.

These intermediate results are then use to develop the final QHA products that include:

4. A summary of existing conditions and limiting factors at both the watershed (Section 3.5) and subbasin (Section 3.6) scales, and

5. A prioritization of enhancement and protection measures at both the watershed and subbasin scale (Section 3.7).

3.1.1 Subbasin Effects Not Addressed by QHA

The Aquatic Assessment Team identified several additional constraints to performance of the focal species that were not adequately addressed by QHA. These items, described briefly below, were addressed in a qualitative fashion in the Management Plan section of the report.

Major Dams

The QHA identifies obstructions to fish movement related to irrigation diversions, dewatered sections, and minor dams, but does not provide an adequate mechanism to capture the full effect of large dams on fish movement throughout the subbasin. The major dams are basin-scale limiting factors that are significant barriers to fish movement that block access, isolate fish populations, and prevent access to seasonal use of habitats.

Exotic Species

Non-native, warm- and cold-water species are found throughout the subbasin (see section 2.8 above). These species affect the performance of the focal species through direct competition for scarce resources, and in some cases, through piscivorous behavior. The QHA does not have a mechanism to deal with this significant issue in the Malheur subbasin

Aquatic Out of Subbasin Effects

The primary Out-of-Subbasin effect is blockage of fish passage at dams on the Snake River and Columbia Rivers that have contributed to extirpation of anadromous fish stocks. Assessing mainstem river passage of anadromous species of fish is out of scope of this project. These effects will instead be addressed as recommendations for substitution projects or research and monitoring projects that evaluate the obstacles to returning anadromous fish to the Subbasin.

3.2 Reach Selection and Focal Species Range

The first step in conducting the QHA assessment of the Malheur subbasin was to define the subset of streams that would be included. Only those streams that were estimated to currently or historically have supported one or more of the three focal species were included in the assessment. The current and historic range of the focal species were estimated using information summarized in section 0 above, supplemented by the expert opinion of the aquatic technical team.

The next step was to divide the subset of streams identified above into reaches. A reach is a linear segment of stream that is reasonably homogonous with respect to hydrologic and ecologic characteristics and functions. In defining reaches the aquatic technical team sought to keep the total number of reaches as small as possible (for the sake of efficiency) without losing ecological resolution. Sixty-three separate reaches were defined within the Malheur subbasin for the purpose of this assessment. Stream reaches are shown in Attachment 1 - Stream reach maps, and summarized in Attachment 2 - General Assessment reach characteristics and focal species use by reach. For purposes of analysis and summarization the following hierarchy has been defined:

- The Malheur **<u>Subbasin</u>** (entire planning area)
    - Six **<u>Watersheds</u>** (i.e., Main Malheur, Upper Malheur, Willow Creek, Bully Creek, North Fork Malheur, and South Fork Malheur)
        - Sixty-three **<u>Reaches</u>** (see Figure 41 - Figure 46 in attachment one at the end of this report for reach maps)

Once the reaches were divided the aquatic technical team evaluated the importance of each reach to each of the focal species. The purpose of this exercise was to identify those reaches where the focal species is present, and to weight the importance of that reach to each of four life stages: 1) spawning/incubation, 2) summer rearing, 3) winter rearing, and 4) migration. Weightings ranged from 0 to 2 where 0 is not present and 2 would be the highest possible weighting.

For the current condition the technical team used their understanding of focal species use of the streams to evaluate the importance of each reach to each life stage. For the reference condition the team extrapolated from our understanding of what conditions are required by fish at a given life stage and what the conditions would be like if the subbasin were fully restored. In many cases the current distribution was the same as the reference conditions, the primary difference being in those reaches where the species is currently not present, or reaches where current conditions preclude use by a given life stage.

3.3 Current and Historic Habitat Conditions

Within each reach the aquatic technical team characterized current and historical habitat conditions for each of eleven habitat attributes. These rating tables were the heart of the assessment, and the most time-consuming part of the assessment.

For the purposes of this assessment "current" conditions were defined as the condition of the aquatic environment as it exists today. "Reference" conditions were defined as what a given reach would be like if the system were restored to the fullest extent possible short of disrupting infrastructure that is vital to modern society and that is likely to remain in place for the foreseeable future. In those reaches with little cultural modification this reference condition might equate to "historic" conditions (i.e., conditions that were in place prior to European settlement). It is critical to note that reference conditions were not considered to be static, or "one size fits all". To the extent practicable the aquatic assessment team considered how conditions would vary among the reference reaches due to natural environmental conditions and processes. For example, the reference riparian condition for the lower reaches of Willow Creek were recognized as being different from reference riparian conditions in the headwaters of the North Fork Malheur. The lower Willow Creek riparian areas in the reference condition most likely consisted of a narrow and often discontinuous band of hardwood trees (black & narrow leaf cottonwoods, aspen) and shrubs (willows, mountain alder, hawthorn, chokecherry, wood's rose & silver sage). In contrast, headwater streams in the Blue Mountains would have had reference riparian conditions that consisted of coniferous trees (e.g., subalpine fir) and shrubs (e.g., willows, mountain alder) and, in some areas, meadow vegetation, in the immediate streamside area, with large conifers on the adjacent hillslopes.

The eleven habitat attributes considered are listed in Table 8. These are the habitat characteristics that are generally thought to be the main "drivers" of fish production and sustainability.

Table 8. Definitions of QHA habitat attributes

Habitat Attribute	Definition
Riparian Condition	Condition of the stream-side vegetation, land form and subsurface water flow.
Channel Stability	The condition of the channel in regard to bed scour and artificial confinement. Measures how the channel can move laterally and vertically and to form a "normal" sequence of stream unit types.
Habitat diversity	Diversity and complexity of the channel including amount of large woody debris (LWD) and multiple channels
Key Habitat	The complex of habitat types formed by geomorphic processes (including LWD) within the stream (e.g. pools, riffles, glides etc.).
Sediment Load	Amount of fine sediment within the stream, especially in spawning riffles
High Flow	Frequency and amount of high flow events.
Low Flow	Frequency and amount of low flow events.
Oxygen	Dissolved oxygen in water column and stream substrate
High Temperature	Duration and amount of high summer water temperature or low winter temperatures that can be limiting to fish survival

Habitat Attribute	Definition
Pollutants	Introduction of toxic (acute and chronic) substances into the stream

The reference and current condition ratings describe the relative value of the physical environment to the focal species that use the reach. Each of the eleven habitat attributes (Table 8) is rated for each of the 63 reaches according to the following rating scheme:

0 = 0% of optimum **2 = 50% of optimum** **4 = 100% of optimum**
1 = 25% of optimum **3 = 75% of optimum**

Where optimum is the ideal condition (i.e., as good as it gets) for the reach. Given this definition of optimum, all reaches should be (and were) rated as "4.0" (i.e., 100% of optimum) for all attributes in the reference condition[2] (C. McConnaha, Mobrand Biometrics, pers. comm., 11/3/2003).

The aquatic technical team rated current conditions during a series of meetings that took place during Fall 2003 and Winter 2003/2004 in Vale, Ontario, and Burns, Oregon. Members of the team synthesized existing information from a variety of sources (e.g., Figure 2) in arriving at current reach ratings. In only one instance (i.e., Upper Malheur watershed Reach #4 – Cottonwood Creek) did the team members feel that there was insufficient knowledge to provide reach ratings for the 11 attributes. Additionally, the team did not feel that the QHA ratings were appropriate to apply to the four primary reservoirs in the subbasin (Warm Springs, Malheur, Bully Creek, and Beulah Reservoirs), consequently these reaches were not rated. Results for the current habitat attribute ratings are summarized as a series of bar charts included in Attachment 3 - Current Aquatic Habitat Attributes.

Also included, as part of the reach rating, was an explicit estimation of the level of confidence the assessment team had in their current habitat ratings using a rating scale that ranged from 0 (speculative) to 1 (expert opinion) to 2 (well documented). This rating identified the teams overall knowledge of individual reaches. These individual confidence ratings provide a sense of where understanding of conditions and processes within the subbasin is strong, and where additional understanding is needed.

The QHA spreadsheet also provides a separate worksheet to document the information used in the reach ratings. However, in practice the aquatic team found this cumbersome to use. As an

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[2] This is an important point, and a source of some confusion to reviewers. By definition, the reference condition for all attributes in all reaches is 4.0, i.e., 100% of optimum. However, this does not imply that reference conditions are the same in all reaches. As the example on the preceding page indicates, the reference riparian condition for the lower reaches of Willow Creek most likely consisted of a narrow discontinuous band of hardwood trees and shrubs. In contrast, headwater streams in the Blue Mountains would have had reference riparian conditions that consisted of coniferous trees and shrubs and/or meadow vegetation, in the immediate streamside area, with large conifers on the adjacent hillslopes. In both cases however, the reference condition was rated as 4.0; optimum (or as good as it gets) for that particular location.

alternative a documentation matrix was assembled that lists the information that was synthesized by the team when making the reach ratings. This is available in Attachment 4 - Documentation Matrix.

3.4 Aquatic Species Hypothesis

The QHA process requires the aquatic technical team to develop species-specific hypotheses regarding the relative importance of each life stage to overall fish productivity and sustainability. Life stages are first rated as to their overall importance in the subbasin. Four life stages are considered in this analysis – spawning, summer rearing, winter rearing and migration. For each focal species the technical team rated life stages on a 4 to 1 scale; with 4 being most important. This process defines the life stage(s) that are used to evaluate the importance of the various habitat factors. The life stage rank hypotheses for the Malheur subbasin are given for redband trout in the first row of Table 9; for bull trout in the first row of Table 10; and for Spring Chinook in the first row of Table 11 below.

Table 9. Species habitat hypothesis - Focal Species: Redband Trout in Malheur Subbasin

	Spawning/ Incubation	Summer Rearing	Winter Rearing	Migration
Life Stage Rank (1-4)	2.5	4.0	3.0	1.0

Weight assigned to each attribute relative to its importance to the life stage (value range: 0-2)				
Riparian Condition	2.0	2.0	1.0	0.5
Channel stability	2.0	2.0	2.0	1.0
Habitat Diversity	2.0	2.0	2.0	0.8
Fine sediment	2.0	1.5	1.5	0.0
High Flow	2.0	1.0	1.0	1.5
Low Flow	2.0	2.0	0.5	2.0
Oxygen	1.0	2.0	0.0	1.0
Low Temp	1.0	0.0	2.0	0.0
High Temp	2.0	2.0	0.0	0.0
Pollutants	0.0	1.0	1.0	1.0
Obstructions	0.0	0.0	1.0	2.0

Table 10. Species habitat hypothesis - Focal Species: Bull Trout in Malheur Subbasin

	Spawning/incubation	Summer Rearing	Winter Rearing	Migration
Life Stage Rank (1-4)	3.5	4.0	3.5	2.0

Weight assigned to each attribute relative to its importance to the life stage (value range: 0-2)				
Riparian Condition	2.0	2.0	2.0	0.5
Channel stability	2.0	2.0	2.0	1.0
Habitat Diversity	2.0	2.0	2.0	0.8

	Spawning/incubation	Summer Rearing	Winter Rearing	Migration
Fine sediment	2.0	1.5	1.5	0.0
High Flow	2.0	1.0	1.0	1.5
Low Flow	2.0	2.0	0.5	2.0
Oxygen	1.0	2.0	0.0	1.0
Low Temp	2.0	0.0	2.0	0.0
High Temp	2.0	2.0	0.0	0.0
Pollutants	0.0	1.0	1.0	1.0
Obstructions	0.0	0.0	1.0	2.0

Table 11. Species habitat hypothesis - Focal Species: Spring Chinook in Malheur Subbasin

	Spawning/incubation	Summer Rearing	Winter Rearing	Migration
Life Stage Rank (1-4)	4.0	3.0	2.0	4.0
Weight assigned to each attribute relative to its importance to the life stage (value range: 0-2)				
Riparian Condition	2.0	2.0	1.0	0.5
Channel stability	2.0	2.0	2.0	1.0
Habitat Diversity	2.0	2.0	2.0	1.0
Fine sediment	2.0	1.5	1.5	0.0
High Flow	2.0	1.0	1.0	1.5
Low Flow	2.0	2.0	0.5	2.0
Oxygen	2.0	2.0	0.0	1.0
Low Temp	1.0	0.0	1.0	0.0
High Temp	2.0	2.0	0.0	1.0
Pollutants	2.0	1.0	1.0	1.0
Obstructions	0.0	1.0	1.0	2.0

These overall life stage rank values indicate that for redband trout the aquatic technical team believes that summer rearing is the most important life stage, and migration the least likely to be limiting (Table 9). For bull trout the team believes that summer rearing is also the most important life stage, however spawning/incubation and winter rearing are almost as important (Table 10). In contrast, the technical team recognized that for Spring Chinook both migration and spawning/incubation are the most important life stages (Table 11).

In addition to the overall life stage ranking the aquatic technical team also ranked rate each habitat characteristic for each life stage. The ranking scale ranged from 0 to 2, with 0 indicating that the habitat attribute has no effect on the life stage, and value of 1 indicating some effect, and a value of 2 indicating a critical effect.

The combined rating for both life stage and habitat characteristics establishes a simple hypothesis about how each focal species interacts with its environment in the Malheur subbasin. The QHA applies these hypotheses for each of the three focal species to the attribute ratings described in section 3.3 above. The result is several output products (described in detail in following sections) that identify:

1) Within-reach ranking of which habitat attribute is most limiting,

2) Among-reach ranking of which reach would most benefit the focal species of concern were that reach restored to reference condition, and

3) Among-reach ranking of which reach is most important to protect in order to benefit the focal species of concern.

3.5 Reference and Current Conditions, and Limiting Factors, at the Watershed Scale

In this section the results of the QHA are presented and summarized by watershed. A summary is first presented for each of the eleven QHA attributes (i.e., Table 8), for both reference and current conditions. This summary is then followed by an overall summary of limiting factors at the watershed scale for each of the three focal species.

3.5.1 Main Malheur Watershed1

The Main Malheur watershed contains five QHA reaches (see Figure 41 for reach locations, and Attachment 2 - General Assessment reach characteristics and focal species use by reach). The following is a summary of reference and current conditions for each of the eleven QHA attributes.

Channel Stability

Reference conditions: For the purposes of QHA channel stability is defined as the condition of the channel in regard to bed scour and artificial confinement. Channel stability in this context is a measure of how the channel can move laterally and vertically and to form a "normal" sequence of stream unit types. As is true for all of the habitat attributes, there are no specific reference conditions available for channel condition in the Malheur subbasin. We can approximate reference conditions by 1) classifying channels into a common framework, and 2) inferring reference characteristics based on channel type. No single stream classification has been performed for the entire assessment area. Consequently, a simple stream classification was performed based on channel gradient and confinement. Channels with similar gradient and confinement would be expected to respond similarly to inputs of water, sediment and large woody debris.

Gradient was calculated for the assessment reaches within GIS using USGS 1/3 arc-second (approximately 10-meter resolution) digital elevation model (DEM) data (USGS, 2004a), and reference confinement was estimated using valley slope perpendicular to the stream reach. Channel gradient classes and reference channel confinement classes are shown in Figure 3. The distribution of reference gradient and confinement for the Main Malheur watershed is shown in Figure 4. Low-gradient unconfined channels made up the largest single grouping within the Main Malheur watershed (Figure 4). In their reference condition these channels would most likely have been classified as Rosgen type C, or E channels (Table 12; Rosgen, 1996). The next largest grouping is the low-gradient confined channels (Figure 4). In their reference condition these channels would most likely have been classified as Rosgen type F channels (Table 12). The remaining channels are all in confined category (Figure 4), and in their reference condition would most likely have been classified as Rosgen type Aa+, A or B channels, depending on gradient (Table 12).

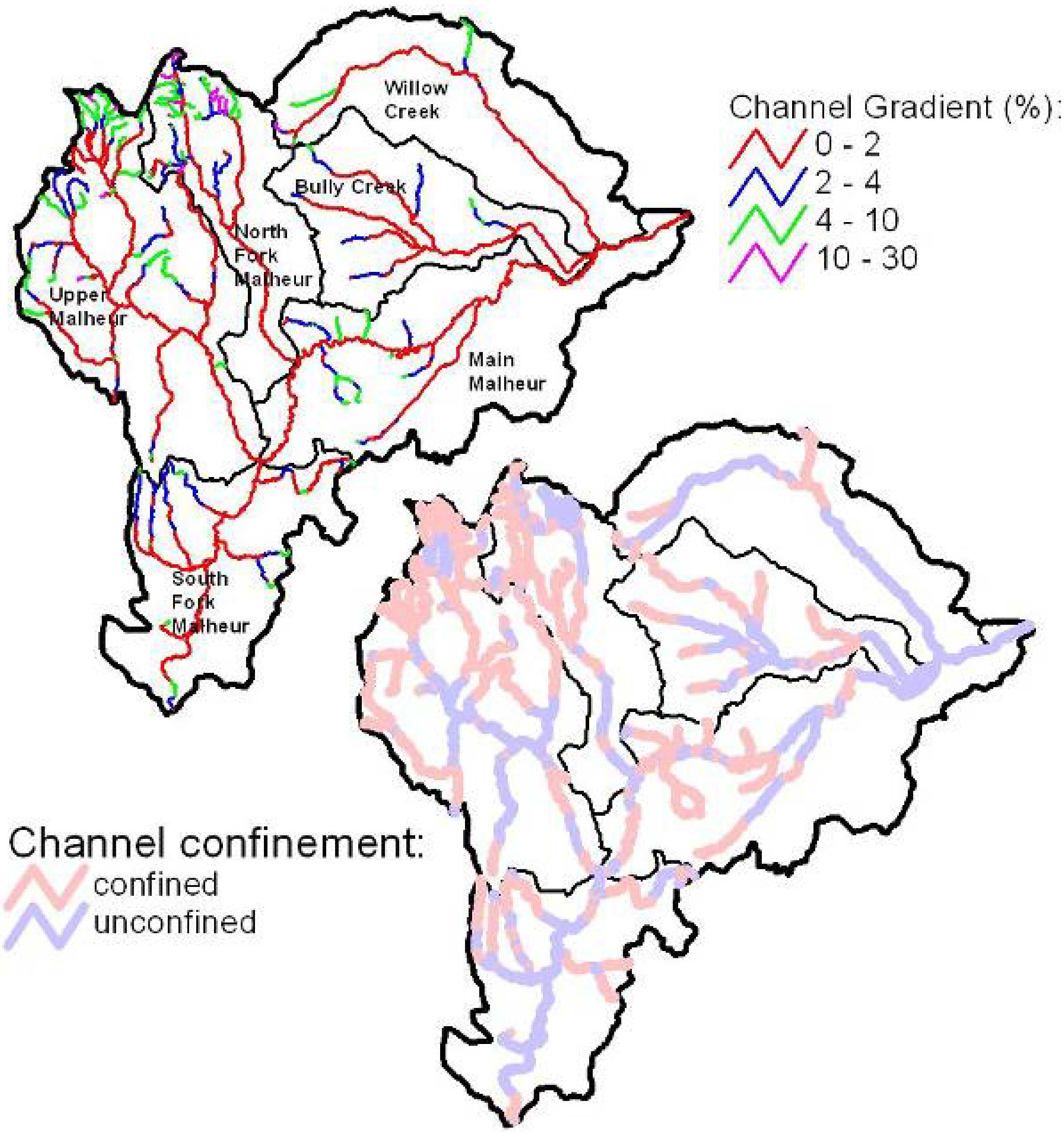

Figure 3. Estimated reference channel gradient and confinement for QHA reaches within the Malheur Subbasin.

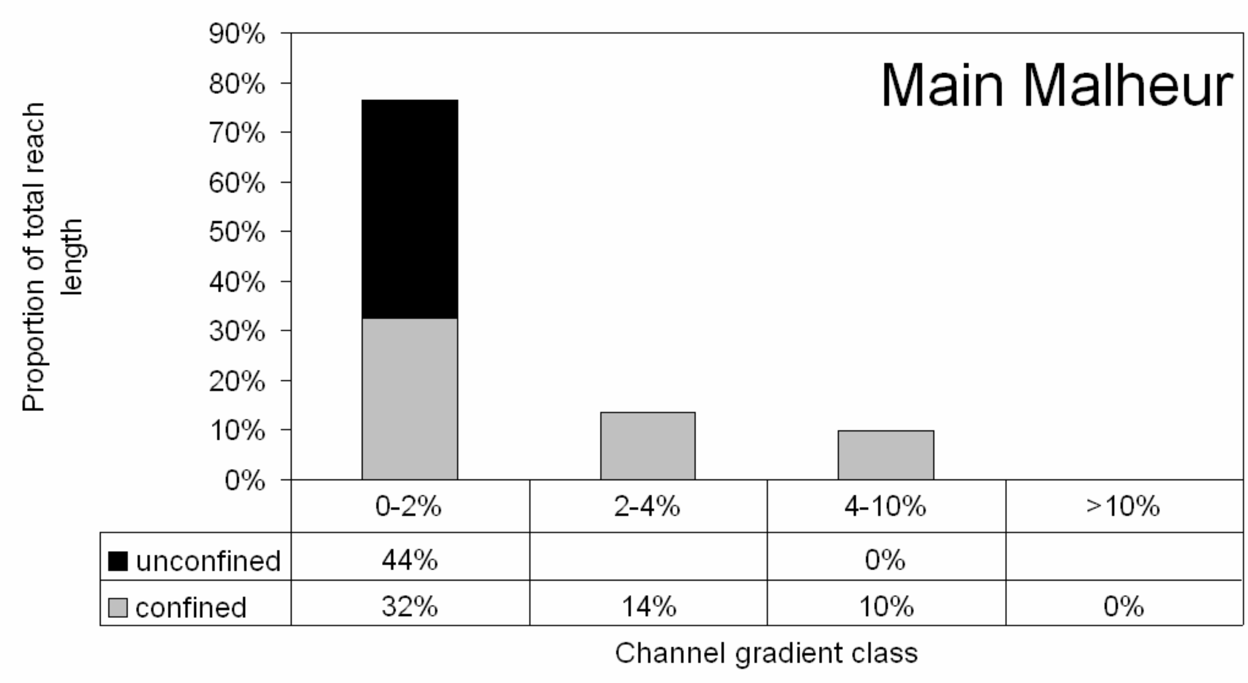

Figure 4. Estimated distribution of reference channel type in the Main Malheur watershed.

Table 12. General stream type descriptions (from Rosgen, 1996).

Stream type	General description	Entrench-ment ratio	W/D ratio	Sinuos-ity	Slope	Landform/soils/features
Aa +	Very steep, deeply entrenched, debris transport streams.	< 1.4	< 12	1.0 to 1.1	>0.10	Very high relief. Erosional, bedrock or depositional features; debris flow potential. Deeply entrenched streams. Vertical steps with/deep scour pools; waterfalls.
A	Steep, entrenched, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.	< 1.4	< 12	1.0 to 1.2	0.04 to 0.10	High relief. Erosional or depositional and bedrock forms. Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in associated step-pool bed morphology.
B	Moderately entrenched, moderate gradient, riffle dominated channel, with infrequently spaced pools. Very stable plan and profile. Stable banks.	1.4 to 2.2	> 12	> 1.2	0.02 to 0.039	Moderate relief, colluvial deposition and/or residual soils. Moderate entrenchment and W/D ratio. Narrow, gently sloping valleys. Rapids predominate with occasional pools.
C	Low gradient, meandering, point-bar, riffle/pool, alluvial channels with broad, well defined floodplains	> 2.2	> 12	> 1.4	< 0.02	Broad valleys with terraces, in association with floodplains, alluvial soils. Slightly entrenched with well-defined meandering channel. Riffle-pool bed morphology.
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks.	n/a	> 40	n/a	< 0.04	Broad valleys with alluvial and colluvial fans. Glacial debris and depositional features. Active lateral adjustment, with abundance of sediment supply.
DA	Anastomosing (multiple channels) narrow and deep with expansive well vegetated floodplain and associated wetlands. Very gentle relief with highly variable sinuosities. Stable streambanks.	> 4.0	< 40	Vari abl e	< 0.005	Broad, low-gradient valleys with fine alluvium and/ or lacustrine soils. Anastomosed (multiple channel) geologic control creating fine deposition with well-vegetated bars that are laterally stable with broad wetland floodplains.
E	Low gradient, meandering riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander width ratio.	> 2.2	< 12	> 1.5	< 0.02	Broad valley/meadows. Alluvial materials with floodplain. Highly sinuous with stable, well vegetated banks. Riffle-pool morphology with very low width/depth ratio.
F	Entrenched meandering rime/pool channel on low gradients with high width/depth ratio.	< 1.4	> 12	> 1.4	< 0.02	Entrenched in highly weathered material. Gentle gradients, with a high WjD ratio. Meandering, laterally unstable with high bank-erosion rates. Riffle-pool morphology.
G	Entrenched "gulley" step/pool and low Width/depth ratio on moderate Gradients.	< 1.4	< 12	> 1.2	0.02 to 0.039	Gulley, step-pool morphology with moderate slopes and low W\D ratio. Narrow valleys, or deeply incised in alluvial or colluvial materials; i.e., fans or deltas. Unstable, with grade control problems and high bank erosion rates.

Current condition: Current channel stability is significantly impaired within both mainstem Malheur River reaches within the Main Malheur watershed (Figure 47; see Figure 41 for reach locations). Channel stability has been compromised in this area due to confinement by highways and railroads, as well as diking and straightening associated with agricultural operations. Current channel stability is also significantly impaired within the lower Cottonwood Creek reach (Figure 47), where a majority (50%) of the channel length was blown out due to a flood event in 1984. The stream currently goes sub surface within this reach. The remaining two QHA reaches within the Main Malheur watershed; in upper Cottonwood Creek and the "Other tributaries" reach, are in relatively good shape with respect to channel stability (Figure 47).

Riparian Condition:

Reference conditions: For the purposes of QHA, Riparian Condition is defined as the condition of the stream-side vegetation, land form and subsurface water flow. Reference riparian vegetation conditions were estimated for the entire Malheur subbasin using two data sources. GIS maps showing historical vegetation, available from the Oregon Natural Heritage Program (ONHP, 2002), were used to characterize reference riparian conditions. However, ONHP data is mapped at a 30-meter pixel resolution, and as such, is produced at too coarse of a resolution to capture reference conditions in the near-stream area. Consequently, riparian descriptions prepared for EPA Ecoregions (see Subbasin Overview for Ecoregions map; WPN 2001) were used to further refine reference riparian conditions. The underlying geomorphic variability among streams (i.e., Figure 4) also influences riparian conditions. For example, wide areas of phreatophytic vegetation would have been expected to develop along low-gradient unconfined reaches in response to fluvial deposition of fine sediments, and a high near-stream water table.

Almost the entire riparian length in the Main Malheur watershed is located within either the Snake River Plain or Northern Basin and Range level III Ecoregions (see Subbasin Overview for Ecoregions map). Reference conditions in the immediate streamside area would have consisted primarily of hardwood species (black & narrow leaf cottonwoods, aspen) and shrubs (willows, mountain alder, hawthorn, chokecherry, wood's rose & silver sage) (WPN, 2001). Moving laterally away from the streams the riparian and adjacent upland vegetation consisted primarily of Wyoming big sagebrush (58% of total length), Riparian hardwoods (15%), other sagebrush species (Basin big sagebrush, low sagebrush-Wyoming big sagebrush, Low sagebrush, Wyoming big sagebrush-squawapple – 10%) (ONHP 2002).

Current condition: Current riparian condition was rated as being somewhat impacted (approximately 75% of riparian function as compared to reference) within all reaches of the Main Malheur watershed, with the exception of the lower Cottonwood Creek reach, which has been heavily impaired (25% of reference function; Figure 48; see Figure 41 for reach locations). Riparian function has been compromised in this area due to the loss of cottonwood galleries associated with highways and railroads, and agricultural operations. Impacts within the lower Cottonwood Creek reach are due to channel damage associated with a large flood event in 1984.

Habitat Diversity

Reference conditions: For the purposes of QHA habitat diversity is defined as the diversity and complexity of the channel, including amount of large woody debris (LWD) and multiple channels. It includes the complex of habitat types formed by geomorphic processes within the stream (e.g. pools, riffles, glides etc.). In the reference condition habitat diversity would have varied due to the overriding valley geomorphology (i.e., Figure 4), as well as the biological limitations of adjacent riparian areas (with respect to LWD inputs). As such, habitat diversity is closely related to the previous two environmental attributes. Sequences of habitat units would be expected to follow a distribution that was consistent with channel type (Table 12). Given this inherent variability it is not possible to use a static metric (e.g., frequency of pools, frequency of LWD pieces) to describe habitat diversity in the reference condition, and it is beyond the scope of this document to develop reference conditions. In assembling the QHA database participants considered, based on expert opinion, what the likely habitat conditions were in the reference state, and compared present conditions against these hypothesized reference conditions.

Current condition: Current habitat diversity is similar to current channel stability for the five reaches in the Mainstem Malheur watershed. Habitat diversity is significantly impaired within both mainstem Malheur River reaches (less then 50% of reference condition), and is also significantly impaired within the lower Cottonwood Creek reach (approximately 25% of reference, Figure 49; see Figure 41 for reach locations). Activities identified in the previous sections (i.e., confinement by highways and railroads; diking, straightening and loss of cottonwood gallery forests associated with agricultural operations; flood damage in lower Cottonwood Creek reach) are responsible for the loss of diversity. The remaining two reaches within the Main Malheur watershed; in upper Cottonwood Creek and the "Other tributaries" reach, are in relatively good shape (75% reference) with respect to habitat diversity (Figure 49).

Fine Sediment

Reference conditions: Fine sediment is defined as the amount of fine sediment within the stream, especially in spawning riffles. In the reference condition fine sediment inputs would vary around the basin due to the underlying geology of the upstream contributing area, variations in watershed and riparian vegetation, and variability in the timing and distribution of disturbance (most notably fire and floods). Fine sediment deposition would be driven by the overriding valley geomorphology (Figure 4), which would result in higher deposition within the low gradient, unconfined reaches, and higher rates of deposition in steeper more confined channels. Reference sediment levels would also be driven by natural rates of bank erosion (driven in part by the reference riparian vegetation conditions), upland vegetation and disturbance, and flow regime.

Current conditions: Current fine sediment levels are severe in the two Mainstem Malheur reaches (approximately 50% of reference), and the lower Cottonwood Creek reach (approximately 25% of reference, Figure 50; see Figure 41 for reach locations). Activities influencing sediment levels include high sediment load due to irrigation return flows in the mainstem, and the recent flood damage in lower Cottonwood Creek. The remaining two reaches within the Main Malheur watershed; in upper Cottonwood Creek and the "Other tributaries" reach, are in relatively good shape (75% reference) with respect to current fine sediment levels (Figure 50)

High Flow

Reference conditions: High flow is defined within QHA as the frequency and amount of high flow events. Volumes of runoff within the entire Malheur subbasin are greatest during the spring months, occurring primarily from runoff associated with snowmelt (WPN, 2001). Peak flows occur typically in the winter months and can be generated by either rainstorms or rain-on-snow events, particularly in the northern area bordering the Blue Mountains. Frozen ground contributes to the winter flooding events. Spring peak flows associated with both rain and snowmelt also occur in portions of the Subbasin. Summer rainstorms also generate peak flows in this area, although infrequently.

Current conditions: Current high flow conditions approximate reference conditions within all three tributary reaches in the Main Malheur watershed (Figure 51; see Figure 41 for reach locations), however, high flows are adversely affected (approximately 50% of reference) by dam operations on the mainstem Malheur, which result in significant decreases in wintertime high flows.

Low Flow

Reference conditions: Low Flow is defined within QHA as the frequency and amount of low flow events. Natural volumes of runoff are lowest in both tributary (Figure 5) and mainstem reaches (Figure 6) during the late summer and early fall. Within low-elevation tributaries (i.e., those lacking significant snow pack) the ratio of low flow to high flows is quite large (Figure 5) as compared to mainstem reaches (Figure 6) which are buffered by late season snowmelt.

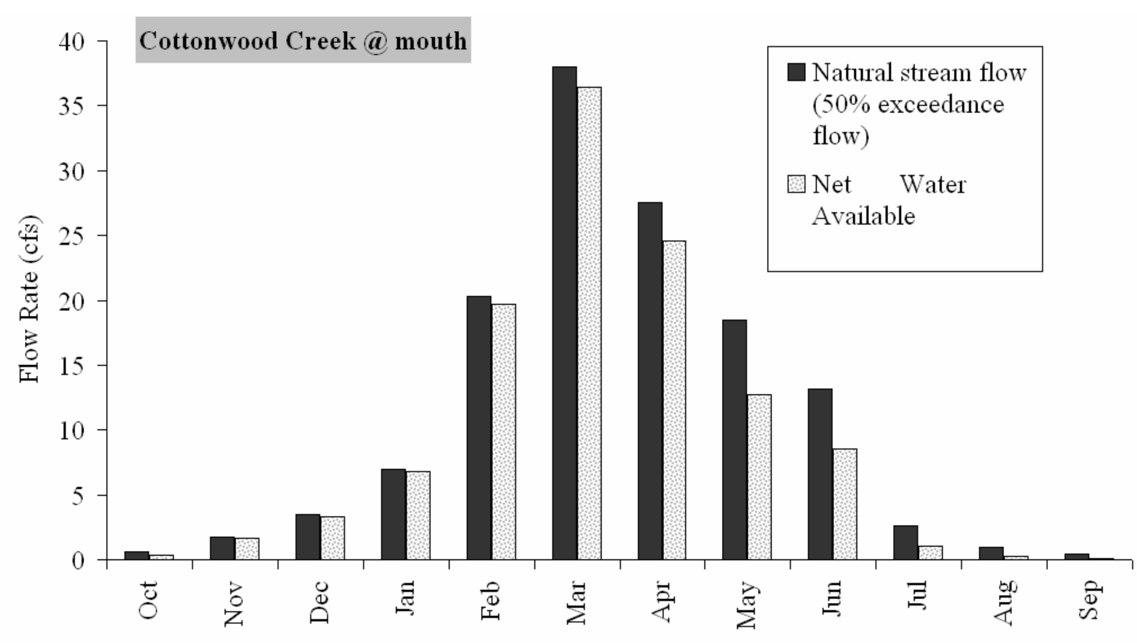

Figure 5: Estimated natural streamflow, and net available flow, at the mouth of Cottonwood Creek (Main Malheur watershed) (OWRD, 2004a)

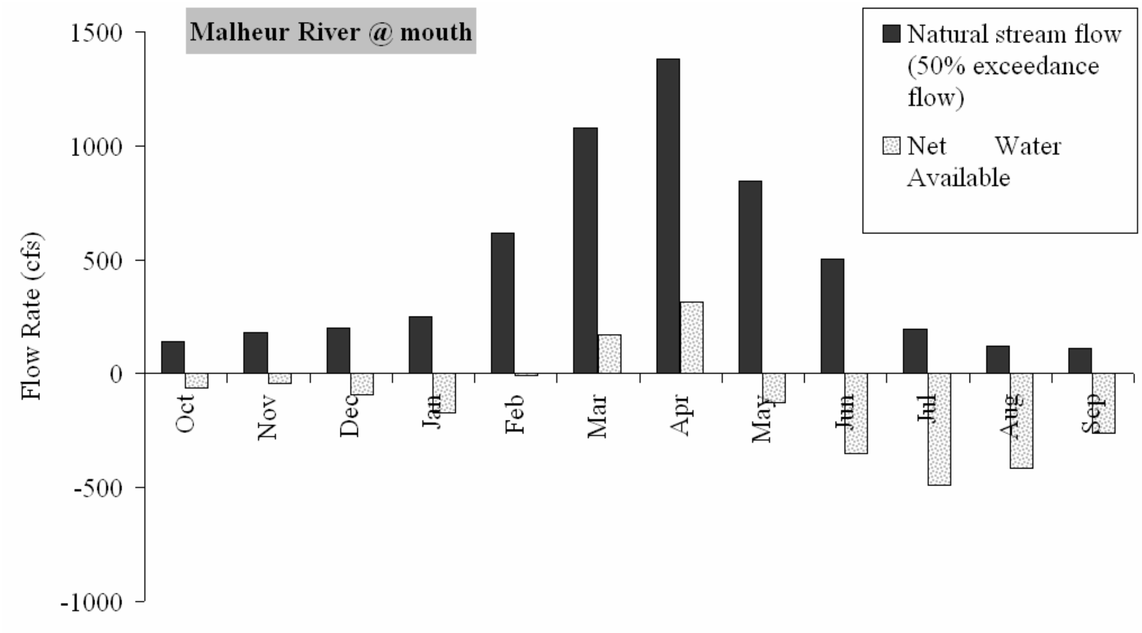

Figure 6: Estimated natural streamflow, and net available flow[3], at the mouth of the Malheur River (OWRD, 2004a)

Current conditions: Current low flow conditions approximate reference conditions within the three tributary reaches in the Main Malheur watershed (Figure 52; see Figure 41 for reach locations; Figure 5), however, low flows are adversely affected by irrigation withdrawals and dam operations on the mainstem Malheur (Figure 52, Figure 6).

Oxygen

Reference conditions: Oxygen is defined as the levels of dissolved oxygen (D.O.) in water column and stream substrate. Natural D.O. levels are not known within streams of the Malheur Subbasin, however, they would be expected to be inversely proportional to water temperatures, which would vary with elevation and stream shading. Consequently, reference D.O. levels would be expected to be higher in the forested headwater reaches than in the lower elevation, non-forested streams.

Current conditions: Current oxygen conditions are the most severe within the lower Cottonwood Creek reach (Figure 53; see Figure 41 for reach locations), where low subsurface flow and lack of riparian cover (due to recent flood event) contribute to low D.O. levels. The two mainstem Malheur River reaches are also impacted by water withdrawals, poor channel conditions (high-width to depth ratios) and dam operations. Only the upper Cottonwood Creek and Other Tributaries reaches approximate reference conditions with respect to D.O. (Figure 53).

[3] A negative value for net-available flow indicates that the amount allowed for withdrawal under existing water rights exceeds the estimated natural streamflow.

Low Temperature

Reference conditions: Low temperature is defined as the duration and amount of low winter temperatures that can be limiting to fish survival. Low wintertime temperatures can negatively impact fish when anchor ice forms. Natural low water temperatures are a result of a lack of thermal retention along streams (due in part to a lack of riparian canopy), shallow streams, low wintertime water levels, and elevation. The extent to which low water temperature was a limiting factor to the focal species during reference conditions is unknown, however, low temperature problems would have been influenced by thermal cover from riparian vegetation, and would have increased with elevation.

Current conditions: Current low temperatures approximate reference conditions within the upper Cottonwood and Other Tributaries reaches (Figure 54; see Figure 41 for reach locations), however, low temperatures are severe within the two mainstem Malheur river reaches, and within the lower Cottonwood Creek reach (Figure 54) due to low wintertime streamflows and poor channel conditions (high width-depth ratios).

High Temperature

Reference conditions: High temperature is defined as the duration and amount of high summer water temperatures that can be limiting to fish survival. Reference conditions for high summertime water temperatures would be expected to be inversely proportional to elevation and riparian cover, and would be influenced by streamside microclimate.

Current conditions: Current high temperatures are between 50% and 75% of reference in the Malheur River from Namorf to Warm Springs, in upper Cottonwood Creek and in the Other Tributaries reach (Figure 55; see Figure 41 for reach locations). The Malheur River downstream of Namorf to the mouth, and the lower reach of Cottonwood Creek, currently have severe summertime water temperature levels, due to the combination of water withdrawals, high width-depth ratios, and degraded riparian conditions.

Pollutants

Reference conditions: Pollutants are defined as toxic (acute and chronic) substances introduced into the stream. In the reference condition it is unlikely that any significant sources of pollutants existed within the subbasin.

Current condition: In general, pollutants are not a significant impact within most reaches within the subbasin (Figure 56; see Figure 41 for reach locations). However, within the Main Malheur watershed pollutants currently have impacts within the two mainstem Malheur River reaches, due to agricultural runoff high in nutrients (as evidenced by algal blooms), and some industrial-related substances.

Obstructions

Reference conditions: Obstructions are defined as physical barriers to the movement of fish throughout the reach. In the reference condition it is unlikely that any significant sources of obstructions existed within the reaches defined for this assessment.

Current condition: In general, obstructions are not a significant impact within most reaches within the subbasin (Figure 57; see Figure 41 for reach locations). However, within the Main Malheur watershed obstructions currently have severe impacts within the two mainstem Malheur River reaches, due to low water levels (associated with dam operations) and the presence of numerous push up dams.

Summary of limiting factors in the Main Malheur watershed

The preceding sections discussed the reference and current state of the separate factors that affect survival of the three focal species evaluated in the Main Malheur watershed, and identified the primary human-related impacts to these factors. However, the relative importance of each of the factors to each fish species is not known. The QHA output identifies the most important attribute affecting survival within each reach, however, there is no way to evaluate the important limiting factors at the watershed scale. Within this section the relative magnitude of each attribute on each focal species is examined.

The reach ratings for each of the eleven habitat attributes were the same for each of the three focal species, however, the three species do not necessarily respond to the same attribute conditions in the same way. As discussed elsewhere, the three species habitat hypotheses (Table 9, Table 10, Table 11) define our understanding of how each of the three species uses (or used) the various reaches throughout the basin. For example, summer rearing is the most important (highest weighted) life stage for Redband trout and bulltrout (Table 9 and Table 10), whereas spawning/incubation and migration are the most important (or limiting) life stages for Spring Chinook (Table 11). Similarly, the individual attributes themselves are weighted differently for each of the three species (Table 9, Table 10, Table 11). The result of these species hypotheses is that different attributes will be more or less important to a given species.

The summary of limiting factors for each of the three species found within the Main Malheur watershed are presented in Figure 7. The values in Figure 7 have been normalized[4] so that the highest rated attribute (the attribute having the biggest overall impact on that species in the watershed) has a value of 1.0. All other attribute impacts are scaled to this highest ranked impact. Results for the Main Malheur watershed show that for redband trout channel form (as described above) is the most important limiting factor overall, while for bull trout and Spring Chinook obstructions are the most limiting factor.

[4] Values were normalized by first taking the sum of the ranking for each attribute within the watershed, then dividing the minimum sum of all attributes in the watershed by the sum for each attribute. The result is a relative value (ranging from 0 to 1) of the importance of each attribute to the focal species of interest in that watershed.

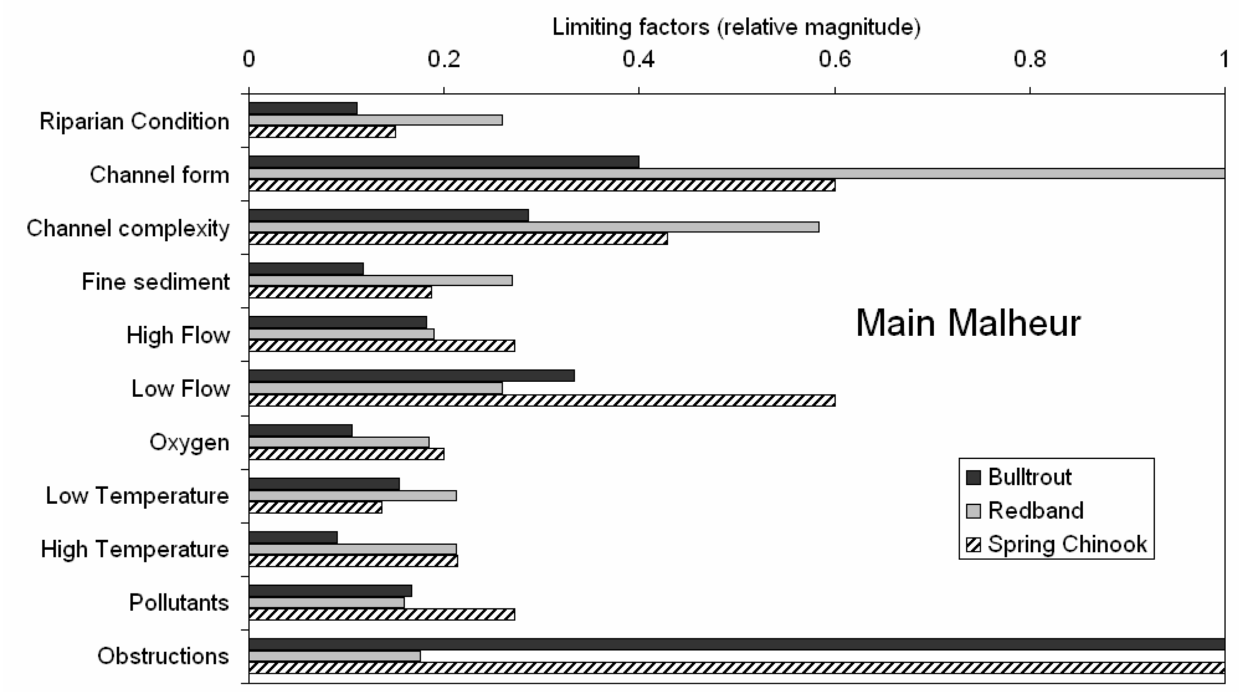

Figure 7. Summary of limiting factors by focal species within the Main Malheur watershed.

3.5.2 Upper Malheur Watershed

The Upper Malheur watershed contains twenty-five QHA reaches (see Figure 42 for reach locations, and Attachment 2 - General Assessment reach characteristics and focal species use by reach). One of the reaches (Mid-Malheur #1) was not rated because it consists of the Warm Springs reservoir, and the assessment team felt that the current version of QHA was inadequate to address reservoir concerns. Furthermore, an additional reach (Mid-Malheur #4 – Cottonwood Creek) was not rated because no data was available for this reach, and no one on the assessment team had sufficient personal knowledge to rate the reach. The following is a summary of reference and current conditions for each of the 11 QHA attributes.

Channel Stability

Reference conditions: Estimated reference channel gradient and confinement classes within the Upper Malheur watershed are shown in Figure 3. The distribution of reference gradient and confinement for the Upper Malheur is shown in Figure 8. Low-gradient unconfined channels make up the largest single grouping within the Upper Malheur watershed (Figure 8). In their reference condition these channels would most likely have been classified as Rosgen type C, or E channels (Table 12; Rosgen, 1996). The next largest grouping is the low-gradient confined channels (Figure 8). In their reference condition these channels would most likely have been classified as Rosgen type F channels (Table 12). The majority of the remaining channels are all in the confined category (Figure 8), which would, in their reference condition, most likely have been classified as Rosgen type Aa+, A or B channels, depending on gradient (Table 12).

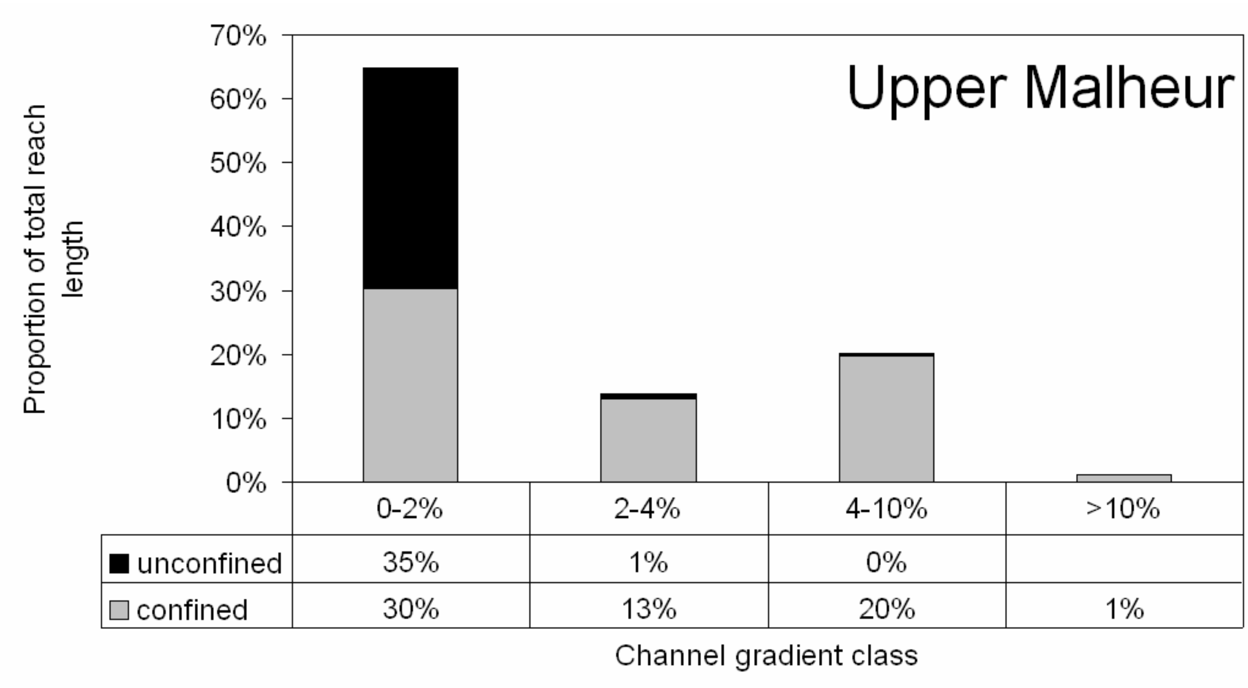

Figure 8. Estimated distribution of reference channel type in the Upper Malheur watershed.

Current condition: Current channel stability within the Upper Malheur falls within three general groupings. Eight of the 25 QHA reaches have current channel stability conditions that approximate reference conditions (reaches with blue bars; Figure 47; see Figure 42 for reach locations). Of the remaining reaches, 14 have current reference conditions that are impacted, but still functional (from 50% to 75% of reference function), these are the reaches with the green bars shown in Figure 47. Channel stability has been compromised in these reaches primarily due to channelization to accommodate pasture, and due to road fills impinging on channels in locations. In reach #23 an old railroad grade also impacts channel form and function. The most heavily impacted reach within the watershed is Upper Malheur reach 2; the mainstem Malheur River from the upstream end of the Warm Springs Dam inundation area to near Griffin Creek (Figure 47). The channel within this reach has been disturbed due to straightening associated with agricultural activities.

Riparian Condition:

Reference conditions: The Upper Malheur watershed is split approximately half within the Northern Basin and Range level III Ecoregions (the southern, or lower elevation half) and half within the Blue Mountains Level III (see Subbasin Overview, Ecoregion section; USEPA, 2003). Thirteen of the 24 reaches within the watershed are wholly or in part located within the Northern Basin and Range level III Ecoregions, and 18 of the 24 reaches are wholly or in part located within the Blue Mountains level III ecoregion. Reference conditions for the immediate streamside area along streams that are located within the Northern Basin and Range level III ecoregion would have consisted primarily of hardwood species (black & narrow leaf cottonwoods, aspen) and shrubs (willows, mountain alder, hawthorn, chokecherry, wood's rose & silver sage) (WPN, 2001). More detail on reference conditions for the immediate streamside area is available for streams that are located within the Blue Mountains level III ecoregion. Reference conditions for these streams have been characterized by level IV ecoregion (Table 13).

Table 13. Potential riparian conditions along streams located within the Blue Mountains level IV ecoregions (WPN, 2001).

Level IV Ecoregion	Potential streamside vegetation
11d: Melange	Dense stands of small-sized hardwoods (alder, cottonwood, & aspen) and shrubs (willows, Sitka alder, mountain alder, and common snowberry) in the immediate streamside area. Moving away from the streams riparian stands grade to dense stands of large conifers (Douglas-fir, true fir, ponderosa pine)
11h: Continental Zone Highlands	Dense stands of small-sized hardwoods (black cottonwood, aspen) and shrubs (pacific, Booth, Geyer and Lemmon willow, common snowberry, Mountain alder) in the immediate streamside area. Moving away from the streams riparian stands grade to Sparse stands of large conifers (white fir, Douglas fir, lodgepole and ponderosa pine)
11i: Continental Zone Foothills	Primarily shrubs (willows, sagebrush) and Cusick's bluegrass in the immediate streamside area. In some areas the riparian vegetation may contain dense stands of small hardwoods (aspen) and shrubs (Booth, Geyer and Lemmon willows, shrubby cinquefoil, silver sage, big sage) Cusick's bluegrass, and wooly sedge
11l: Mesic Forest Zone	Dense stands of small hardwoods and shrubs (willows, bog blueberry, dogwood, mountain alder, Pacific ninebark, common snowberry) in the immediate streamside area. Moving away from the streams riparian stands grade to dense stands of large conifers (Engelmann spruce, Douglas-fir, true fir, larch, lodgepole pine)
11m: Subalpine-Alpine Zone, and 11o: Cold Basins	Sparse stands of small conifers (subalpine fir) and shrubs (willows, mountain alder, common snowberry, bog blueberry) and, in some areas, meadow vegetation, in the immediate streamside area. Moving away from the streams riparian conditions grade to sparse stands of medium sized conifers (Grand fir, Engelmann spruce and subalpine fir)

Moving laterally away from the streams the riparian and adjacent upland vegetation consisted primarily of Ponderosa pine (30% of total riparian length), Wyoming big sagebrush (18%), Basin big sagebrush (12%), willows (8%) and mountain big sagebrush (8%) (ONHP 2002). Lodgepole pine, Western juniper woodland, Grand fir, and Idaho fescue each made up approximately 4% of the total riparian length in reference conditions (ONHP 2002).

Current condition: Current riparian conditions are severely impacted (25% or less of reference riparian function) in five of the 24 reaches found within the Upper Malheur watershed (red bars; Figure 48; see Figure 42 for reach locations). Impacts in these areas are primarily due to grazing by livestock and wildlife, and other agricultural operations. Current riparian conditions are highly impacted (25% to 50% of reference riparian function) in an additional six reaches within the Upper Malheur watershed (orange bars; Figure 48). Impacts in these areas are due primarily to grazing by livestock and wildlife, and other agricultural uses (irrigated meadow hay), although riparian function is recovering in some areas (e.g., reach #2 downstream of the highway). Current riparian conditions are moderately impacted (50% to 75% of reference riparian function) in an additional nine reaches within the Upper Malheur watershed (green bars; Figure 48). Impacts in these reaches are split between grazing by livestock and wildlife, and impacts from past timber harvest operations. Changes in management have resulted in considerable improvements in some streams (e.g., reach #13, Little Pine Creek) where changes in grazing management have resulted in reestablishment of sedge meadows and woody vegetation in places. Current riparian conditions are minimally impacted (> 75% of reference riparian function) in three reaches within the Upper Malheur watershed (blue bars; Figure 48).

Habitat Diversity

Reference conditions: As discussed above, it is not possible to use a static metric (e.g., frequency of pools, frequency of LWD pieces) to describe habitat diversity in the reference condition, and it is beyond the scope of this document to develop reference conditions. In assembling the QHA database participants considered, based on expert opinion, what the likely habitat conditions were in the reference state, and compared present conditions against these hypothesized reference conditions.

Current condition: Current habitat diversity ratings in the Upper Malheur watershed (Figure 49; see Figure 42 for reach locations) generally fall numerically between the channel stability ratings (Figure 47) and the riparian ratings (Figure 48) underscoring the influence of these two factors on habitat diversity. Severe impacts to habitat diversity have occurred within six reaches within the watershed (red and orange bars; Figure 49; see Figure 42 for reach locations). These ratings are due to the impacts identified for channel stability and riparian conditions above, as well as low water conditions (associated with irrigation withdrawals) and mechanical disturbance to the stream beds and banks. Current habitat diversity in the remaining reaches is rated as only moderately impacted (50% to 75% of reference riparian function; green bars Figure 49) in 13 reaches and only minimally impacted (> 75% of reference riparian function; blue bars Figure 49) in four reaches. Impacts within these reaches are due to the same suite of activities identified above (i.e., loss of riparian function due to grazing by livestock and wildlife, and past timber harvest; loss of channel stability due to agriculturally related stream straightening and encroachment by roads; dewatering due to irrigation withdrawals, and mechanical damage to stream bed and banks).

Fine Sediment

Reference conditions: As discussed in section 3.5.1 above, it is not possible to describe reference conditions for fine sediment due to the variability in factors that drive fine sediment inputs to the reach, and deposition within the reach. In assembling the QHA database participants considered, based on expert opinion, what the fine sediment dynamics were in the reference state, and compared present conditions against these hypothesized reference conditions.

Current conditions: Current fine sediment impacts generally decrease moving upstream within the Upper Malheur watershed (Figure 50; see Figure 42 for reach locations), and as such reflect the dominant land uses. The most severe impacts occur in those reaches (red and orange bars; Figure 50) that are located within the areas that are most heavily managed for livestock production. Areas that are less impacted (green bars; Figure 50) either occur in areas where the valley form is not conducive to active management (e.g., the narrow canyon along the mainstem Malheur River in reach #3) or where management impacts (i.e., loss of riparian function due to grazing by livestock and wildlife, and past timber harvest; loss of channel stability due to agriculturally related stream straightening and encroachment by roads; dewatering due to irrigation withdrawals, and mechanical damage to stream bed and banks) are less-severe. Current fine sediment impacts are minimal in eight of the 24 reaches, primarily located in headwater areas (blue bars; Figure 50).

High Flow

Reference conditions: As discussed above, peak flows in the Upper Malheur watershed are driven primarily by winter rain, rain-on-snow, spring snowmelt, and (to a lesser extent) summer rainstorms. Peak flows in streams draining the Blue Mountains have high flows later into the season due to the greater snowpack in higher elevation areas,

Current conditions: Current high flow conditions approximate reference conditions within most of the reaches in the Upper Malheur watershed (blue bars; Figure 51; see Figure 42 for reach locations). Moderate impacts to high flows (green bars; Figure 51), occur in some streams primarily due to the impacts of land management on peak flows. These impacts are due to increased snow accumulation and melt during winter time rain-on-snow events in forested areas, attributable to past timber harvest; and increased compaction (leading to increased runoff efficiency) associated with timber harvest, road construction and grazing by livestock and wildlife. The only severe impact to high flows noted within the watershed (red bars; Figure 51) was a decrease in wintertime high flows due to reservoir storage in lower Stinkingwater Creek.

Low Flow

Reference conditions: As described above, natural volumes of runoff are lowest in both tributary and mainstem reaches during the late summer and early fall. Within low-elevation tributaries (i.e., those lacking significant snow pack) the ratio of low flow to high flows is quite large (e.g., Figure 5) as compared to mainstem reaches (e.g., Figure 6) and tributaries draining high elevation areas (e.g., Figure 9), which are buffered by late season snowmelt.

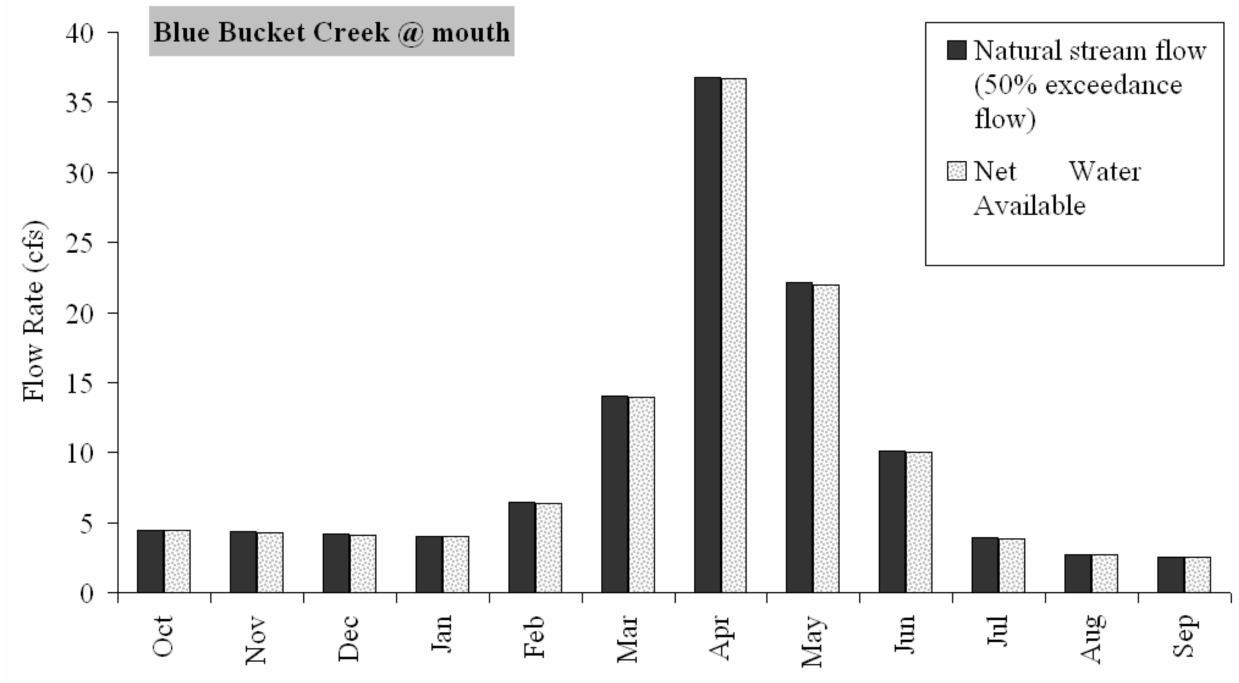

Figure 9. Estimated natural streamflow, and net available flow, at the mouth of Bluebucket Creek (OWRD, 2004).

Current conditions: Current low flow conditions are severely impacted along the mainstem of the Malheur River upstream of Warm Springs Reservoir and in lower Stinkingwater Creek (red bars; Figure 52; see Figure 42 for reach locations), and are highly impacted in five additional tributary reaches within the Upper Malheur watershed (orange bars; Figure 52). Irrigation withdrawals are the primary impacts to low flows. Moderate low-flow impacts exist in three additional reaches (green bars; Figure 52), but approximately half of the reaches have only minimal low flow impacts (blue bars; Figure 52)

Oxygen

Reference conditions: As discussed above, reference dissolved oxygen (D.O.) levels are not known within streams of the Malheur Subbasin, however, they would be expected to be inversely proportional to water temperatures, which would vary with elevation and stream shading. Consequently, reference D.O. levels would be expected to be higher in the forested headwater reaches than in the lower elevation, non-forested streams.

Current conditions: Current oxygen conditions (Figure 53; see Figure 42 for reach locations) generally track current high temperature conditions (Figure 55) within the Upper Malheur watershed. Current oxygen impacts are severe in six reaches (red and orange bars; Figure 53), moderate in eight reaches (green bars), and minimal in nine reaches (blue bars). Current oxygen conditions are generally the result of the same activities that have impacted riparian and channel conditions described above.

Low Temperature

Reference conditions: As discussed above, low winter water temperatures negatively impact fish when anchor ice forms. Natural low water temperatures are a result of a lack of thermal retention along streams (due in part to a lack of riparian canopy), shallow streams, low wintertime water levels, and elevation.

Current conditions: Current low temperature impacts are generally minimal throughout the watershed (green and blue bars; (Figure 54; see Figure 42 for reach locations), however, moderate impacts do occur within the two Otis Creek reaches and within the lower Stinkingwater Creek reach (orange bars, Figure 54). Impacts within Otis Creek are tied to lack of riparian cover and poor channel conditions (high width-depth ratios), while lower Stinkingwater is impacted by low wintertime streamflow associated with diversions to reservoir storage.

High Temperature

Reference conditions: As discussed above, reference conditions for high summertime water temperatures would be expected to be inversely proportional to elevation and riparian cover, and would be influenced by streamside microclimate.

Current conditions: Approximately half of the reaches within the Upper Malheur watershed currently have moderate high temperature impacts (green bars; Figure 55; see Figure 42 for reach locations), while an additional four reaches are rated as having minimal impacts (blue bars; Figure 55). Impacts in these reaches are generally the result of channel and riparian impacts discussed above. The remaining six reaches have severe impacts (red and orange bars; Figure 55) due to not only riparian and channel conditions, but also heavy water withdrawals for irrigation and storage.

Pollutants

Reference conditions: As discussed above, pollutants (acute and chronic toxic substances) are unlikely to have existed in significant quantities under reference conditions.

Current condition: Pollutants are not a significant impact within any reach within the Upper Malheur watershed (Figure 56; see Figure 42 for reach locations). Only reach #2, the mainstem Malheur above Warm Springs reservoir, is rated for any impact at all, and this is a minimal impact due to agricultural-related pollutants.

Obstructions

Reference conditions: As discussed above, it is unlikely that any significant sources of obstructions existed within the reaches defined for this assessment.

Current condition: Impacts due to obstructions are severe in several reaches within the Upper Malheur watershed (red and orange bars; Figure 57; see Figure 42 for reach locations). The mainstem Malheur River in reach #2, and the lower Stinkingwater Creek reach are impacted by the extremely low flows that result from irrigation diversions, which obstruct fish passage. Obstructions in reaches #7, #9 and #10 are due to dams that obstruct passage at the downstream end of the reaches. Upper Bosonberg Creek (reach #23) is obstructed by an old railroad grade, which completely blocks access to the reach. The remaining reaches are impacted to varying degrees by irrigation withdrawals, which have a minor to moderate impact on fish passage.

Summary of limiting factors in the Upper Malheur watershed

The preceding sections discussed the reference and current state of the separate habitat attributes that affect survival of the three focal species evaluated in the Upper Malheur watershed, and identified the primary human-related impacts to these factors. However, the relative importance of each of the factors to each fish species is not known. The QHA output identifies the most important attribute affecting survival within each reach, however, there is no way to evaluate the important limiting factors at the watershed scale. Within this section the relative magnitude of each attribute on each focal species is examined. The summary of limiting factors presented at the end of Section 3.5.1 above describes in detail the approach that was taken here. The summary of limiting factors for each of the three species found within the Upper Malheur watershed is presented in Figure 10. The values in Figure 10 have been normalized so that the highest rated attribute (the attribute having the biggest overall impact on that species in the watershed) has a value of 1.0. All other attribute impacts are scaled to this highest ranked impact. Results for the Upper Malheur watershed show that for redband trout and Spring Chinook channel (or habitat) complexity is the most important limiting factor overall, while for bull trout riparian condition is the most limiting factor.

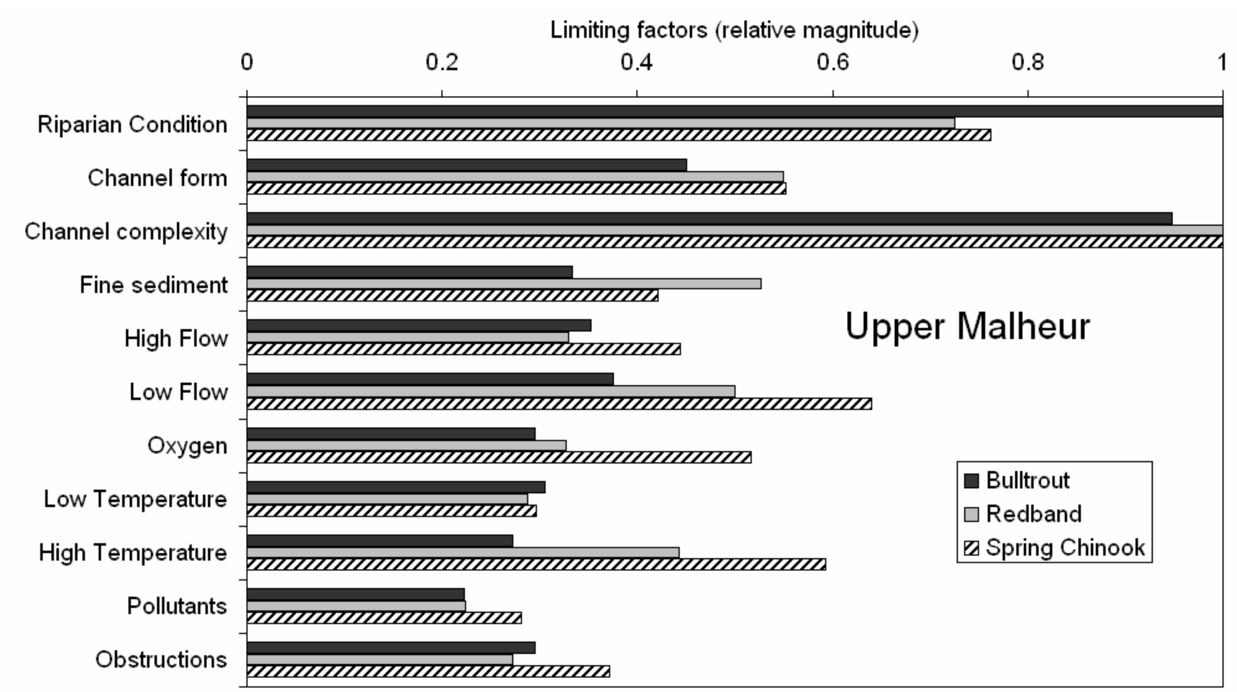

Figure 10. Summary of limiting factors by focal species within the Upper Malheur watershed.

3.5.3 Willow Creek Watershed

The Willow Creek watershed contains six QHA reaches (see Figure 43 for reach locations, and Attachment 2 - General Assessment reach characteristics and focal species use by reach). One of the reaches (Willow Creek #3) was not rated because it consists of the Malheur Reservoir, and the assessment team felt that the current version of QHA was inadequate to address reservoir concerns. The following is a summary of reference and current conditions for each of the 11 QHA attributes

Channel Stability

Reference conditions: Estimated reference channel gradient and confinement classes within the Willow Creek watershed are shown in Figure 3. The distribution of reference gradient and confinement for the Willow Creek watershed is shown in Figure 11. Low-gradient unconfined channels make up over 2/3 of the total reach length within the Willow Creek watershed (Figure 11). In their reference condition these channels would most likely have been classified as Rosgen type C, or E channels (Table 12; Rosgen, 1996). Low-gradient confined channels make up an additional 10% of the total reach length in the watershed (Figure 11). In their reference condition these channels would most likely have been classified as Rosgen type F channels (Table 12). The majority of the remaining channels are all in the confined category (Figure 11), which would, in their reference condition, most likely have been classified as Rosgen type Aa+, A or B channels, depending on gradient (Table 12).

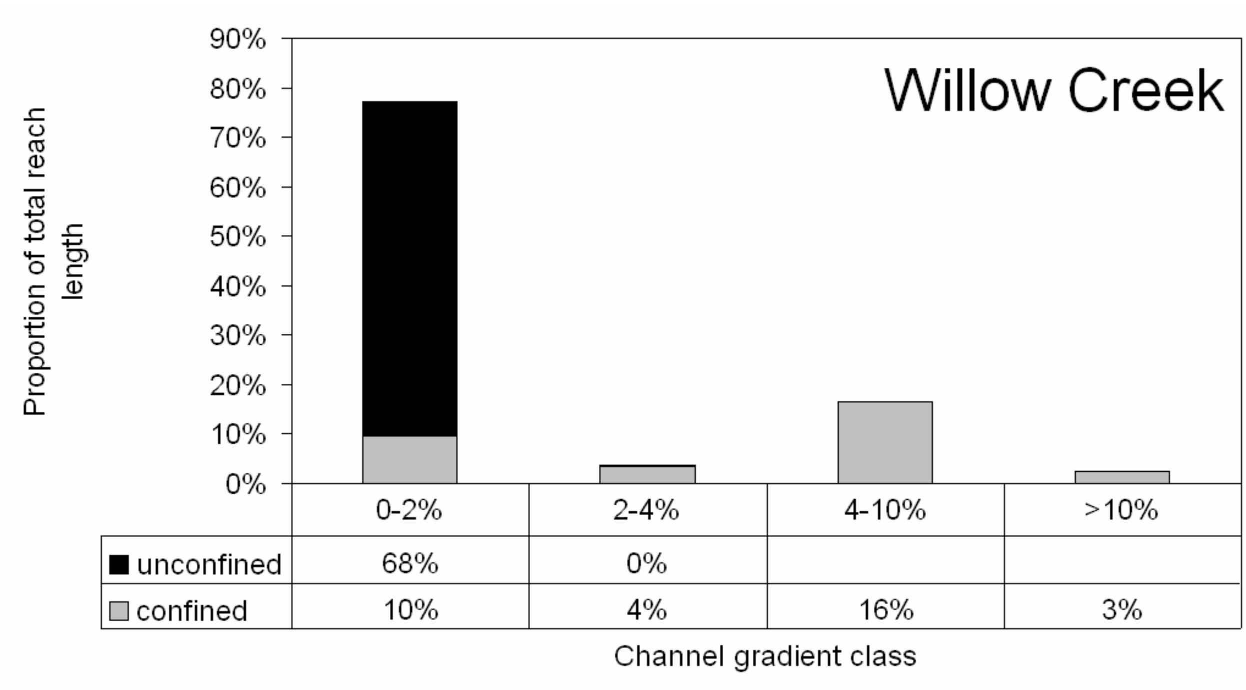

Figure 11. Estimated distribution of reference channel type in the Willow Creek watershed.

Current condition: Current channel stability within Willow Creek is generally poor (Figure 47; see Figure 43 for reach locations). Reach #1 (Willow Creek from the confluence with Malheur

River to near Brogan) has been extensively channelized, and in areas has deeply incised (in general it has been converted to a drain). Reach #5 (South Willow Ck, Dutch John Ck, Bridge Ck) has also undergone some channelization, while Reach #6 (Basin Creek) has legacy impacts from hydraulic and placer mining. Reach #2 (Willow Creek from Brogan to Malheur Reservoir outlet) also has legacy hydraulic mining impacts, but her impact on current conditions is less severe. Reach #4 (Willow Creek from Malheur Reservoir to Ironside) has some limited areas of riprap.

Riparian Condition:

Reference conditions: Reach #1 (Willow Creek from the confluence with Malheur River to near Brogan) is located within the Snake River Plain level III ecoregion (see Subbasin Overview for Ecoregions map; USEPA, 2003). Reference conditions for the immediate streamside area along this reach would have consisted primarily of hardwood species (black & narrow leaf cottonwoods, aspen) and shrubs (willows, mountain alder, hawthorn, chokecherry, wood's rose & silver sage) (WPN, 2001). The remaining five reaches are located within the Continental Zone Foothills level IV ecoregion. Reference conditions for the immediate streamside area along these reaches would be expected to be similar to the conditions described in Table 13.

Moving laterally away from the streams the riparian and adjacent upland vegetation consisted primarily of Riparian hardwoods along reach #1; and predominately Wyoming big sagebrush (80% of total riparian length) and other sagebrush species (Mountain big sagebrush, Basin big sagebrush, Wyoming big sagebrush-squawapple, Bluebunch wheatgrass and Low sagebrush – 18%) along the remaining reeaches (ONHP 2002).

Current condition: Current riparian conditions are generally poor along most reaches of Willow Creek, ranging from approximately 15% to 60% of reference riparian function (Figure 48; see Figure 43 for reach locations). Impacts in these areas are primarily due to channelization (reach #1), legacy mining conditions (reaches #6 and #2), grazing by livestock and wildlife, and other agricultural operations. Changes in management have resulted in considerable improvements in some streams. Reach #2 has some areas of intact and recovering vegetation, and reach #4 alternates between areas of only limited woody vegetation and dense patches of willows and other shrubs, depending on management practices.

Habitat Diversity

Reference conditions: As discussed above, it is not possible to use a static metric (e.g., frequency of pools, frequency of LWD pieces) to describe habitat diversity in the reference condition, and it is beyond the scope of this document to develop reference conditions. In assembling the QHA database participants considered, based on expert opinion, what the likely habitat conditions were in the reference state, and compared present conditions against these hypothesized reference conditions.

Current condition: Current habitat diversity ratings in the Willow Creek watershed (Figure 49; see Figure 43 for reach locations) generally reflect both channel stability ratings (Figure 47) and riparian ratings (Figure 48), underscoring the influence of these two factors on habitat diversity. Severe impacts to habitat diversity have occurred along reach #1 (red bars; Figure 49), which has been channelized, is devoid of moist riparian vegetation, and is operated as an agricultural drain.

Habitat diversity in reach #5 (orange bar; Figure 49), also reflects impacts to riparian conditions and channel form described above. The remaining three reaches are all rated as currently having approximately 75% of the habitat diversity that was present in the reference condition (green bars; Figure 49), due in part to the better riparian and channel conditions described above, but also (in the case of reach #2 and #6) to the more resilient nature of high gradient, confined channels to management-related changes.

Fine Sediment

Reference conditions: As discussed above, it is not possible to describe reference conditions for fine sediment due to the variability in factors that drive fine sediment inputs to the reach, and deposition within the reach. In assembling the QHA database participants considered, based on expert opinion, what the fine sediment dynamics were in the reference state, and compared present conditions against these hypothesized reference conditions.

Current conditions: The same pattern of impact seen for the preceding inputs is repeated for fine sediment; reach #1 is the most severely impacted, followed by reach # 5, with the remaining three reaches having moderate impacts (Figure 50; see Figure 43 for reach locations). In addition to the riparian and channel problems identified above there is also significant bank erosion from mechanical disturbance of the bed and banks, particularly in reach #5.

High Flow

Reference conditions: As discussed above, peak flows in the Willow Creek watershed are driven primarily by winter rain, rain-on-snow, spring snowmelt, and (to a lesser extent) summer rainstorms.

Current conditions: Moderate to severe impacts to high flows identified in reaches #1 and #2 (red and orange bars; Figure 51; see Figure 43 for reach locations) are due to operations within Malheur Reservoir decreasing wintertime flows. Current high flow conditions approximate reference conditions within reaches #4, #5, and #6 (blue bars; Figure 51). These minimal impacts are due to increased compaction (leading to increased runoff efficiency) associated with road construction and grazing by livestock and wildlife.

Low Flow

Reference conditions: As described above, natural volumes of runoff are lowest in tributary reaches (e.g., Figure 12) during the late summer and early Fall. Within lower elevation tributaries like Willow Creek, which have relatively smaller snowpack, the ratio of low flow to high flows is quite large (e.g., Figure 12) as compared to tributaries draining high elevation areas that are buffered by late season snowmelt.

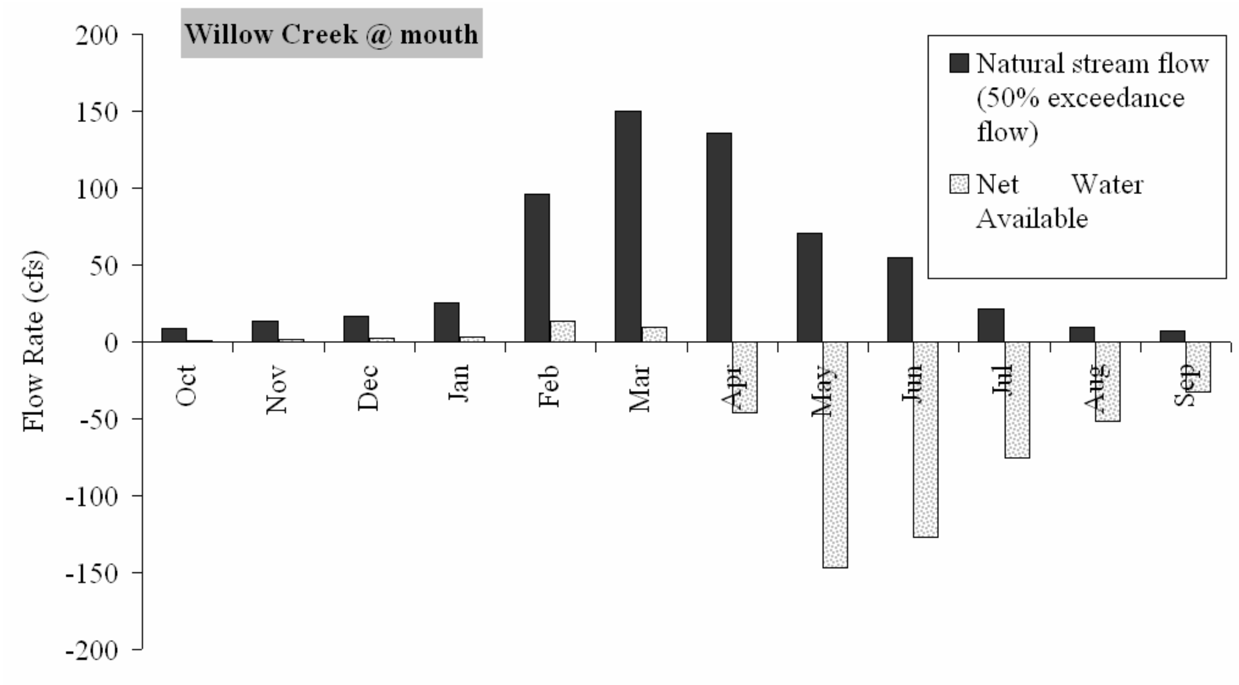

Figure 12. Estimated natural streamflow, and net available flow, at the mouth of Willow Creek (OWRD, 2004)

Current conditions: Current low flow conditions are severely impacted within reach #1 (red bars; Figure 52; see Figure 43 for reach locations) due to irrigation operations (Reservoir releases travel through ditch, with little water released directly to the stream channel, return flow enters channel at downstream end). Current low flow conditions within the remaining reaches are moderately impacted (green bars; Figure 52). Irrigation withdrawals are the primary impacts to low flows.

Oxygen

Reference conditions: As discussed above, reference dissolved oxygen (D.O.) levels are not known within streams of the Malheur Subbasin, however, they would be expected to be inversely proportional to water temperatures, which would vary with elevation and stream shading. Consequently, reference D.O. levels would be expected to be higher in the headwater reaches than in the lower elevation streams.

Current conditions: Current oxygen conditions (Figure 53; see Figure 43 for reach locations) generally track current high temperature conditions within the Willow Creek watershed. Current oxygen impacts are severe in reaches #1 and #2 (red and orange bars; Figure 53) and moderate in the remaining reaches (green bars; Figure 53). Current oxygen conditions are generally the result of the same activities that have impacted riparian and channel conditions described above.

Low Temperature

Reference conditions: As discussed above, low winter water temperatures negatively impact fish when anchor ice forms. Natural low water temperatures are a result of a lack of thermal retention along streams (due in part to a lack of riparian canopy), shallow streams, low wintertime water levels, and elevation.

Current conditions: Current low temperature impacts are generally minimal throughout the watershed (green and blue bars; Figure 54; see Figure 43 for reach locations), and are due to lack of riparian cover and poor channel conditions (high width-depth ratios). Moderate impacts occur within reach #2 (orange bars, Figure 54) due to low wintertime streamflow associated with diversions to reservoir storage.

High Temperature

Reference conditions: As discussed above, reference conditions for high summertime water temperatures would be expected to be inversely proportional to elevation and riparian cover, and would be influenced by streamside microclimate.

Current conditions: High temperature impacts exist within all reaches within the Willow Creek watershed, and generally worsen from upstream to downstream (;Figure 55; see Figure 43 for reach locations). The highest impacts are in reaches #1 and #2, but all reaches are impacted by the diminished riparian cover, channel disturbances, and low flows discussed above.

Pollutants

Reference conditions: As discussed above, pollutants (acute and chronic toxic substances) are unlikely to have existed in significant quantities under reference conditions.

Current condition: Pollutants are not a significant impact within the headwater reaches in the Willow Creek watershed, and only moderately impacting within reach #2 (Figure 56; see Figure 43 for reach locations). However, reaches #1 is significantly impacted by runoff from livestock feedlots (Figure 56).

Obstructions

Reference conditions: As discussed above, it is unlikely that any significant sources of obstructions existed within the reaches defined for this assessment.

Current condition: Impacts due to obstructions are moderate to minimal in the reaches within the Willow Creek watershed (green and blue bars; Figure 57; see Figure 43 for reach locations). Obstructions within these reaches are primarily due to irrigation diversions, which obstruct fish passage.

Summary of limiting factors in the Willow Creek watershed

The preceding section discussed the reference and current state of the separate factors that affect survival of focal species evaluated in the Willow Creek watershed, and identified the primary human-related impacts to these factors. However, the relative importance of each of the factors to redband trout[5] is not known. The QHA output identifies the most important attribute affecting

[5] Of the three focal species used in this assessment only redband trout has been identified as having existed historically and currently within the Willow Creek watershed.

survival within each reach, however, there is no way to evaluate the important limiting factors at the watershed scale. Within this section the relative magnitude of each attribute on each focal species is examined. Section 3.5.1 above describes in detail the approach that was taken here. The summary of limiting factors for Redband trout within the Willow Creek watershed is presented in Figure 13. The values in Figure 13 have been normalized so that the highest rated attribute (the attribute having the biggest overall impact on that species in the watershed) has a value of 1.0. All other attribute impacts are scaled to this highest ranked impact. Results for the Willow Creek watershed show that for redband trout riparian condition, followed by channel from and low flows are the most important limiting factors.

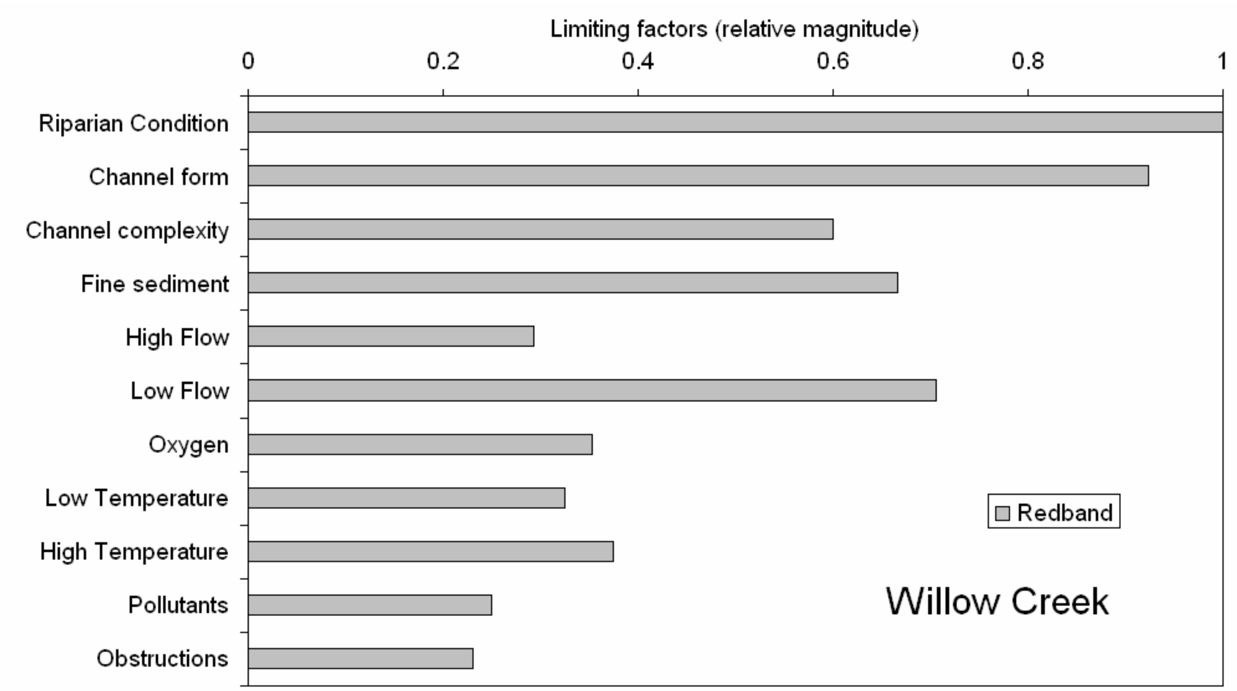

Figure 13. Summary of limiting factors by focal species within the Willow Creek watershed.

3.5.4 Bully Creek Watershed

The Bully Creek watershed contains eleven QHA reaches (see Figure 44 for reach locations, and Attachment 2 - General Assessment reach characteristics and focal species use by reach). One of the reaches (Bully Creek #2) was not rated because it consists of the Bully Creek reservoir, and the assessment team felt that the current version of QHA was inadequate to address reservoir concerns. During the process of the assessment it was decided that reaches #6 and #8 had significant enough within-reach variability to warrant splitting these reaches into separate parts (i.e., reaches #6a and #6b, and reaches #8a and #8b). The following is a summary of reference and current conditions for each of the 11 QHA attributes.

Channel Stability

Reference conditions: Estimated reference channel gradient and confinement classes within the Bully Creek watershed are shown in Figure 3. The distribution of reference gradient and confinement for the Bully Creek watershed is shown in Figure 14. Low-gradient unconfined channels make up approximately half the total reach length within the Bully Creek watershed (Figure 14). In their reference condition these channels would most likely have been classified as Rosgen type C, or E channels (Table 12; Rosgen, 1996). The next largest grouping is the low-gradient confined channels (Figure 14), which make up an additional 20% of total reach length. In their reference condition these channels would most likely have been classified as Rosgen type F channels (Table 12). The majority of the remaining channels are all in the confined category (Figure 14), which would, in their reference condition, most likely have been classified as Rosgen type Aa+, A or B channels, depending on gradient (Table 12).

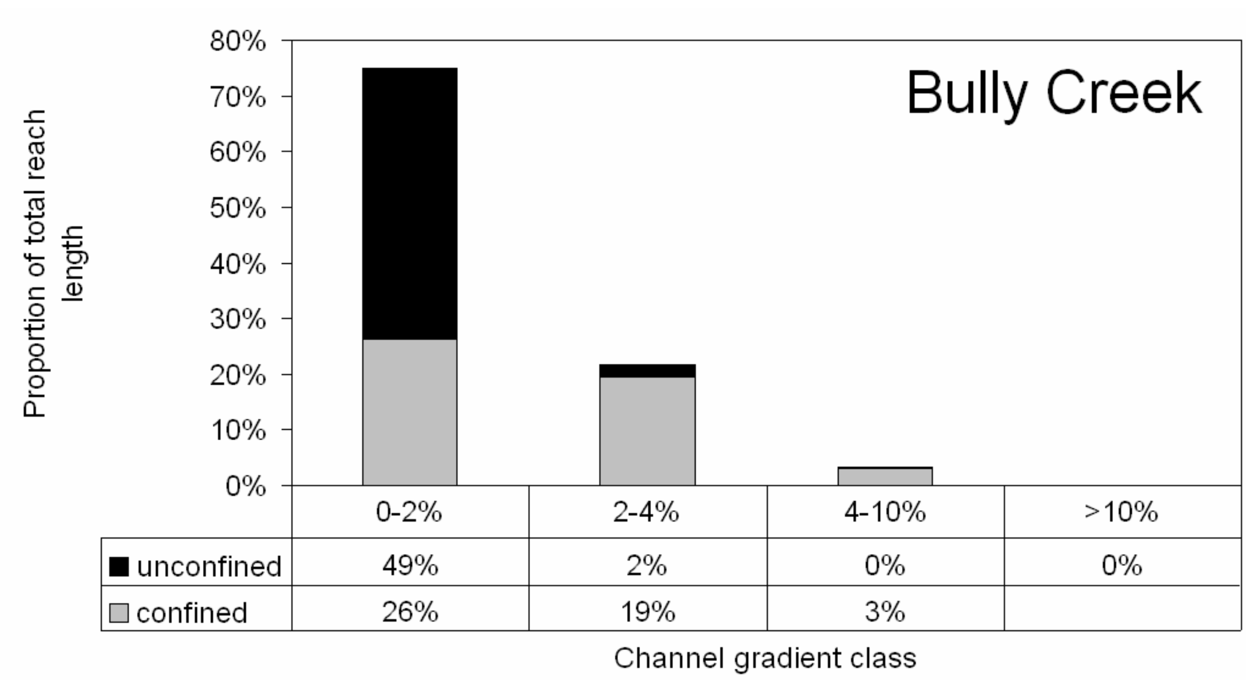

Figure 14. Estimated distribution of reference channel type in the Bully Creek watershed.

Current condition: Four of the 11 QHA reaches within the Bully Creek watershed have current channel stability conditions that approximate reference conditions (reaches with blue bars; Figure 47; see Figure 44 for reach locations). Of the remaining reaches, an additional 4 have current reference conditions that are impacted, but still functional (from 50% to 75% of reference function), these are the reaches with the green bars shown in Figure 47. Channel stability has been compromised in these reaches primarily due to channelization to accommodate pasture, and due to road fills impinging on channels in locations. Reach #8a, Cottonwood Creek, has experienced similar impacts, and is rated slightly more disturbed then the preceding channels. The most heavily impacted reach within the watershed is reach #1, the mainstem Bully Creek from the confluence with the Malheur River upstream to the Bully Creek Reservoir. Reach #1 is extensively channelized, and is essentially managed as a drain.

Riparian Condition:

Reference conditions: Approximately 60% of the total reach length within the Bully Creek watershed is located within the either the Snake River Plain or the Northern Basin and Range level III ecoregions (see Subbasin Overview for Ecoregions map; USEPA, 2003). Reference conditions for the immediate streamside area along these streams would have consisted primarily of hardwood species (black & narrow leaf cottonwoods, aspen) and shrubs (willows, mountain alder, hawthorn, chokecherry, wood's rose & silver sage) (WPN, 2001). The remaining 40% of total reach length is located within the Continental Zone Foothills level IV ecoregion. Reference conditions for the immediate streamside area along these reaches would be expected to be similar to the conditions described in Table 13. Moving laterally away from the streams the riparian and adjacent upland vegetation consisted primarily of Wyoming big sagebrush (42% of total length), Basin big sagebrush (19%), riparian hardwoods (10%) (ONHP 2002).

Current condition: Current riparian conditions are generally poor (approximately 40% to 50% of reference functionality) along six reaches within the Bully Creek watershed (orange bars; Figure 48; see Figure 44 for reach locations). Impacts in these areas are primarily due to channelization (reach #1), and grazing by livestock and wildlife. Changes in management have resulted in considerable improvements in some streams as noted in BLM Proper Functioning Condition (PFC) assessments. Of the remaining four reaches the Reds Creek and South Fork Indian Creek reaches (green bars; Figure 48) have been moderately impacted, but are currently in an improving condition due to changes in management. Two reaches within the watershed (blue bars; Figure 48) have minimal riparian impacts.

Habitat Diversity

Reference conditions: As discussed above, it is not possible to use a static metric (e.g., frequency of pools, frequency of LWD pieces) to describe habitat diversity in the reference condition, and it is beyond the scope of this document to develop reference conditions. In assembling the QHA database participants considered, based on expert opinion, what the likely habitat conditions were in the reference state, and compared present conditions against these hypothesized reference conditions.

Current condition: Current habitat diversity ratings in the Bully Creek watershed (Figure 49; see Figure 44 for reach locations) generally fall numerically between the channel stability ratings and the riparian ratings, underscoring the influence of these two factors on habitat diversity. Severe impacts to habitat diversity have occurred within three reaches (red and orange bars; Figure 49). These impacts are due to channelization and reservoir management that keeps flows low (particularly in reaches #1), channel downcutting, bank erosion (leading to high width-depth ratios) and riparian vegetation loss associated with livestock and wildlife grazing. Moderate impacts (green bars) have occurred in four reaches, and three reaches (blue bars) have only minimal impacts.

Fine Sediment

Reference conditions: As discussed above, it is not possible to describe reference conditions for fine sediment due to the variability in factors that drive fine sediment inputs to the reach, and deposition within the reach. In assembling the QHA database participants considered, based on expert opinion, what the fine sediment dynamics were in the reference state, and compared present conditions against these hypothesized reference conditions.

Current conditions: Current fine sediment impacts within the Bully Creek watershed range from severe (in reach #1 along the lower mainstem of Bully Creek) to minimal (in the West Fork Cottonwood Creek reach; Figure 50; see Figure 44 for reach locations). Elevated sediment sources within the watershed are attributable to high intensity grazing by livestock and wildlife, an increase in annual upland species (cheat grass etc.), and stream bank erosion. Channel modifications within reach #1 have also resulted in higher levels of bank erosion.

High Flow

Reference conditions: As discussed above, peak flows in the Bully Creek watershed are driven primarily by winter rain, rain-on-snow, spring snowmelt, and (to a lesser extent) summer rainstorms. Peak flows in streams draining the Blue Mountains have high flows later into the season due to the greater snowpack in higher elevation areas,

Current conditions: Current high flow conditions approximate reference conditions within most of the reaches in the Bully Creek watershed (blue bars; Figure 51; see Figure 44 for reach locations). Moderate impacts to high flows (green bars), are noted in reach #8a (Cottonwood Creek), and are attributable to increased compaction (leading to increased runoff efficiency) associated with grazing by livestock and wildlife. The only severe impact to high flows noted within the watershed (red bars) was a decrease in wintertime high flows due to reservoir storage in reach #1 below the Bully Creek reservoir.

Low Flow

Reference conditions: As described above, natural volumes of runoff are lowest during the late summer and early fall. Within low-elevation tributaries (i.e., those lacking significant snow pack) the ratio of low flow to high flows is quite large (e.g., Figure 15, Figure 16) as compared tributaries draining high elevation areas (e.g., Figure 9), which are buffered by late season snowmelt.

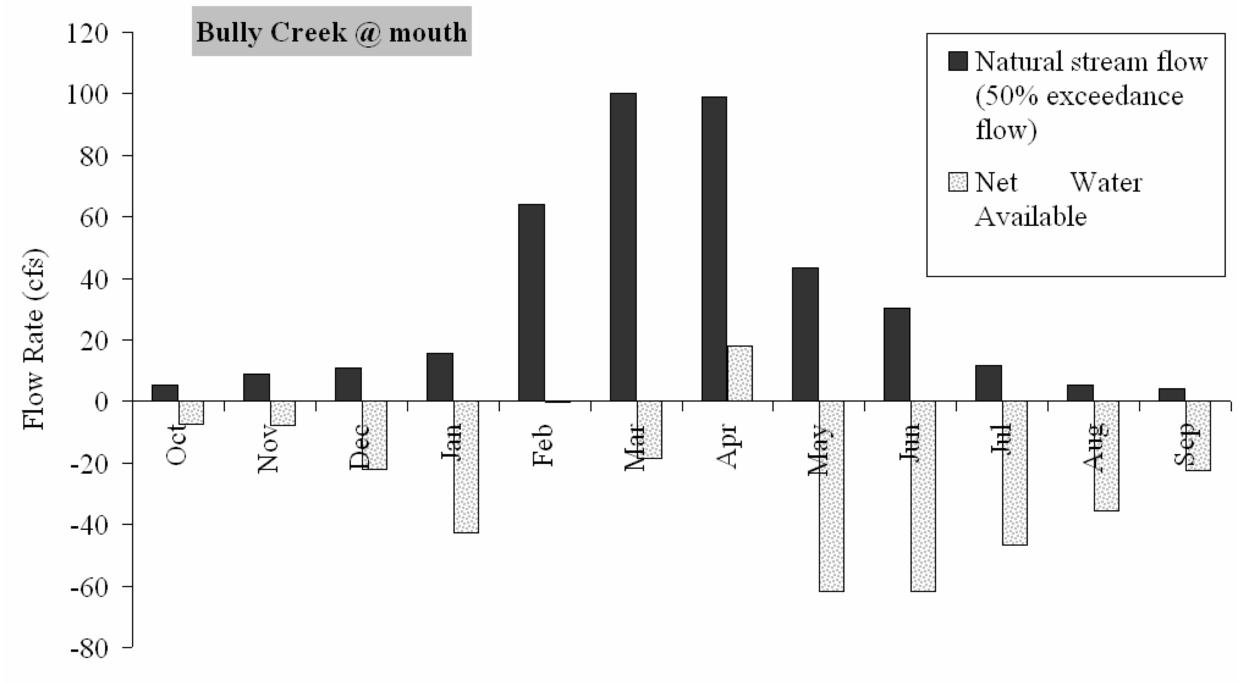

Figure 15. Estimated natural streamflow, and net available flow, at the mouth of Bully Creek (OWRD, 2004).

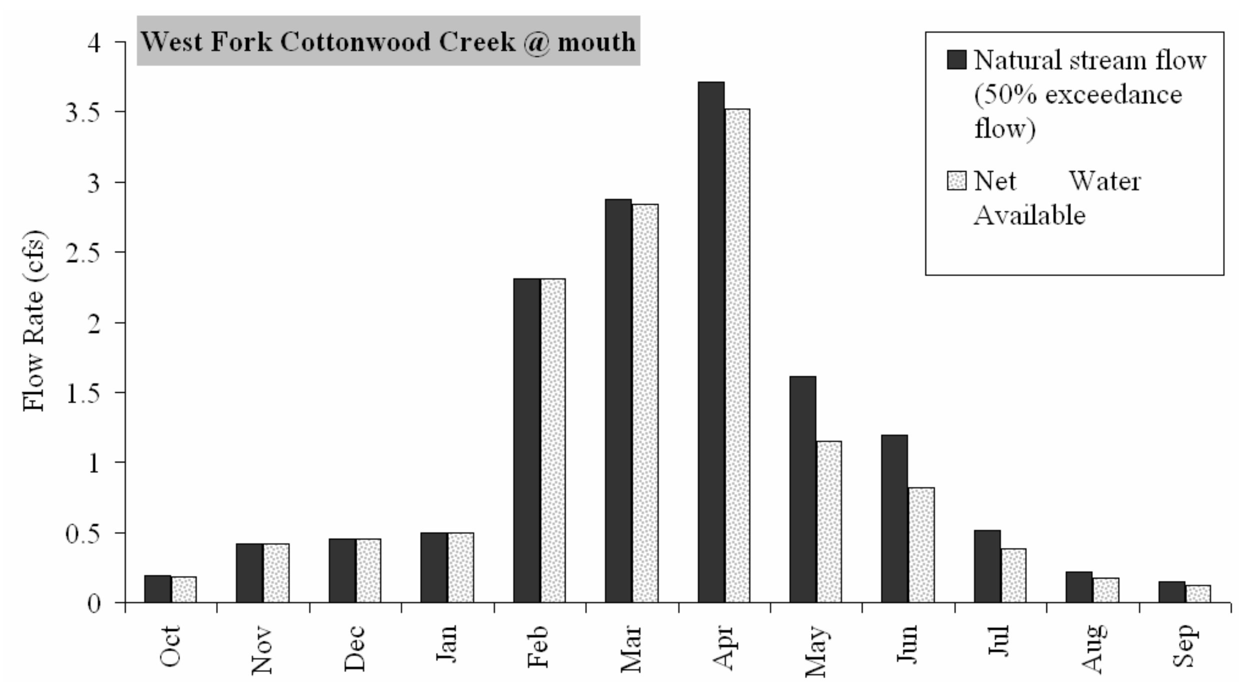

Figure 16. Estimated natural streamflow, and net available flow, at the mouth of West Fork Cottonwood Creek (OWRD, 2004).

Current conditions: Current low flow conditions are only minimally impacted (e.g., Figure 16) in four reaches within the Bully Creek watershed (blue bars; Figure 52; see Figure 44 for reach locations). At the other end of the spectrum, the lowest mainstem Bully Creek reach has been extremely impacted (red bars) by dam operations at the reservoir (Figure 15). The remaining five reaches have been either severely impacted (orange bars;) or moderately impacted (green bars) with respect to low flows, primarily by irrigation withdrawals.

Oxygen

Reference conditions: As discussed above, reference dissolved oxygen (D.O.) levels are not known within streams of the Malheur Subbasin, however, they would be expected to be inversely proportional to water temperatures, which would vary with elevation and stream shading. Consequently, reference D.O. levels would be expected to be higher in the forested headwater reaches than in the lower elevation, non-forested streams.

Current conditions: Current oxygen conditions (Figure 53; see Figure 44 for reach locations) generally track current high temperature conditions and riparian conditions within the Bully Creek watershed. Current oxygen impacts are severe in four reaches (orange bars), moderate in two reaches (green bars), and minimal in four reaches (blue bars). Current oxygen conditions are generally the result of the same activities that have impacted riparian and channel conditions described above.

Low Temperature

Reference conditions: As discussed above, low winter water temperatures negatively impact fish when anchor ice forms. Natural low water temperatures are a result of a lack of thermal retention along streams (due in part to a lack of riparian canopy), shallow streams, low wintertime water levels, and elevation.

Current conditions: Current low temperature impacts are generally minimal throughout the Bully Creek watershed (green and blue bars; Figure 54; see Figure 44 for reach locations), however, moderate impacts do occur within reach #1 - mainstem Bully below reservoir, and reach #8a - Cottonwood Creek (orange bars) Impacts within reach #1 are due primarily to the channelization, which has resulted in loss of thermal cover from riparian vegetation, and the low wintertime streamflow associated with diversions to reservoir storage. Conditions within reach #8a are limited by poor channel conditions (high width-depth ratio) and lack of thermal cover associated with poor riparian conditions

High Temperature

Reference conditions: As discussed above, reference conditions for high summertime water temperatures would be expected to be inversely proportional to elevation and riparian cover, and would be influenced by streamside microclimate.

Current conditions: Four reaches within the Bully Creek watershed currently have moderate high temperature impacts (green bars; Figure 55; see Figure 44 for reach locations), while an additional two reaches are rated as having minimal impacts (blue bars). Impacts in these reaches are generally the result of the channel and riparian impacts discussed above. The remaining three reaches have severe impacts (red and orange bars) due not only to riparian and channel conditions, but also large water withdrawals for irrigation and storage. Reach #1 is particularly impacted, due to the extensive channelization that has occurred.

Pollutants

Reference conditions: As discussed above, pollutants (acute and chronic toxic substances) are unlikely to have existed in significant quantities under reference conditions.

Current condition: Pollutants are not a significant impact within any reach within the Bully creek watershed, with the exception of reach #1, which is severely impacted (Figure 56; see Figure 44 for reach locations). Impacts in reach #1 are due to agricultural-related pollutants in return flows.

Obstructions

Reference conditions: As discussed above, it is unlikely that any significant sources of obstructions existed within the reaches defined for this assessment.

Current condition: Obstructions are not a significant impact within any of the Bully Creek watershed reaches (Figure 57; see Figure 44 for reach locations). Minor within-reach obstructions are due primarily to irrigation diversion structures.

Summary of limiting factors in the Bully Creek watershed

The preceding section discussed the reference and current state of the separate factors that affect survival of focal species evaluated in the Bully Creek watershed, and identified the primary human-related impacts to these factors. However, the relative importance of each of the factors to redband trout[6] is not known. The QHA output identifies the most important attribute affecting survival within each reach, however, there is no way to evaluate the important limiting factors at the watershed scale. Within this section the relative magnitude of each attribute on the focal species is examined. The summary of limiting factors presented at the end of Section 3.5.1 above describes in detail the approach that was taken here. The summary of limiting factors for Redband trout within the Bully Creek watershed is presented in Figure 17. The values in Figure 17 have been normalized so that the highest rated attribute (the attribute having the biggest overall impact on that species in the watershed) has a value of 1.0. All other attribute impacts are scaled to this highest ranked impact. Results for the Bully Creek watershed show that for redband trout riparian condition and habitat diversity are the most important limiting factors, followed by channel from and fine sediment impacts.

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[6] Of the three focal species used in this assessment only redband trout has been identified as having existed historically and currently within the Bully Creek watershed.

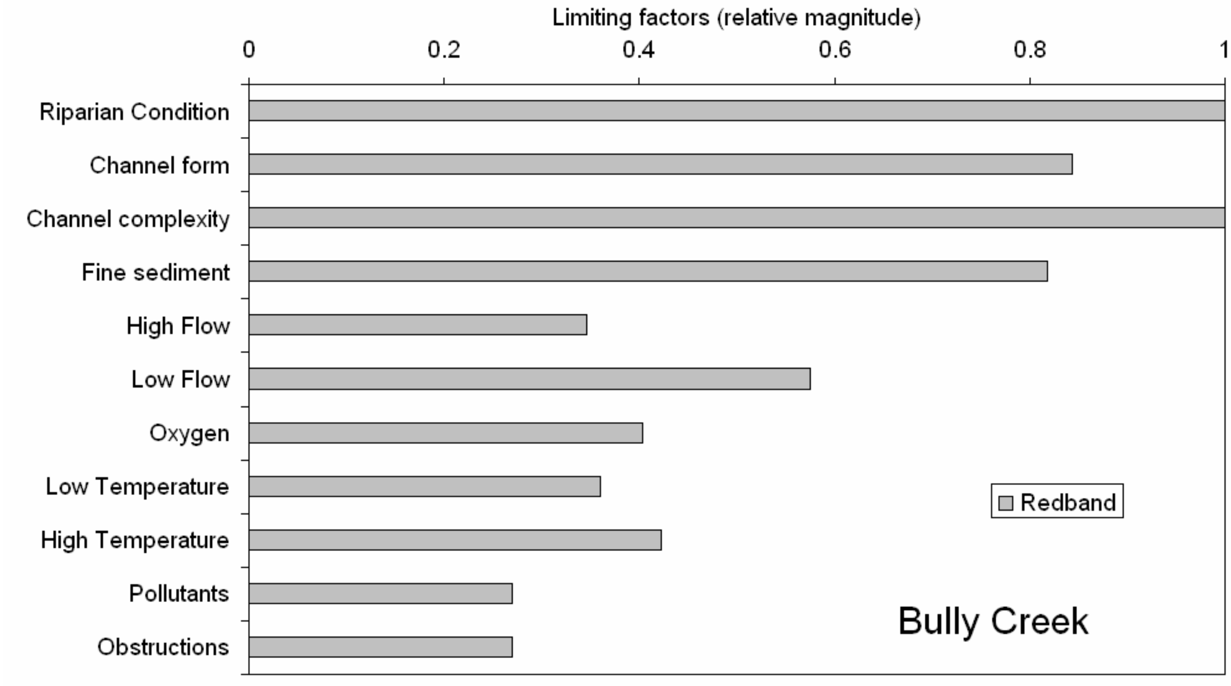


Figure 17. Summary of limiting factors by focal species within the Bully Creek watershed.

3.5.5 North Fork Malheur Watershed

The North Fork Malheur watershed contains ten QHA reaches (see Figure 45 for reach locations, and Attachment 2 - General Assessment reach characteristics and focal species use by reach). One of the reaches (North Fork #2) was not rated because it consists of Beulah Reservoir, and the assessment team felt that the current version of QHA was inadequate to address reservoir concerns. The following is a summary of reference and current conditions for each of the 11 QHA attributes.

Channel Stability

Reference conditions: Estimated reference channel gradient and confinement classes within the North Fork Malheur watershed are shown in Figure 3. The distribution of reference gradient and confinement for the North Fork Malheur is shown in Figure 18. The largest single grouping within the North Fork Malheur watershed is the low-gradient confined channels (Figure 18). In their reference condition these channels would most likely have been classified as Rosgen type F channels (Table 12; Rosgen, 1996). The next largest grouping is the low-gradient unconfined channels (Figure 18), which in their reference condition would most likely have been classified as Rosgen type C, or E channels (Table 12). The majority of the remaining channels are all in the confined category (Figure 18), which would, in their reference condition, most likely have been classified as Rosgen type Aa+, A or B channels, depending on gradient (Table 12).

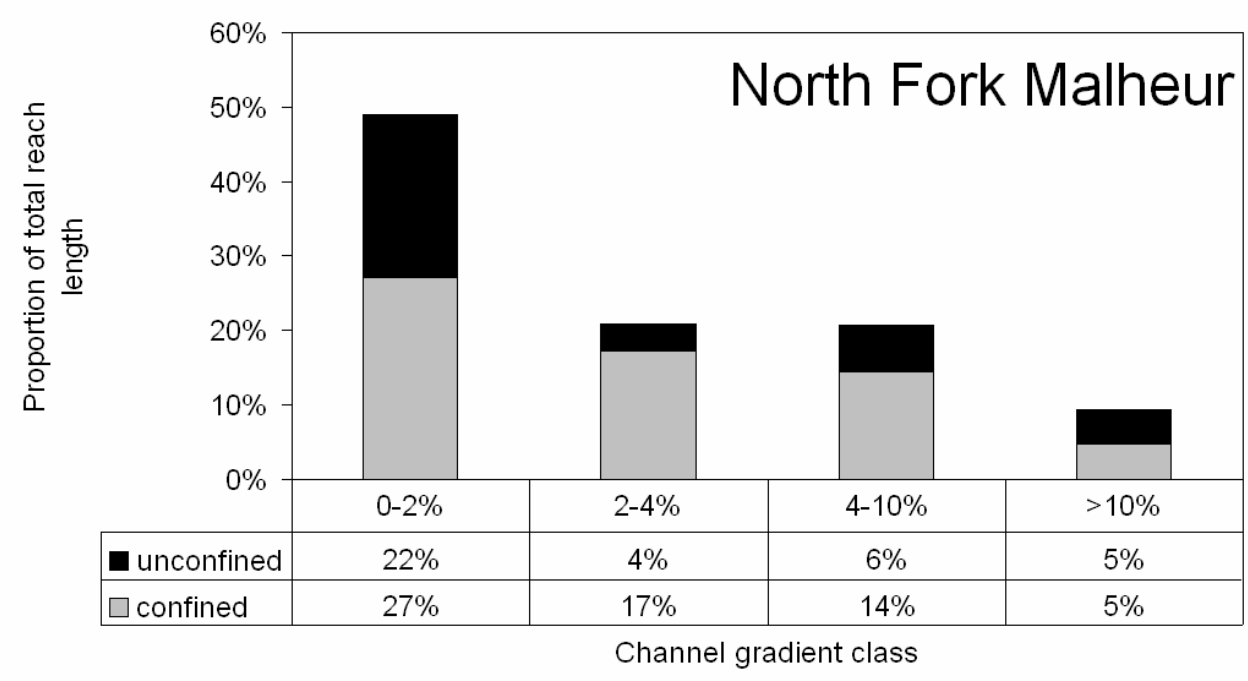


Figure 18. Estimated distribution of reference channel type in the North Malheur watershed.

Current condition: Current channel stability is generally good within the North Fork Malheur watershed. Five of the ten reaches have only minimal impacts (reaches with blue bars; Figure 47; see Figure 45 for reach locations), and an additional three reaches only moderate impacts (reaches with green bars) Channel stability has been compromised in these reaches primarily due to occasional road fills impinging on channels in locations, and limited areas of channelization to accommodate pasture. The only heavily impacted reach within the watershed is North Fork Malheur reach #1; the North Fork Malheur from the confluence with the Main Malheur upstream to Beulah Reservoir (orange bar). The channel within this reach has been disturbed due to straightening associated with agricultural activities.

Riparian Condition:

Reference conditions: Only the downstream half of the North Fork Malheur reach #1 is located within the Northern Basin and Range level III ecoregions (see Subbasin Overview for Ecoregions map; USEPA, 2003). Reference conditions for the immediate streamside area along streams that are located within the Northern Basin and Range level III ecoregion would have consisted primarily of hardwood species (black & narrow leaf cottonwoods, aspen) and shrubs (willows, mountain alder, hawthorn, chokecherry, wood's rose & silver sage) (WPN, 2001). The remaining reaches are all located within the Blue Mountains level III ecoregion. Approximately 40% of the stream length is located within level IV ecoregion 11h (Continental Zone Highlands), an additional 40% of length within ecoregion 11i (Continental Zone Foothills), and 25% within ecoregion 11l (Mesic Forest Zone). Detail on reference conditions for the immediate streamside area is available for these streams in (Table 13). Moving laterally away from the streams the riparian and adjacent upland vegetation consisted primarily of Ponderosa pine (38% of total riparian length), Wyoming big sagebrush (26%), and Grand fir (15%) (ONHP 2002).

Current condition: Current riparian conditions are generally functional within the majority of the North Fork Malheur watershed. Three of the ten reaches have only minimal impacts (reaches with blue bars; Figure 48; see Figure 45 for reach locations), and an additional three reaches only moderate impacts (reaches with green bars). The only reaches that are identified as being severely impacted (red and orange bars) are reaches #1 (North Fork downstream of Beulah Reservoir) and the two Little Malheur tributaries (reaches #9 and #10). Impacts in reach #10 are due to high intensity wildfires that occurred in 2002. The main source of impacts in reach #9 are intensive grazing, and to a lesser extent wildfire damage. Reach #1 is impacted primarily agricultural activities (hay production) and grazing.

Habitat Diversity

Reference conditions: As discussed above, it is not possible to use a static metric (e.g., frequency of pools, frequency of LWD pieces) to describe habitat diversity in the reference condition, and it is beyond the scope of this document to develop reference conditions. In assembling the QHA database participants considered, based on expert opinion, what the likely habitat conditions were in the reference state, and compared present conditions against these hypothesized reference conditions.

Current condition: Current habitat diversity ratings in the North Fork Malheur watershed are also generally good. Five of the ten reaches have only minimal impacts (reaches with blue bars; Figure 49; see Figure 45 for reach locations), and an additional three reaches only moderate impacts (reaches with green bars). The only reach identified as being severely impacted (orange bars) is reach #1 (North Fork downstream of Beulah Reservoir), which is impacted by bank erosion and mechanical damage to banks and stream beds, as well as the riparian and channelization impacts discussed above.

Fine Sediment

Reference conditions: As discussed above, it is not possible to describe reference conditions for fine sediment due to the variability in factors that drive fine sediment inputs to the reach, and deposition within the reach. In assembling the QHA database participants considered, based on expert opinion, what the fine sediment dynamics were in the reference state, and compared present conditions against these hypothesized reference conditions.

Current conditions: Current fine sediment ratings in the North Fork Malheur watershed are also generally good. Three of the ten reaches have only minimal impacts (reaches with blue bars; Figure 50; see Figure 45 for reach locations), and an additional three reaches have only moderate impacts (reaches with green bars). Three reaches are identified as being severely impacted (orange bars). Reach #1 (North Fork downstream of Beulah Reservoir) is impacted by bank erosion and mechanical damage to banks and streambeds, as well as the riparian and channelization impacts discussed above. The reach immediately upstream of Beulah Reservoir (reach #3) and Little Malheur reach #9 are impacted primarily due to grazing practices. The wildfire that resulted in reduced riparian cover in reach #10 has not yet resulted in adverse fine sediment impacts within that reach.

High Flow

Reference conditions: As discussed above, peak flows in the North Fork Malheur watershed are driven primarily by winter rain, rain-on-snow, spring snowmelt, and (to a lesser extent) summer rainstorms. Peak flows in streams draining the Blue Mountains have high flows later into the season due to the greater snowpack in higher elevation areas,

Current conditions: Current high flow conditions approximate reference conditions within most of the reaches in the North Fork Malheur watershed (blue bars; Figure 51; see Figure 45 for reach locations). Moderate impacts to high flows (green bars), occur in the Little Malheur reaches (#9 and #10) due to recent wildfires in the headwater areas. The only severe impact to high flows noted within the watershed was in reach #1 (orange bars), due to reservoir operations that result in a decrease in wintertime high flows.

Low Flow

Reference conditions: As described above, natural volumes of runoff are lowest during the late summer and early fall. Within low-elevation tributaries (i.e., those lacking significant snow pack) the ratio of low flow to high flows is quite large (e.g., Figure 5) as compared to mainstem reaches (e.g., Figure 6) and tributaries draining high elevation areas (e.g., Figure 9, Figure 19), which are buffered by late season snowmelt.

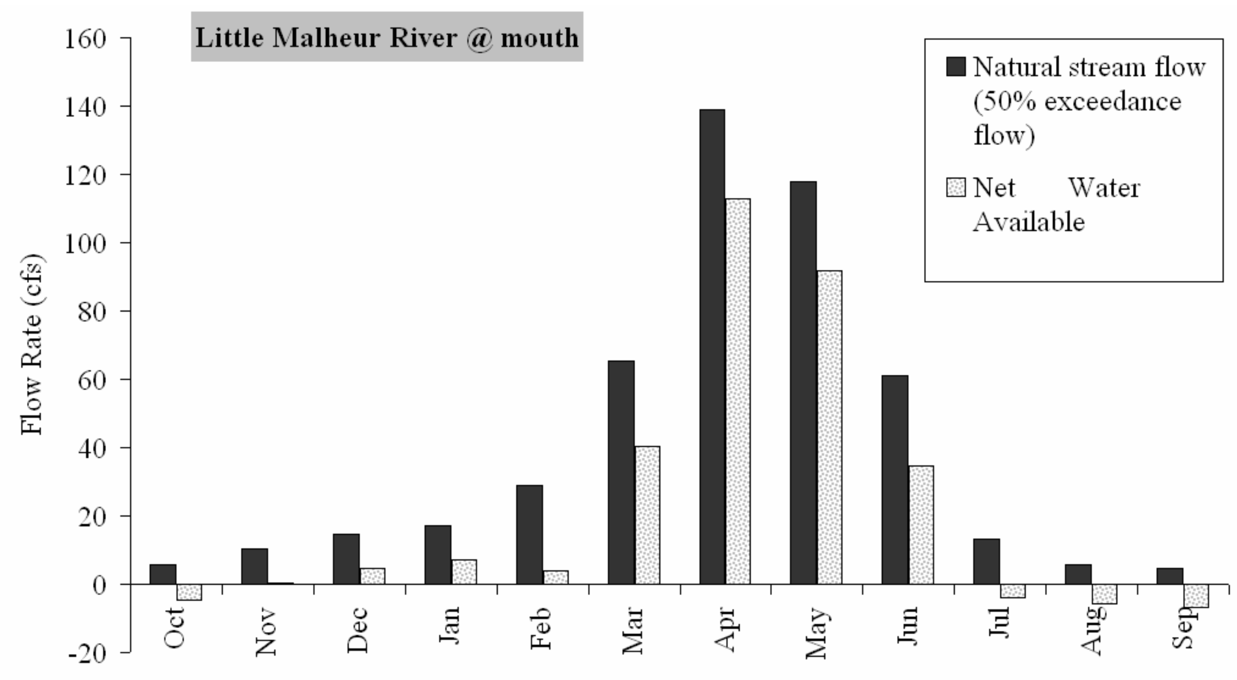


Figure 19. Estimated natural streamflow, and net available flow, at the mouth of the Litle Malheur River (OWRD, 2004).

Current conditions: Current low flow conditions approximate reference conditions within most of the reaches in the North Fork Malheur watershed (blue bars; Figure 52; see Figure 45 for reach locations). However, severe impacts to low flows (red and orange bars), occur in the Little Malheur reach #9 (Figure 19), the North Fork Malheur form Beulah upstream to the Little Malheur (reach #3), and reach #1. Impacts in reaches #3 and #9 are due to irrigation withdrawals. Impacts in reach #1 are due to increased summertime flows associated with dam releases and conveyance down the stream channel.

Oxygen

Reference conditions: As discussed above, reference dissolved oxygen (D.O.) levels are not known within streams of the Malheur Subbasin, however, they would be expected to be inversely proportional to water temperatures, which would vary with elevation and stream shading. Consequently, reference D.O. levels would be expected to be higher in the forested headwater reaches than in the lower elevation, non-forested streams.

Current conditions: Current oxygen conditions (Figure 53; see Figure 45 for reach locations) generally track current high temperature conditions within the North Fork Malheur watershed. Current oxygen impacts are minimal in most reaches (green and blue bars), and moderate in only reach #9 (orange bars), due primarily to low flows and high water temperatures associated with irrigation withdrawals.

Low Temperature

Reference conditions: As discussed in section 3.5.1 above, low winter water temperatures negatively impact fish when anchor ice forms. Natural low water temperatures are a result of a lack of thermal retention along streams (due in part to a lack of riparian canopy), shallow streams, low wintertime water levels, and elevation.

Current conditions: Current low temperature impacts are generally minimal throughout the watershed (green and blue bars; Figure 54; see Figure 45 for reach locations), however, severe to moderate impacts do occur within reach #1 and #9 (red and orange bars). Impacts within reach #9 are tied to lack of riparian cover, while reach #1 is impacted by low wintertime streamflow associated with reservoir storage.

High Temperature

Reference conditions: As discussed above, reference conditions for high summertime water temperatures would be expected to be inversely proportional to elevation and riparian cover, and would be influenced by streamside microclimate.

Current conditions: Current high temperature impacts are generally minimal throughout the watershed (green and blue bars; Figure 55; see Figure 45 for reach locations), however, severe to moderate impacts do occur within reach #3 and #9 (red and orange bars) due to lack of riparian cover and irrigation withdrawals. It is interesting to note that reach #1 is only moderately impacted by high temperatures, due to summertime dam releases and conveyance down the stream channel.

Pollutants

Reference conditions: As discussed above, pollutants (acute and chronic toxic substances) are unlikely to have existed in significant quantities under reference conditions.

Current condition: Pollutants are not a significant impact within any reach within the North Fork Malheur watershed (Figure 56; see Figure 45 for reach locations). Only reach #1, the north Fork below Beulah Reservoir, is rated for any impact at all, and this is a minimal impact due to agricultural-related pollutants.

Obstructions

Reference conditions: As discussed above, it is unlikely that any significant sources of obstructions existed within the reaches defined for this assessment.

Current condition: Impacts due to within-reach obstructions are minimal or non-existent in most reaches within the North Fork watershed (Figure 57; see Figure 45 for reach locations). The minor impacts identified are due to local obstructions caused by irrigation diversions.

Summary of limiting factors in the North Fork Malheur watershed

The preceding section discussed the reference and current state of the separate factors that affect survival of the three focal species evaluated in the North Fork Malheur watershed, and identified the primary human-related impacts to these factors. However, the relative importance of each of the factors to each fish species is not known. The QHA output identifies the most important attribute affecting survival within each reach, however, there is no way to evaluate the important limiting factors at the watershed scale. Within this section the relative magnitude of each attribute on each focal species is examined. The summary of limiting factors presented at the end of Section 3.5.1 above describes in detail the approach that was taken here. The summary of limiting factors for each of the three species found within the North Fork Malheur watershed is presented in Figure 20. The values in Figure 20 have been normalized so that the highest rated attribute (the attribute having the biggest overall impact on that species in the watershed) has a value of 1.0. All other attribute impacts are scaled to this highest ranked impact. Results for the North Fork Malheur watershed show that for all three focal species channel (or habitat) complexity is the most important limiting factor overall. Riparian condition is equally limiting for Redband trout, and the second most important element for bull trout.

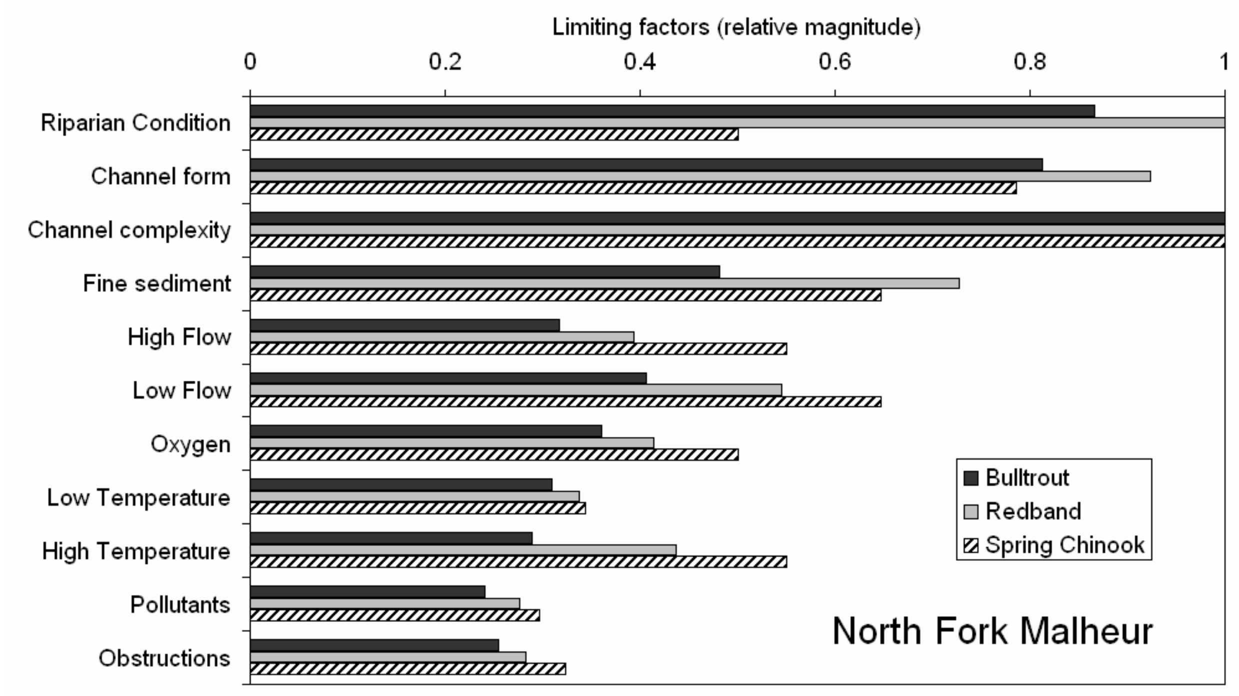


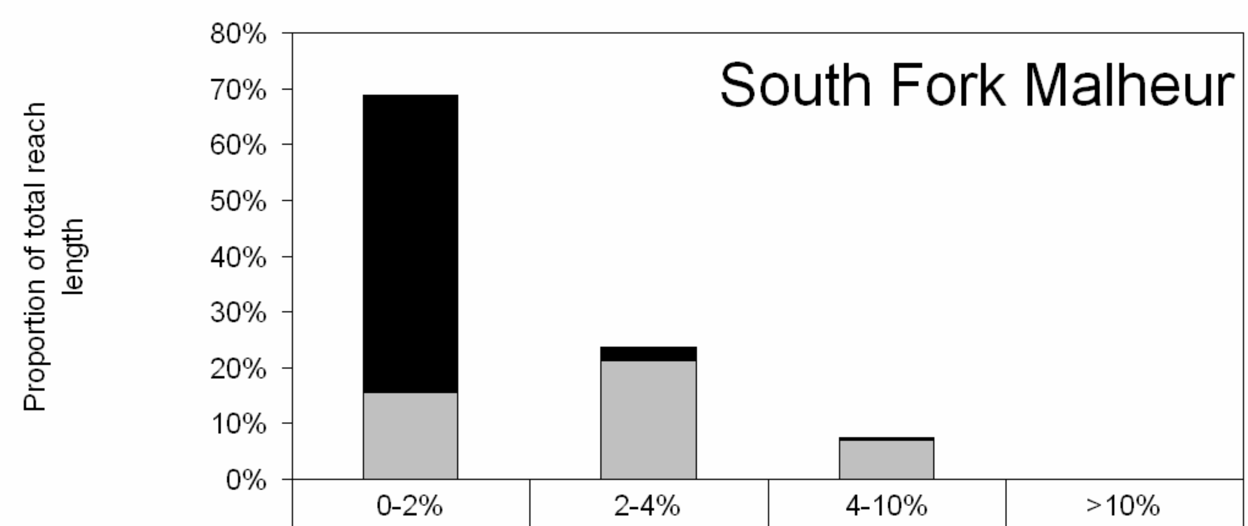
Figure 20. Summary of limiting factors by focal species within the North Fork Malheur watershed.

3.5.6 South Fork Malheur Watershed

The South Fork Malheur watershed contains six QHA reaches (see Figure 46 for reach locations, and Attachment 2 - General Assessment reach characteristics and focal species use by reach). The following is a summary of reference and current conditions for each of the 11 QHA attributes.

Channel Stability

Reference conditions: Estimated reference channel gradient and confinement classes within the South Fork Malheur watershed are shown in Figure 3. The distribution of reference gradient and confinement for the South Fork Malheur is shown in Figure 21. Low-gradient unconfined channels make up approximately half of the total reach length within the South Fork Malheur watershed (Figure 21). In their reference condition these channels would most likely have been classified as Rosgen type C, or E channels (Table 12; Rosgen, 1996). The low-gradient confined channels (Figure 21) make up an additional 16% of total reach length. In their reference condition these channels would most likely have been classified as Rosgen type F channels (Table 12). The majority of the remaining channels are all in the confined category (Figure 21), which would, in their reference condition, most likely have been classified as Rosgen type Aa+, A or B channels, depending on gradient (Table 12).



	0-2%	2-4%	4-10%	>10%
■ unconfined	53%	2%	1%	
□ confined	16%	21%	7%	

Figure 21. Estimated distribution of reference channel type in the North Malheur watershed.

Current condition: Current channel stability is rated as poor to moderate within the South Fork Malheur watershed. Three of the reaches are rated as having moderate impacts (reaches with green bars; Figure 47; see Figure 46 for reach locations), and an additional three reaches as having severe impacts (reaches with orange bars). Along the severely impacted reaches channel stability has been compromised by railroad (reaches #1 and #5 only) and highway fills. Impacts in the moderately impacted reaches are due primarily to localized areas of channelization associated with agricultural activities, and occasional road fills impinging on channels.

Riparian Condition:

Reference conditions: The entire South Fork Malheur watershed is located within the Northern Basin and Range level III ecoregions (see Subbasin Overview for Ecoregions map; USEPA, 2003). Reference conditions for the immediate streamside area consist primarily of hardwood species (black & narrow leaf cottonwoods, aspen) and shrubs (willows, mountain alder, hawthorn, chokecherry, wood's rose & silver sage) (WPN, 2001). Moving laterally away from the streams the riparian and adjacent upland vegetation consisted primarily of Wyoming big sagebrush (51% of total riparian length), Low sagebrush (16%), Basin big sagebrush (14%), Low sagebrush-Wyoming big sagebrush (7%), Mountain big sagebrush (4%), and Western juniper woodland (4%) (ONHP 2002).

Current condition: Current riparian conditions are only moderately impacted within two reaches of the of the South Fork Malheur watershed (reaches with green and blue bars; Figure 48; see Figure 46 for reach locations), the Granite and Swamp Creek tributaries, both of which have areas of dense woody vegetation in relatively good condition. The remaining four reaches are all rated as having severe impacts (reaches with orange bars). Riparian conditions within these reaches are impacted primarily by grazing of livestock and wildlife, and in some areas by roads and (abandoned) railroads that limit development of riparian vegetation.

Habitat Diversity

Reference conditions: As discussed above, it is not possible to use a static metric (e.g., frequency of pools, frequency of LWD pieces) to describe habitat diversity in the reference condition, and it is beyond the scope of this document to develop reference conditions. In assembling the QHA database participants considered, based on expert opinion, what the likely habitat conditions were in the reference state, and compared present conditions against these hypothesized reference conditions.

Current condition: Current habitat diversity ratings in the South Fork Malheur watershed (Figure 49; see Figure 46 for reach locations) generally reflect both channel stability ratings and riparian ratings, underscoring the influence of these two factors on habitat diversity. Two of the reaches (#2 and #6) are only moderately impacted (reaches with green bars), while the remaining four reaches are rated as having severe impacts (reaches with orange bars). All of the management actions identified as limiting channel stability and riparian function (grazing, constraints by road and/or railroad fills) limit habitat diversity, with bank erosion and sloughing and low flows due to irrigation withdrawals identified as additional sources of impact.

Fine Sediment

Reference conditions: As discussed above, it is not possible to describe reference conditions for fine sediment due to the variability in factors that drive fine sediment inputs to the reach, and deposition within the reach. In assembling the QHA database participants considered, based on expert opinion, what the fine sediment dynamics were in the reference state, and compared present conditions against these hypothesized reference conditions.

Current conditions: Current fine sediment ratings in the South Fork Malheur watershed show only moderate impacts in four of the six reaches (reaches with green bars; Figure 50; see Figure 46 for reach locations), with only two reaches (#4 - Coleman Creek, and #5 - Crane/Little Crane/Alder Creeks) identified as having severe fine sediment problems (orange bars). Fine sediment problems within the severely impacted reaches are due to bank erosion, bank sloughing, grazing, and road sediments.

High Flow

Reference conditions: As discussed above, peak flows can occur in any season in South Fork Malheur watershed. Winter rainstorms and rain-on-snow generate many of the winter peak flows, and Spring peak flows are commonly generated by both rainfall and snowmelt in this area. Summer thunderstorms also can produce significant peak flow events.

Current conditions: Current high flow conditions approximate reference conditions within most of the reaches in the South Fork Malheur watershed (green bars; Figure 51; see Figure 46 for reach locations). Moderate impacts to high flows are due primarily to increased compaction (leading to increased runoff efficiency) associated with road construction, and grazing by livestock and wildlife.

Low Flow

Reference conditions: As described in Section 3.5.1 above, natural volumes of runoff are lowest during the late summer and early fall. Within low-elevation tributaries (i.e., those lacking significant snow pack) the ratio of low flow to high flows is quite large (e.g., Figure 22) as compared to mainstem reaches (e.g., Figure 6) and tributaries draining high elevation areas (e.g., Figure 9), which are buffered by late season snowmelt.

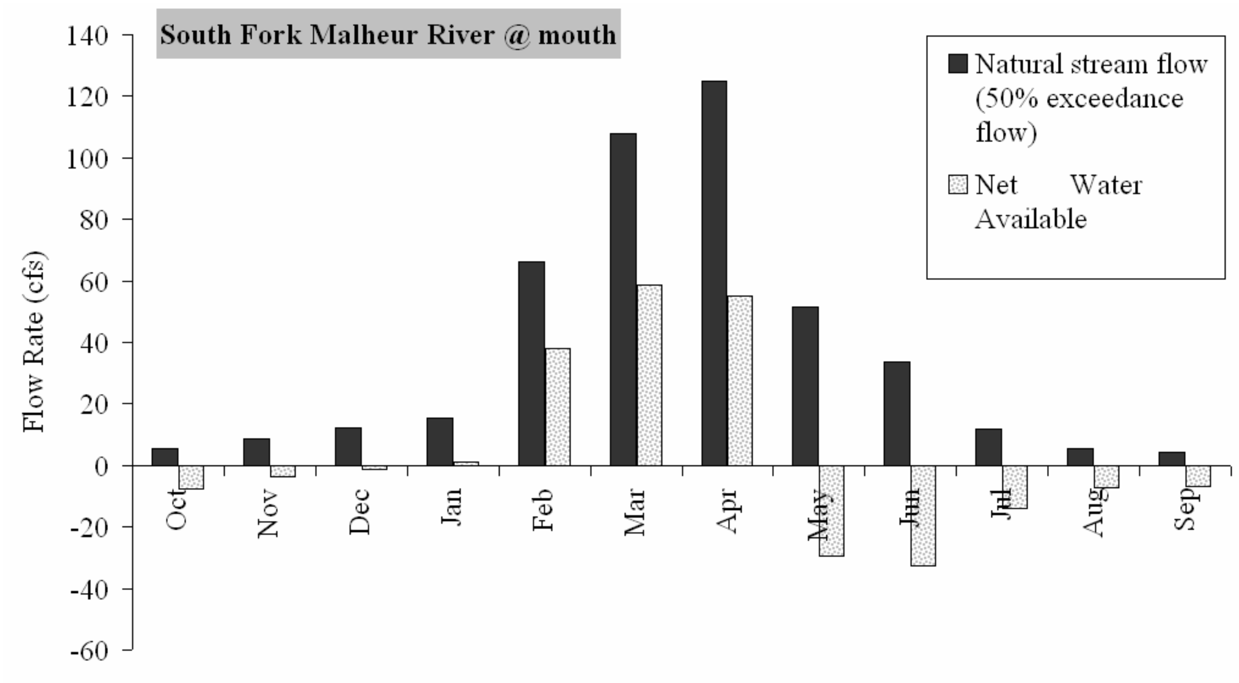


Figure 22. Estimated natural streamflow, and net available flow, at the mouth of the South Fork Malheur River (OWRD, 2004).

Current conditions: Current low flow conditions are severely impacted in all reaches of the South Fork Malheur watershed (Figure 52; see Figure 46 for reach locations). Impacts are due primarily to irrigation withdrawals.

Oxygen

Reference conditions: As discussed above, reference dissolved oxygen (D.O.) levels are not known within streams of the Malheur Subbasin, however, they would be expected to be inversely proportional to water temperatures, which would vary with elevation and stream shading. Consequently, reference D.O. levels would be expected to be higher in the forested headwater reaches than in the lower elevation, non-forested streams such as the South Fork Malheur watershed.

Current conditions: Current oxygen conditions (Figure 53; see Figure 46 for reach locations) generally track current high temperature and low flow conditions within the South Fork Malheur watershed. Current oxygen impacts are severe in all reaches with the exception of reaches #2 (Granite Creek/Big Granite Creek) and #6 (South Fork headwaters). Current impacts are due primarily to poor riparian conditions and irrigation withdrawals resulting in higher temperatures and lower D.O. levels.

Low Temperature

Reference conditions: As discussed above, low winter water temperatures negatively impact fish when anchor ice forms. Natural low water temperatures are a result of a lack of thermal retention along streams (due in part to a lack of riparian canopy), shallow streams, low wintertime water levels, and elevation.

Current conditions: Current low temperature impacts are generally minimal to moderate throughout the watershed (green and blue bars; Figure 54; see Figure 46 for reach locations). Impacts are due primarily to lack of riparian cover.

High Temperature

Reference conditions: As discussed above, reference conditions for high summertime water temperatures would be expected to be inversely proportional to elevation and riparian cover, and would be influenced by streamside microclimate.

Current conditions: Current high temperature impacts (Figure 55; see Figure 46 for reach locations) generally track riparian impacts throughout the watershed. Impacts are moderate in four of the six reaches (green bars), and severe (orange bars) within the reach #4 (Coleman Creek) amd reach #5 (Crane/Little Crane/Alder Creeks) due primarily to lack of riparian cover and irrigation withdrawals.

Pollutants

Reference conditions: As discussed above, pollutants (acute and chronic toxic substances) are unlikely to have existed in significant quantities under reference conditions.

Current condition: Pollutants are not a significant impact within any reach within the South Fork Malheur watershed (Figure 56; see Figure 46 for reach locations). Only reach #1, the South Fork from the mouth up to Crane Creek, is rated for any impact at all, and this is a moderate impact due to agricultural-related pollutants.

Obstructions

Reference conditions: As discussed in section 3.5.1 above, it is unlikely that any significant sources of obstructions existed within the reaches defined for this assessment.

Current condition: Impacts due to within-reach obstructions are minimal to moderate in most reaches within the South Fork watershed (Figure 57; see Figure 46 for reach locations). The impacts identified are due to local obstructions caused by irrigation diversions.

Summary of limiting factors in the South Fork Malheur watershed

The preceding section discussed the reference and current state of the separate factors that affect survival of the two focal species[7] evaluated in the South Fork Malheur watershed, and identified the primary human-related impacts to these factors. However, the relative importance of each of these attribute to each fish species is not known. The QHA output identifies the most important attribute affecting survival within each reach, however, there is no way to evaluate the important limiting factors at the watershed scale. Within this section the relative magnitude of each attribute on each focal species is examined. The summary of limiting factors presented at the end of Section 3.5.1 above describes in detail the approach that was taken here. The summary of limiting factors for each of the three species found within the South Fork Malheur watershed is presented in Figure 23. The values in Figure 23 have been normalized so that the highest rated attribute (the attribute having the biggest overall impact on that species in the watershed) has a value of 1.0. All other attribute impacts are scaled to this highest ranked impact. Results for the South Fork Malheur watershed show that for both focal species, channel (or habitat) complexity is the most important limiting factor overall. Channel form, riparian conditions and low flows also result in major limitations to one or both of the focal species.

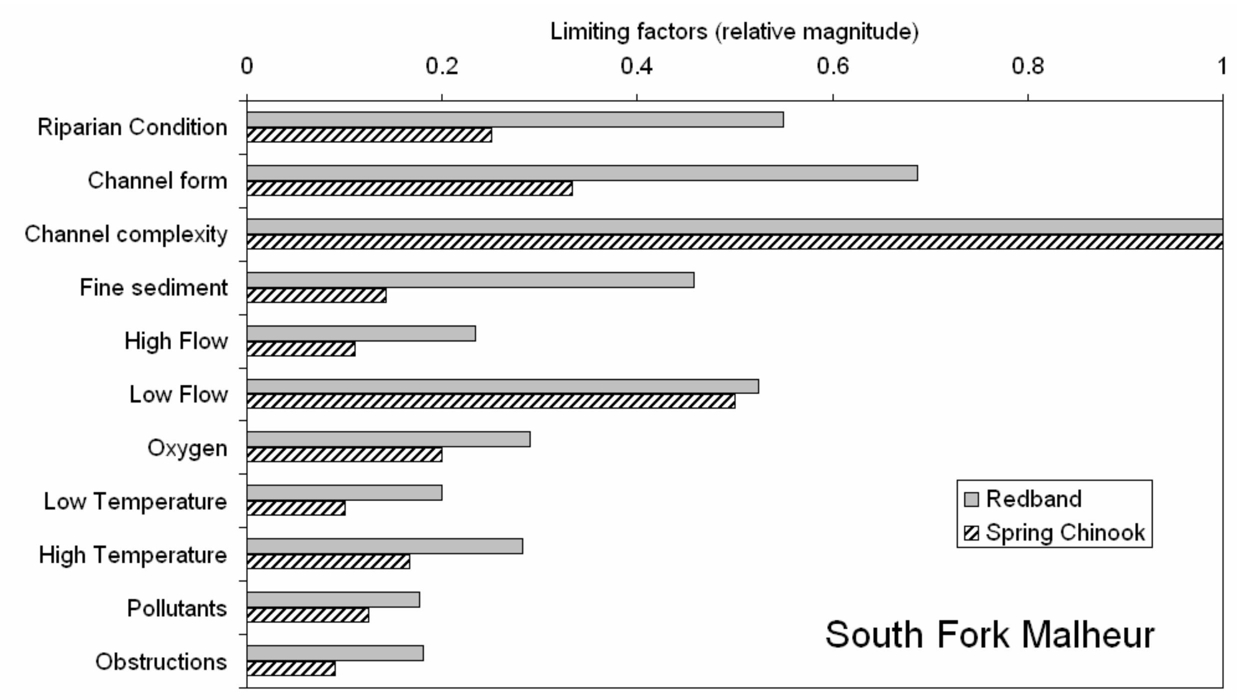


Figure 23. Summary of limiting factors by focal species within the South Fork Malheur watershed.

[7] Of the three focal species used in this assessment only redband trout and Spring Chinook have been identified as having existed historically or currently within the South Fork Malheur watershed.

3.6 Summary of Limiting Factors, at the Subbasin Scale

The summaries of limiting factors presented in the previous section for the six watersheds within the Malheur Subbasin (i.e., Main Malheur -Figure 7, Upper Malheur -Figure 10, Willow Creek - Figure 13, Bully Creek - Figure 17, North Fork Malheur -Figure 20, and South Fork Malheur - Figure 23) demonstrate that the primary limiting habitat attributes are:

1. Riparian Condition,
2. Channel Stability (or form), and
3. Low Flows
4. Obstructions

The following summary of limiting factors focuses on these four primary habitat attributes. It is important to note that the summary presented here is based exclusively on the output from the QHA modeling. In addition to these factors there are additional concerns due to the major dams (QHA does not provide an adequate mechanism to capture the full effect of large dams on fish movement throughout the subbasin) and exotic species (competition for scarce resources, and in some cases, through piscivorous behavior).

3.6.1 Channel Conditions

Current channel conditions throughout the Malheur subbasin are shown in Figure 24, and summarized in Figure 25. The best current channel conditions (i.e., reaches having current channel conditions that are 75-100% of optimum) are located primarily in headwater areas of the Upper Malheur, North Fork Malheur and Bully Creek watersheds (Figure 24), and make up approximately 1/5 of the total reach length in the subbasin (Figure 25). Another 2/5 of the total reach length currently has channel conditions that are in moderately good shape (50-75% of optimum (Figure 25). These streams are located throughout all watersheds, primarily in headwater and middle positions (Figure 24). Streams that currently are rated as having only 25-50% of optimum channel function are located both along mainstem rivers and in tributary headwaters (Figure 24), and comprise about ¼ of the total reach length (Figure 25). Finally, those channels that have the most severe impacts to channel function (currently rated as 0-25% of optimum) are located along the mainstem Malheur River, mouth to Namorf, Bully Creek below the reservoir, and the lower reach of Willow Creek (Figure 24), and comprise about 1/10 of the total reach length (Figure 25). The management that have resulted in these current channel ratings include:

- Roads (highways and forest roads) and railroads (abandoned) encroaching on floodplains and stream channels and limiting lateral channel migration and the development of natural channel habitat sequences.
- Relocation and channelization of formerly unconfined stream reaches for the purpose of maximizing pasture and tillable lands.
- Loss of beaver and beaver dam complexes from most streams and meadows.
- Mechanical damage to stream beds and bank from livestock and wildlife grazing.
- Dikes and other flood control structures.

- Incision due to upland practices that have changed flow regime and sediment dynamics.
- Legacy impacts from hydraulic and placer mining (Willow Creek watershed).
- Utilization of channels as irrigation conveyance (lower Malheur River, Bully Creek and Willow Creek.

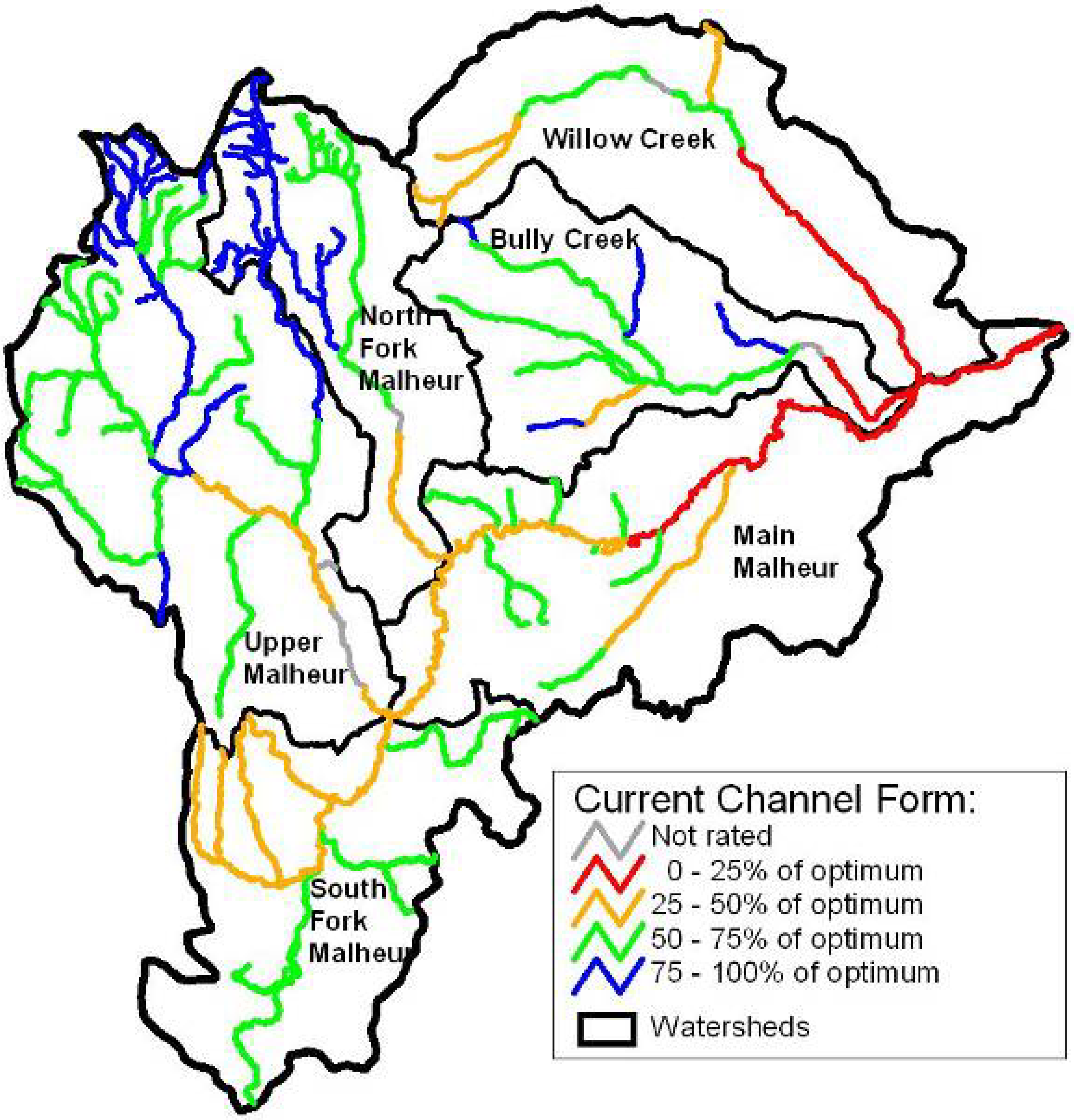


Figure 24. Summary map of current channel conditions within the Malheur Subbasin.

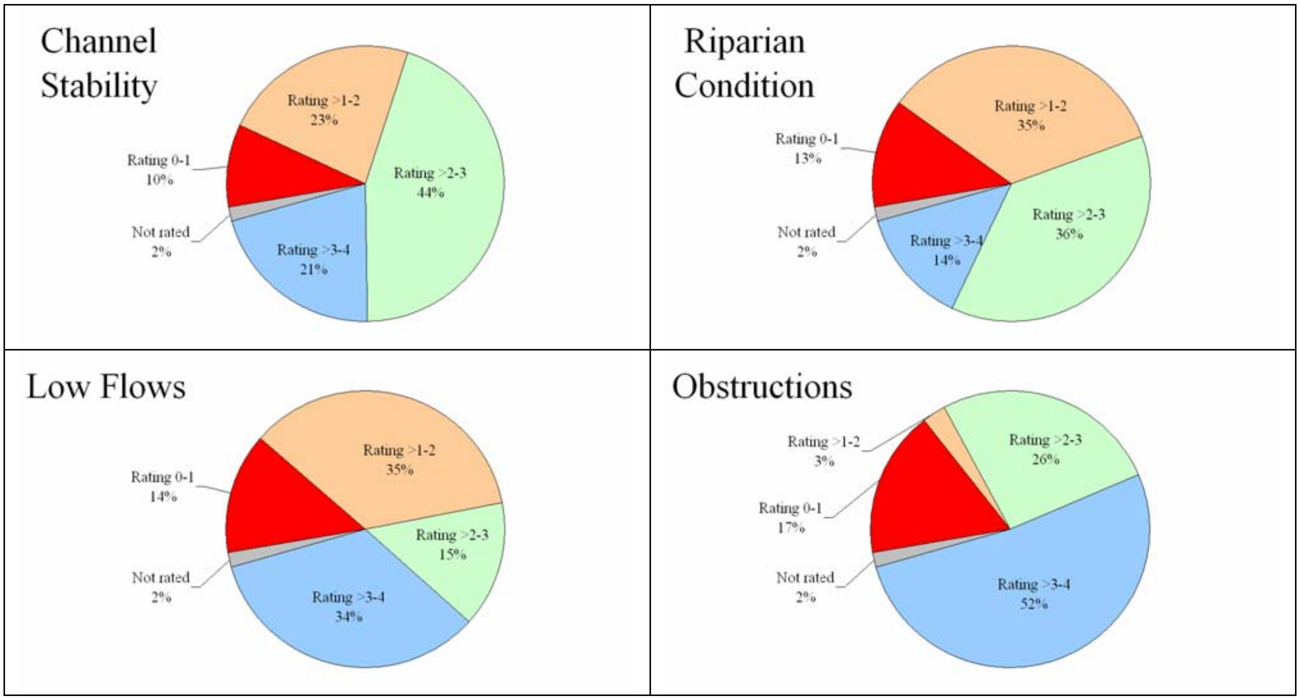


Figure 25. Summary of total reach length within the Malheur Subbasin

3.6.2 Riparian Conditions

Current riparian conditions throughout the Malheur subbasin are shown in Figure 26, and summarized in Figure 25. The best current riparian conditions (i.e., reaches having current conditions that are 75-100% of optimum) are located primarily in headwater areas of the Upper Malheur and North Fork Malheur watersheds (Figure 26), and make up approximately 14% of the total reach length in the subbasin (Figure 25). One third of the total reach length currently has riparian conditions that are in moderately good shape (50-75% of optimum (Figure 25). These streams are located throughout the subbasin, in headwater, middle, and mainstem positions (Figure 26). Interestingly, the lower Malheur River, which was rated as having severe channel impacts (Figure 24) is rated as having only moderate riparian impacts. Streams that currently are rated as having only 25-50% of optimum riparian function make up another 1/3 of total reach length (Figure 25), are located throughout the subbasin, but make up the greatest proportion of reach length in the South Fork and Bully Creek watersheds (Figure 26). Those channels that have the most severe impacts to riparian function (currently rated as 0-25% of optimum) are located along lower Willow Creek, the lower portion of Cottonwood Creek in the Main Malheur watershed, lower Stinkingwater Creek, several stream segments in the Logan Valley area, and in the recently-burned headwaters of the North Fork Malheur (Figure 26). These streams comprise about 14% of the total reach length (Figure 25). The actions that have resulted in these current riparian ratings include:

- Roads (forest and highway) and (abandoned) railroads have eliminated riparian vegetation along some sections of stream. Of particular concern is the probable loss of cottonwood along the larger mainstem rivers.

- Farming practices have limited the functional riparian zone to a narrow band along many streams, and changed the composition and density of riparian species.

- Grazing by livestock and wildlife have changed riparian species composition and density, resulting in fewer large wood recruitment opportunities, and reduced riparian shade. It should be noted that changes in grazing management along some streams have resulted in reestablishment of sedge meadows and woody vegetation in places.

- Exotic vegetation has replaced or reduced native plant communities in some locations

- Loss of beaver and beaver dam complexes from most streams and meadows has eliminated productive riparian and floodplain habitat important to salmonids. In some cases, push-up dams and flood irrigation may mimic beaver dams with respect to locally raising water tables, thereby encouraging development of riparian and wetland vegetation.

- Recent large flood events (e.g., in the lower Cottonwood Creek reach in the Main Malheur watershed) has eliminated woody riparian vegetation in areas.

- Past timber harvest operations has removed riparian vegetation , or limited it to a narrow band along some streams, and changed the composition and density of riparian species. It is expected that current forest practices rules and agency policies will prevent this impact from occurring in the future.

- Channelization and straightening of streams has lowered water tables and eliminated wet meadow systems.

- Wildfire, particularly in the headwaters of the North Fork Malheur, has set riparian vegetation back to an earlier successional phase.

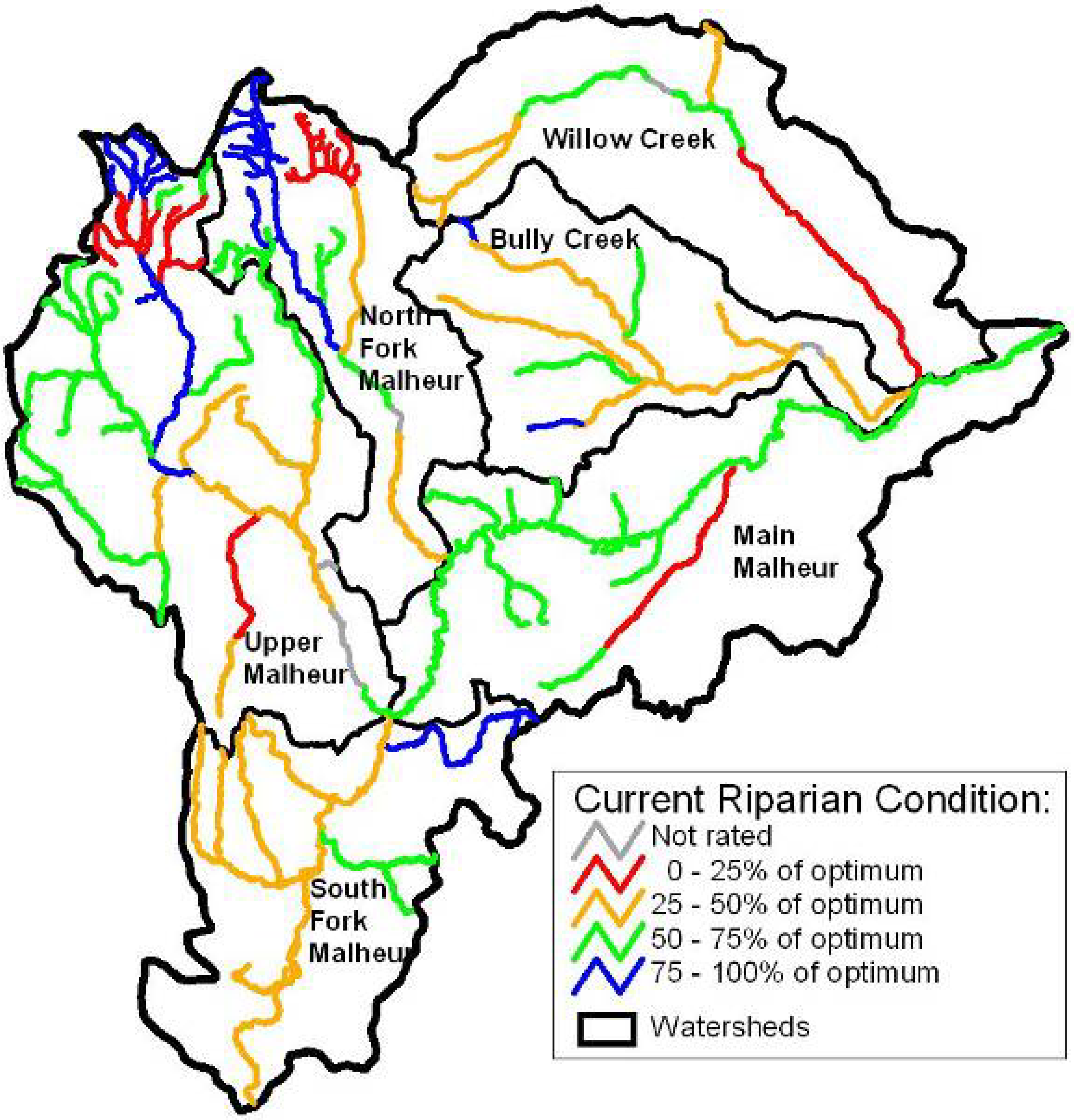


Figure 26. Summary map of current riparian conditions within the Malheur Subbasin.

3.6.3 Low Flow Conditions

Low flow impacts within the Malheur subbasin are shown in Figure 27, and summarized in Figure 25. The best current conditions with respect to low flows (i.e., reaches having current channel conditions that are 75-100% of optimum <u>for that reach</u>) are located primarily in headwater areas of the Upper Malheur and North Fork Malheur watersheds, and in some headwater tributaries in the Bully Creek and Main Malheur watersheds (Figure 27). These reaches make up a total of approximately 1/3 of the total reach length in the subbasin (Figure 25). An additional 15% of the total reach length currently has low flow conditions that are in moderately good shape (50-75% of optimum; Figure 25). These streams are located throughout all watersheds, with the exception of the North Fork Malheur (Figure 27). Streams that currently are rated as having only 25-50% of optimum low flow conditions make up an additional 1/3 of the total reach length (Figure 25), and are located along mainstem rivers, middle portions of streams, and in tributary headwaters (Figure 27). Finally, those channels that have the most severe impacts to low flows (currently rated as 0-25% of optimum) are located along the mainstem Malheur River and lower North Fork Malheur; and along lower Willow, Bully, and Stinkingwater Creeks (Figure 27). This grouping comprises about 14% of the total reach length in the subbasin (Figure 25). The actions that have resulted in these current low flow ratings include:

- Irrigation withdrawals directly reduce instream flows.
- Channels that have been negatively impacted (as described above) often times have lower <u>effective</u> summertime flows due to flow going sub-surface.
- Dam operations have changed instream low flows. In many cases the utilization of channels as irrigation conveyance downstream of dams has resulted in higher low flows than optimum (e.g., North Fork Malheur below Beulah). Conversely, in some areas (e.g., lower Willow Creek) reservoir releases travel through off-channel canals, with little water released directly to the stream channel, and return flow reenters channel far downstream.
- Loss of beaver and beaver dam complexes from most streams and meadows has eliminated water storage, resulting in lower summertime base flows. In some cases, push-up dams and flood irrigation may mimic beaver dams with respect to locally raising water tables, thereby helping to support base streamflows.
- Channelization and straightening of streams has lowered water tables and eliminated wet meadow systems, resulting in decreased water storage and lower summertime base flows.
- Juniper encroachment is widely considered to adversely affect base flows through increased canopy interception and removal of soil moisture. However, it is not clear if this is a significant problem throughout the range of juniper encroachment. The most probable impacts to base flows are in the immediate streamside area and in the vicinity of seeps and springs.
- Inter-basin (or inter watershed) transfers have reduced low-flows in some portions of the subbasin (e.g., Malheur River below Namorf).

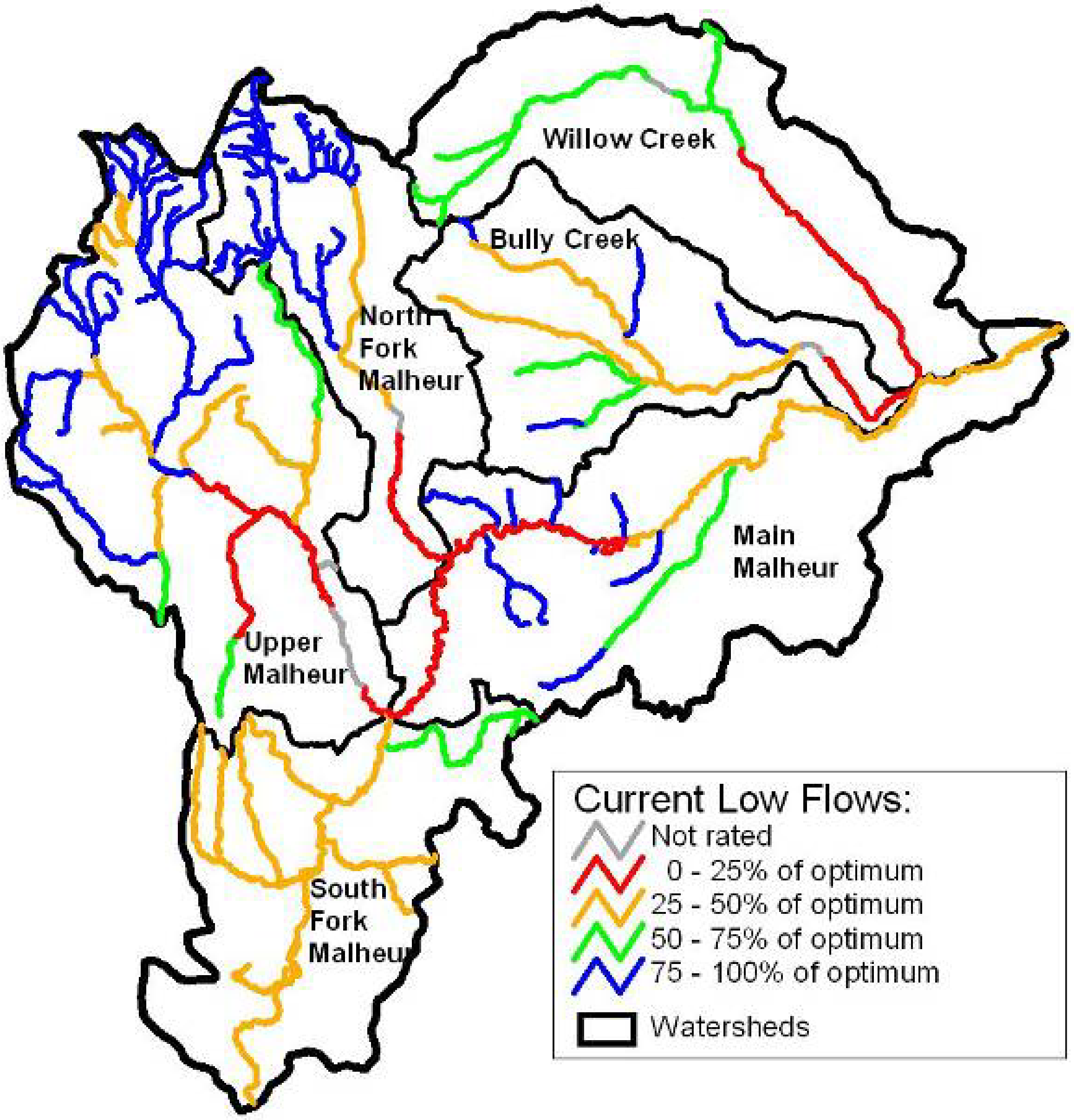


Figure 27. Summary map of current low flow conditions within the Malheur Subbasin.

3.6.4 Obstructions

Reach-level impacts due to obstructions within the Malheur subbasin are shown in Figure 28, and summarized in Figure 25. Obstructions have little impact (i.e., reaches having obstruction ratings that are 75-100% of optimum) over the majority (52%) of the total reach length in the subbasin (Figure 25). These little-impacted reaches are located throughout all watersheds (Figure 28). An additional ¼ of the total reach length has only moderate impacts (50-75% of optimum) with respect to obstructions (Figure 25); these reaches also being located throughout all watersheds (Figure 28). Streams where obstruction result in a current rating of 25-50% of optimum occur only in the Logan Valley area and in Griffin Creek; both located in the Upper

Malheur watershed (Figure 28), and comprising only 3% of total reach length (Figure 25). The reaches having the most severe impacts (0-25% of optimum) with respect to obstructions are make up 17% of the total reach length (Figure 25), and are located along the mainstem Malheur River from the mouth to Griffin Creek, Stinkingwater Creek, upper Cottonwood Creek (Upper Malheur watershed), and upper Bosonberg Creek (Figure 28). The actions that have resulted in these current obstruction ratings include:

- Dams directly blocking fish passage.
- Direct passage blockage form infrastructure associated with irrigation withdrawals (diversion structures, push up dams).
- Channels that have been negatively impacted (as described above) having sub-surface (or extremely low) flows that prevent fish passage.
- Road and (abandoned) railroad culverts that directly block upstream passage.
- Low water levels associated with dam operations.
- Extremely low flows that result from irrigation diversions.

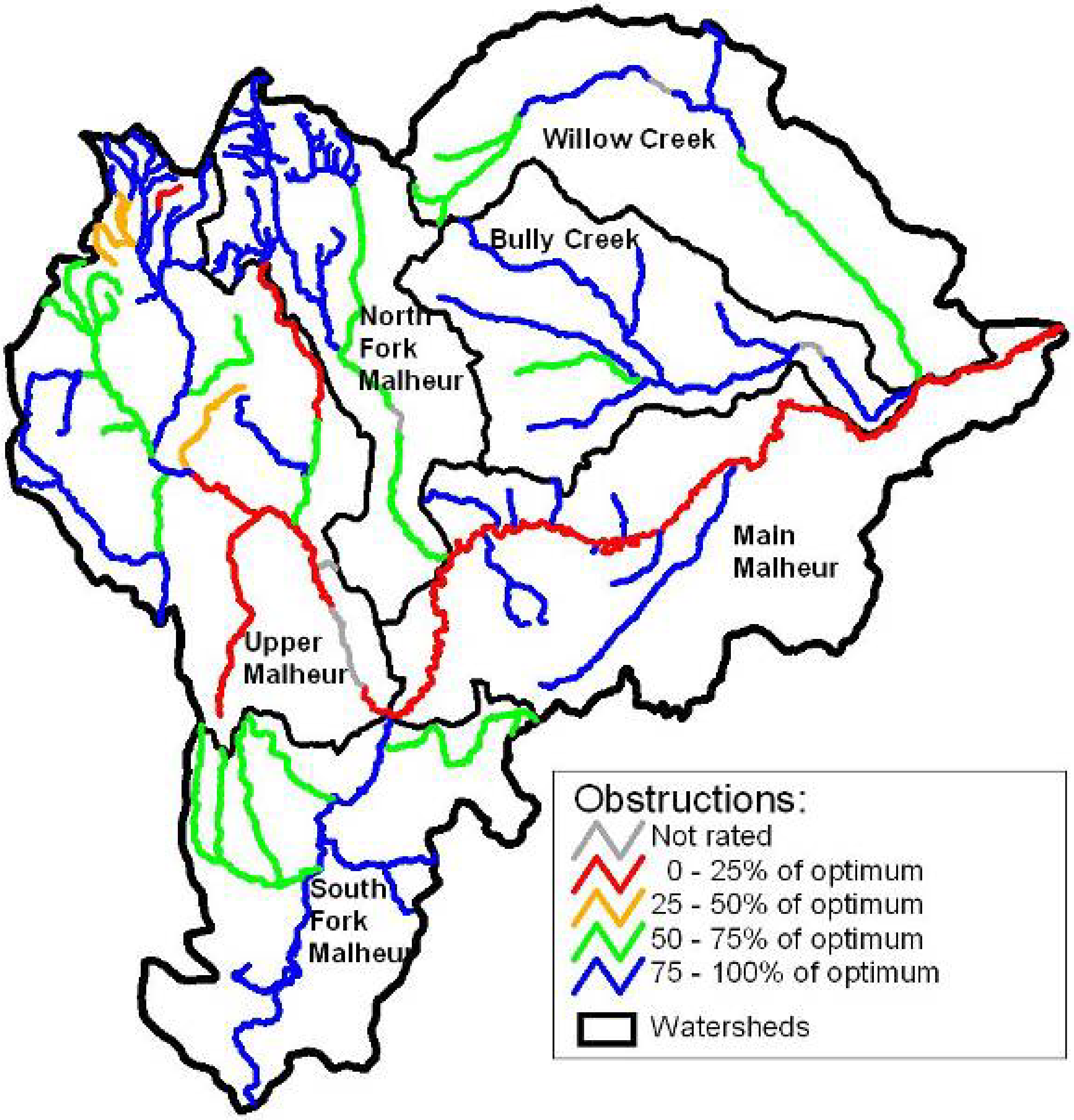


Figure 28. Summary map of current limitations due to obstructions within the Malheur Subbasin.

3.7 Prioritizing Enhancement and Protection at the Watershed and Subbasin Scales

Part of the output from the QHA model is relative protection and restoration ratings for each reach that a given focal species currently uses, or historically used. This rating is based on an algorithm that relates the current and reference condition of each habitat attribute to the life stages of the given focal species that uses that reach, and the species hypothesis developed for that given focal species. The reader is referred to the "QHA User's Guide for Subbasin Planning in Oregon, October 21, 2003" (McConnaha et al., 2003) for further discussion of this algorithm.

The output from QHA provides a first approximation of where and in what order restoration and protection might proceed within the subbasin. However, the initial output must be tempered with an understanding of those factors not accounted for (or not accounted well enough) within QHA, such as large dams and exotic species.

The results from QHA in the Malheur subbasin were difficult to interpret, due to several technical factors. First of all, a separate output page was developed for each of the three focal species. It was difficult to compare among these separate tables and graphics, particularly since there were different numbers of reaches assessed for different focal species. Secondly, the volume of output when considered at the subbasin scale was just too much to meaningfully interpret. Consequently, the QHA output has been reformatted to display the results for each focal species together in the same graphics. Furthermore, the results are discussed here at the watershed scale. We felt that, given the overall size of the subbasin, as well as the regional focus of the primary agencies involved, that the watershed was the appropriate scale to work at.

3.7.1 Main Malheur Watershed

The Main Malheur watershed contains five QHA reaches (refer to Figure 41 for reach location map). The restoration ranking for these five reaches are shown in Figure 29, and the protection rankings in Figure 30. From Figure 29 we can interpret that redband trout currently use all five reaches in the watershed, and Spring Chinook and bull trout are estimated to have used the mainstem Malheur reaches historically (for bull trout the use was primarily passage into or out of the subbasin).

Even though Figure 29 and Figure 30 only show the Mainstem Malheur reaches we can get a sense of how these reaches compare to all reaches in the entire subbasin by looking at the percentiles. For example, mainstem reach #2 is the highest ranked restoration reach in the Main Malheur watershed for redband trout, and it is in approximately the 90th percentile for all 63 reaches in the Malheur subbasin that have or had redband trout. Similarly, reach #2 is the highest ranked restoration reach for Spring Chinook in the watershed, and in approximately the 85th percentile for all 15 reaches that are estimated to have had Spring Chinook in the subbasin.

In terms of restoration both mainstem reaches rank high for bull trout and Spring Chinook, however, only the Namorf to Warm Springs dam reach ranks high for redband; lower Cottonwood Creek estimated to have a greater restoration value to redband then the lowest reach in the Malheur River.

The protection rankings are, to a certain extent, the inverse of the restoration rankings, although not completely so. For example, for redband trout, Mainstem Malheur River reach #1 has a very low protection ranking (there is not much to protect), as well as a relatively low restoration ranking (even if at optimum this reach would be important to redband primarily because of migration into or out of the subbasin; the natural conditions are not favorable to most redband life stages). In contrast, Reach #5, the miscellaneous small tributaries along the mainstem, are important to both protect their current functions (they represent unique habitats) as well as restore their functions to optimum (they have the potential to support limiting life stages).

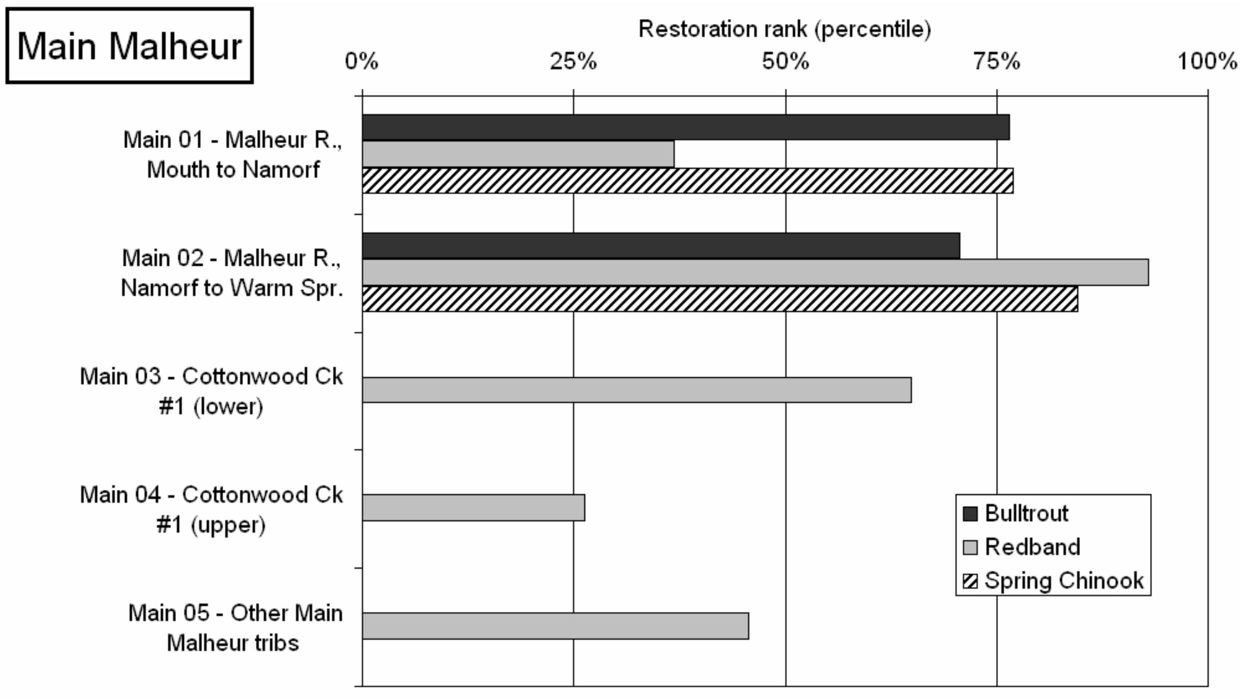


Figure 29. QHA <u>restoration</u> ranking for reaches within the Main Malheur Watershed.

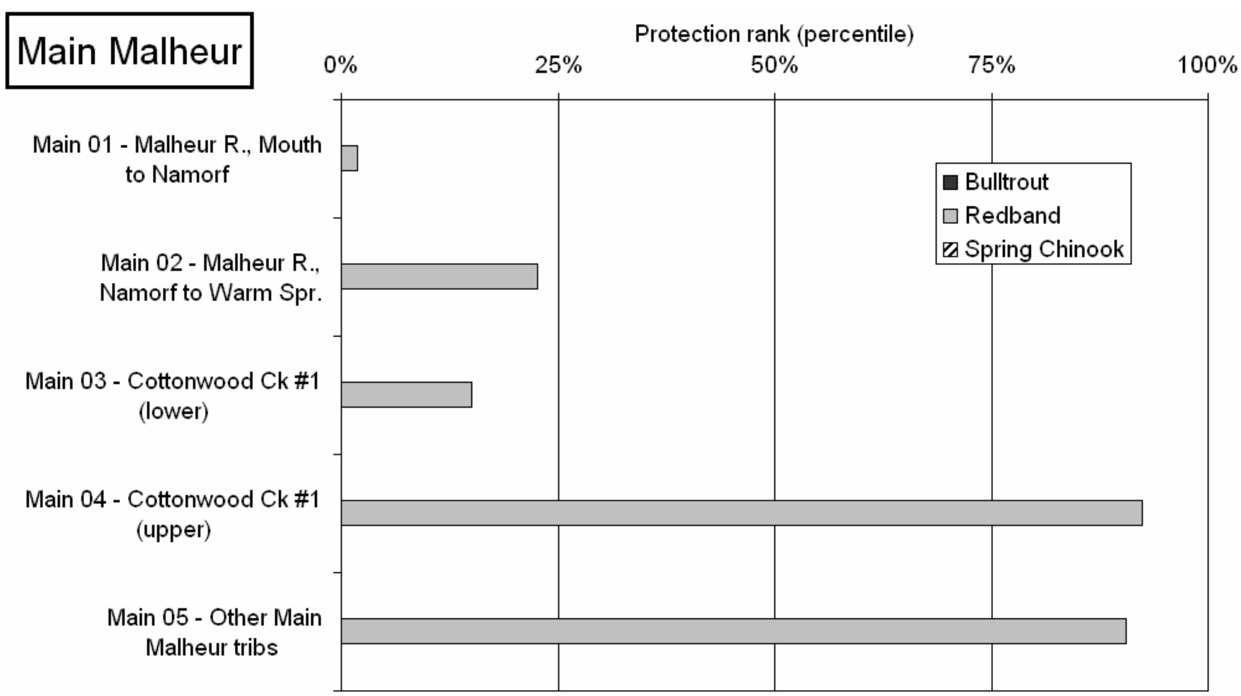


Figure 30. QHA <u>protection</u> ranking for reaches within the Main Malheur Watershed.

3.7.2 Upper Malheur Watershed

The Upper Malheur watershed contains twenty-five QHA reaches (refer to Figure 42 for reach location map). The restoration ranking for these 25 reaches are shown in Figure 31, and the protection rankings in Figure 32. From Figure 32 we can interpret which reaches currently have redband trout (all of them) and bull trout; and from Figure 31 we can see which streams historically had Spring Chinook and bull trout.

For bull trout the highest ranking reaches for restoration include the Logan Valley “west” and “east” reaches, the Summit Creek reaches, and the mainstem Malheur River from Warm Springs Reservoir upstream to Griffin Creek (Figure 31). The Logan Valley West reach is the highest ranked restoration reach for bull trout in the entire Malheur subbasin (100th percentile; Figure 31). The mainstem Malheur Reach is important for restoration primarily for connectivity with the North Fork, and potentially, other populations outside of the subbasin. In terms of protection the Malheur Headwaters reach ranks highest for bull trout (i.e., it is functioning well at the present time), followed by Logan Valley East, Logan Valley West, and the mainstem Malheur River from Warm Springs Reservoir upstream to Griffin Creek (Figure 32).

Restoration priorities for redband trout show a somewhat different pattern then for bull trout (Figure 31). The highest ranked restoration reach is the mainstem Malheur River from Warm Springs Reservoir upstream to Griffin Creek, followed by the Logan Valley West reach. Other important redband restoration reaches include upper Otis Creek and lower Wolf/Calamity Creeks (Figure 31). In terms of protection the Malheur Headwaters, Logan Valley East, and mainstem Malheur River from Warm Springs Reservoir upstream to Griffin Creek rank high, just as they did for bull trout (Figure 32); however, there are several other high-ranking reaches in the watershed. In general, the protection value increases as you move up the watershed; underscoring both the relatively better condition of the upstream reaches in terms of human impacts, as well as the inherently better conditions for redband trout that are found as you move up in elevation into the forested headwaters.

For Spring Chinook the highest ranked reach for restoration is the mainstem Malheur River from Warm Springs Reservoir upstream to Griffin Creek, Logan Valley East and West reaches; all other reaches ranking less then the 50th percentile (Figure 31). In contrast to redband, the Spring Chinook rankings illustrate that the mid-basin reaches have characteristics that are more conducive to large-bodied anadromous fish then the headwater streams. There are of course no protection rankings for Spring Chinook given that it is not currently present in the subbasin.

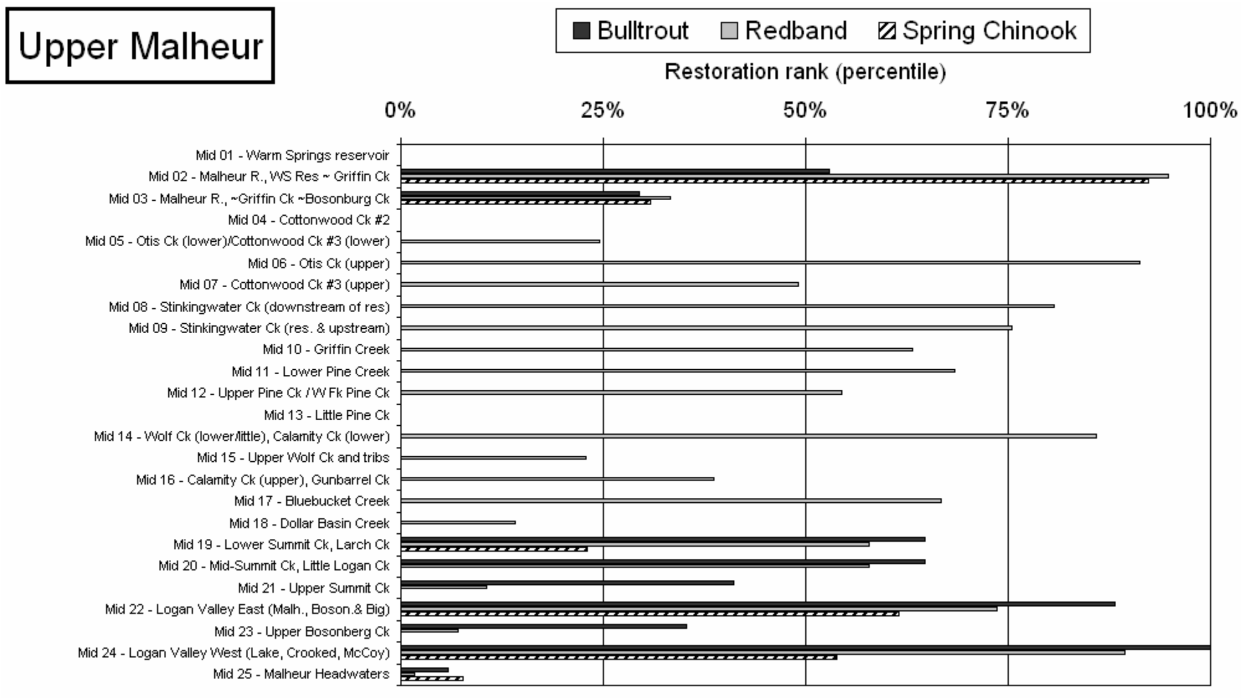


Figure 31. QHA <u>restoration</u> ranking for reaches within the Upper Malheur Watershed.

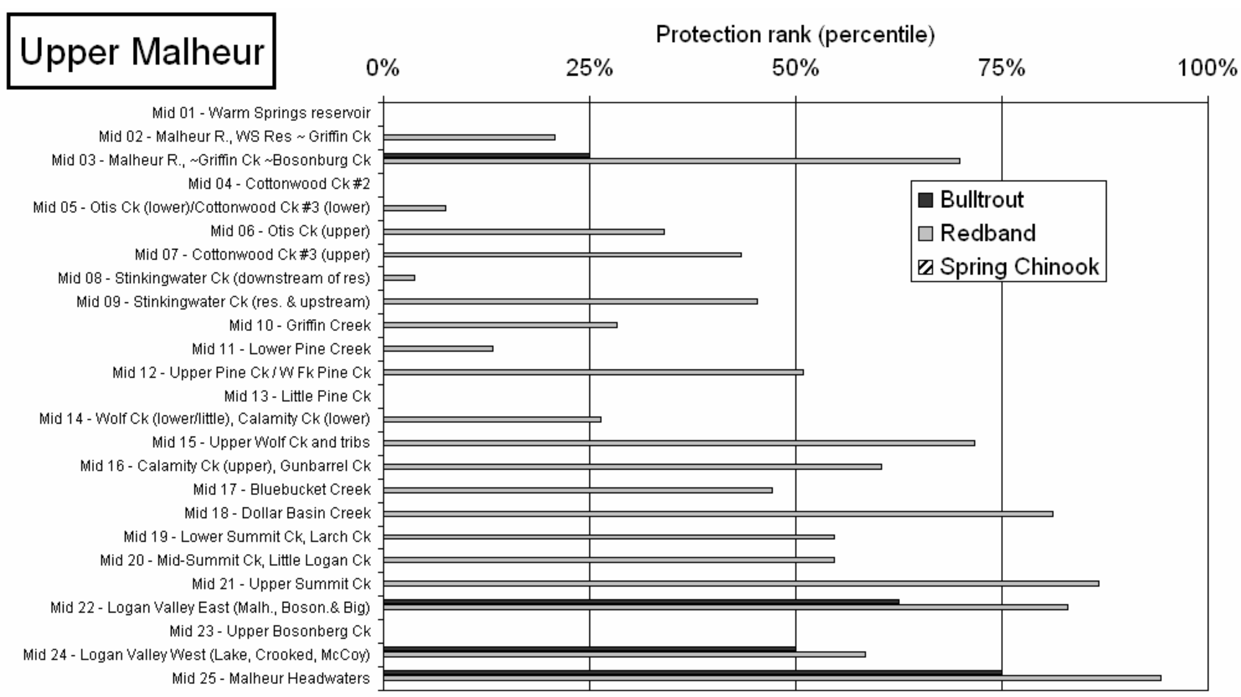


Figure 32. QHA <u>protection</u> ranking for reaches within the Upper Malheur Watershed.

3.7.3 Willow Creek Watershed

The Willow Creek watershed contains six QHA reaches, one of which (Malheur Reservoir) was not rated (refer to Figure 43 for reach location map). The restoration ranking for the five reaches that were rated are shown in Figure 33, and the protection rankings in Figure 34. None of the reaches are estimated to have, or historically have had, either bull trout or Spring Chinook salmon. From Figure 34 we can interpret that redband trout are not currently present in Willow Creek reach #1.

Restoration priority ranking for redband trout generally increases moving up the watershed (Figure 33), which demonstrates that the higher elevation reaches generally provide habitat conditions that are more inherently more favorable for redband trout. This despite the assessment findings that impacts are greatest in the lower watershed. The highest elevation headwater reach (reach #5) ranks in approximately the 85th percentile for restoration in the entire subbasin. Lower Willow Creek reach #1 ranks almost at the 50th percentile for restoration (Figure 33), primarily because of it's importance in offering connectivity between populations in the Willow Creek watershed and other watersheds.

Protection priority also increases moving up the watershed (Figure 34). None of the reaches however score above the 50th percentile for protection subbasin wide (Figure 34). The lowest Willow Creek reach (#1) has no protection rating, as redband trout are not believed to currently use this reach.

3.7.4 Bully Creek Watershed

The Bully Creek watershed contains eleven QHA reaches, one of which (Bully Creek Reservoir) was not rated (refer to Figure 44 for reach location map). The restoration ranking for the ten reaches that were rated are shown in Figure 35, and the protection rankings in Figure 36. None of the reaches are estimated to have, or historically have had, either bull trout or Spring Chinook salmon. From Figure 36 we can interpret that redband trout are not currently present in Bully Creek reach #6a (lower Cottonwood Creek) or Bully Creek reach #1.

From Figure 35 and Figure 36 we can interpret that the lower elevation reaches (i.e., Bully Creek immediately upstream and downstream of the Reservoir) are not inherently favorable for redband trout; both reaches have low restoration and protection scores. The four highest-ranked reaches for restoration (Clover Creek, the headwaters of Bully Creek, Cottonwood Creek, and South Fork Indian Creek; Figure 35) all are in the 50th to 85th percentile for redband restoration subbasin wide, indicating that these reaches are important to restoring redband productivity both within Bully Creek as well as within the entire Malheur subbasin.

From the standpoint of protection (Figure 36), the West Fork of Cottonwood Creek and Rail provides unique high-quality habitat that should be a protection priority. All reaches in the upper watershed rank over the 50th percentile for protection, with the exception of Clover Creek whose current poor condition results in the low protection rating.

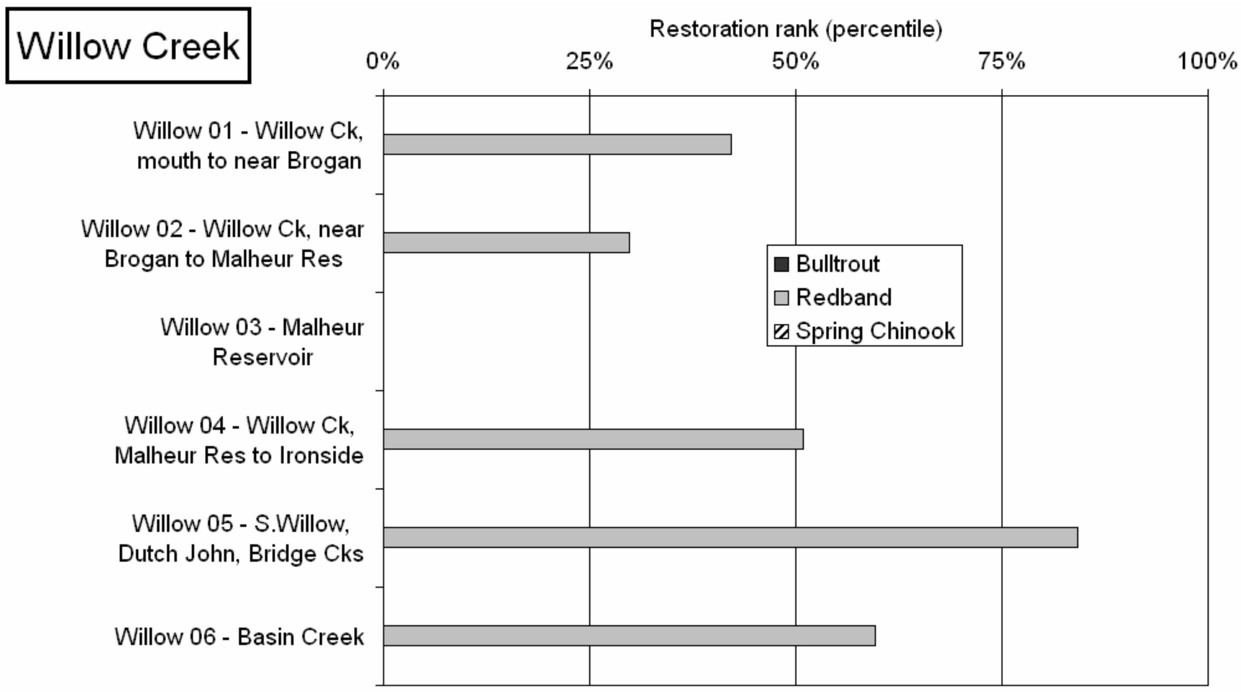


Figure 33. QHA <u>restoration</u> ranking for reaches within the Willow Creek Watershed.

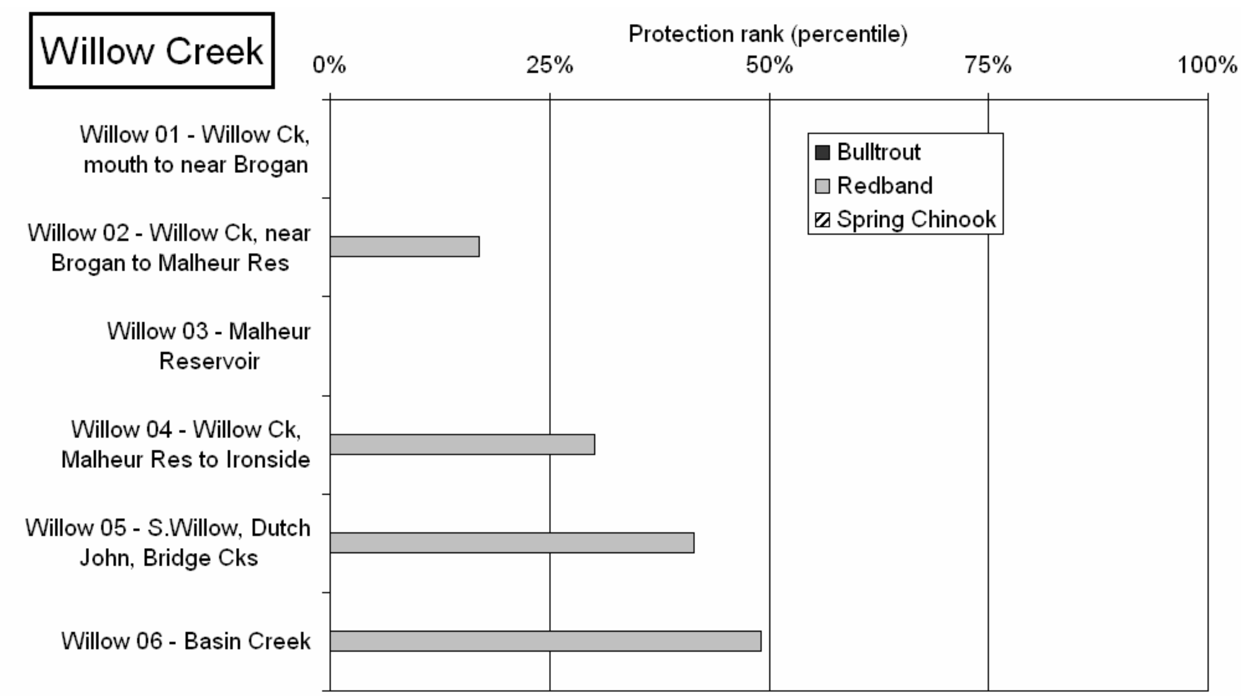


Figure 34. QHA <u>protection</u> ranking for reaches within the Willow Creek Watershed.

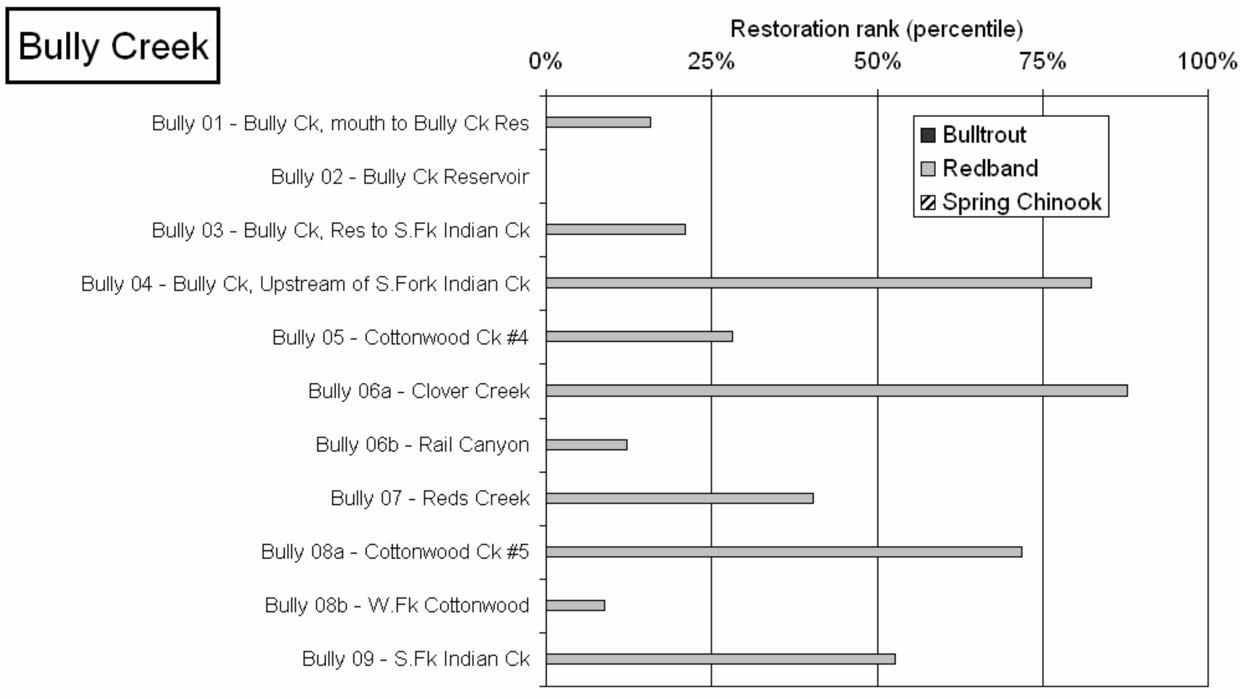


Figure 35. QHA <u>restoration</u> ranking for reaches within the Bully Creek Watershed.

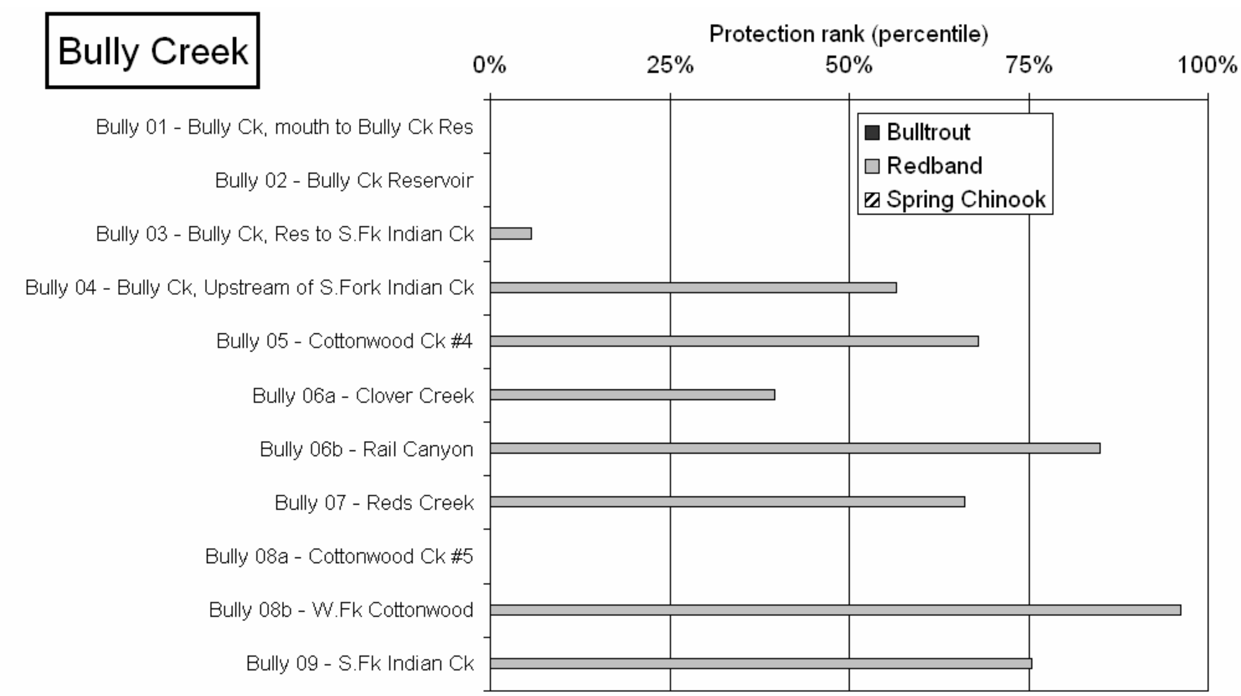


Figure 36. QHA <u>protection</u> ranking for reaches within the Bully Creek Watershed.

3.7.5 North Fork Malheur Watershed

The North Fork Malheur watershed contains ten QHA reaches, one of which (Beulah Reservoir) was not rated (refer to Figure 45 for reach location map). The restoration ranking for these nine reaches is shown in Figure 37, and the protection rankings in Figure 38. From Figure 38 we can interpret which reaches currently have redband trout (all of them) and bull trout; and from Figure 37 we can see which streams historically had Spring Chinook and bull trout.

For all three focal species the North Fork Malheur reach downstream of Beulah Reservoir (reach #1) ranks the highest for restoration, and the reach upstream of the reservoir (reach #3) ranks second highest (Figure 37). The underlying reason for this is that both reaches are estimated to have historically been important to all life stages and all three focal species, and that current conditions are significantly degraded with respect to several of the habitat attributes, most importantly, channel form, riparian condition, low flow, and obstructions. In terms of protection these reaches rank relatively low (or are not rated at all dependent on species: Figure 38) because of the degraded current conditions. These reaches are also critical for connectivity of the North Fork bull trout and redband populations to populations elsewhere in the subbasin.

For bull trout the next highest ranked reach for restoration is the Crane Creek tributaries reach, which is approximately at the 50th percentile for restoration overall (Figure 37), and is not ranked for protection (Figure 38) indicating that bull trout currently do not use this reach. Reach #4 (North Fork Malheur from the Little Malheur to Elk Creek) ranks relatively low for restoration (<25th percentile; Figure 37) and protection (~35th percentile; Figure 38) indicating that it is in relatively good shape currently, but is not the most critical reach for all bull trout life stages. The remaining bull trout reaches (Reaches #5 and #8) rank low for restoration (Figure 37), because they are currently in good shape, and rank high for protection (Figure 38) because they are critical habitat for all bull trout life stages.

Restoration priorities for redband trout show a similar pattern as for bull trout in the reaches where both species are present; low restoration ranking given the relatively good condition of the habitat at present, and high protection ratings given the critical importance of these streams to redband in the subbasin. Differences occur however in the Little Malheur reaches (where bull trout are not found); both streams have a high restoration ranking (~60th to ~70th percentile; Figure 37) indicating that habitat conditions are somewhat degraded, however the much higher protection ranking for the headwaters reach (~80th percentile; Figure 38) vs. the lower Little Malheur reach (~10th percentile; Figure 38) points out that the headwaters habitat is much more critical to all life stages.

For Spring Chinook the low relative restoration ranking for reaches #4 and #5 reflects the relatively good condition of these reaches for Spring Chinook life stages as compared to the lower North Fork Malheur reaches (31 and #3).

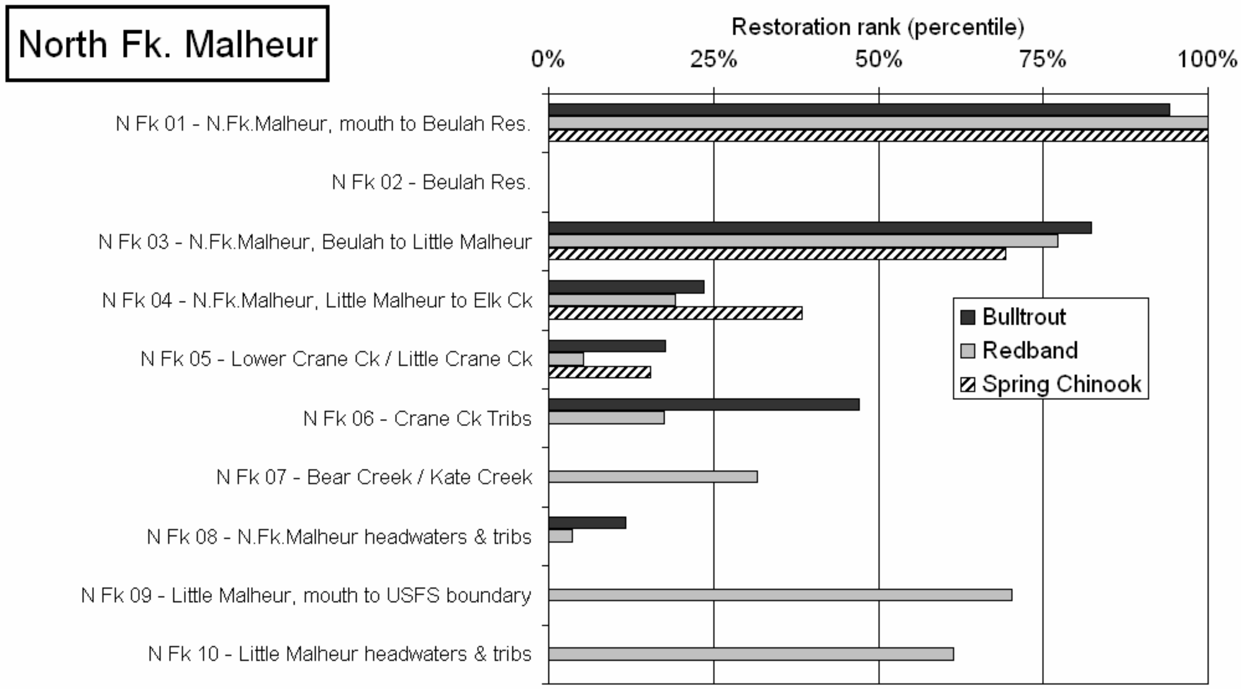


Figure 37. QHA <u>restoration</u> ranking for reaches within the North Fork Malheur Watershed.

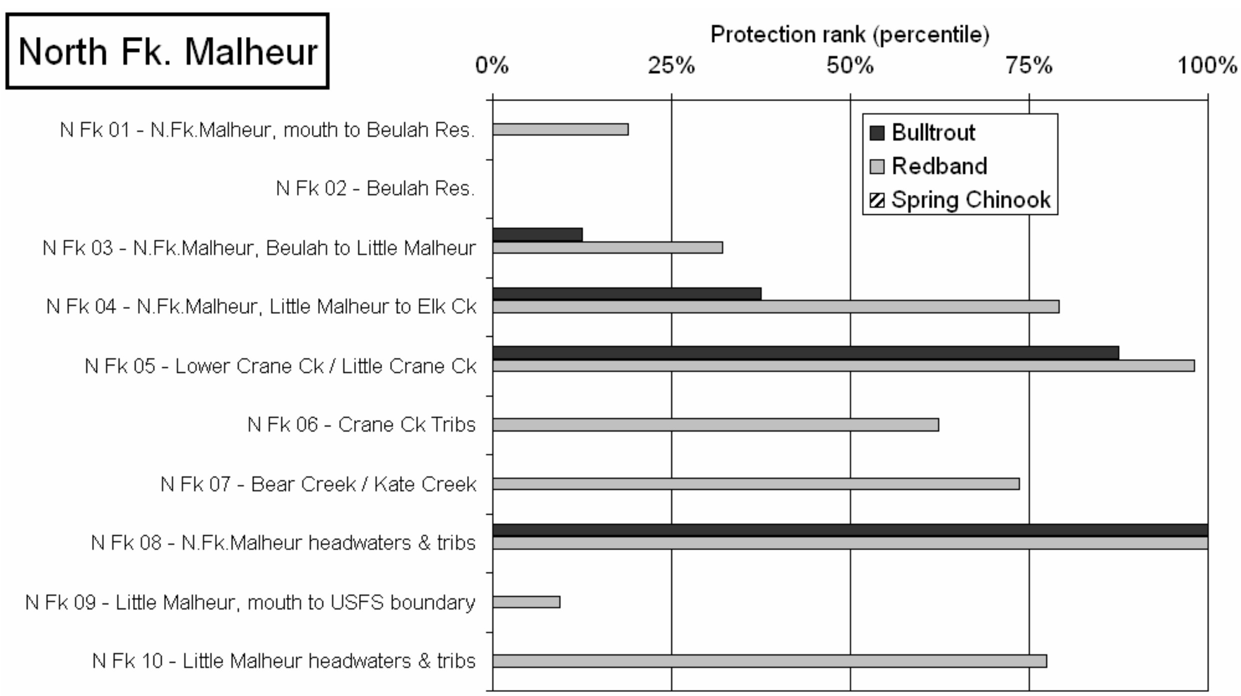


Figure 38. QHA <u>protection</u> ranking for reaches within the North Fork Malheur Watershed.

3.7.6 South Fork Malheur Watershed

The South Fork Malheur watershed contains six QHA reaches (refer to Figure 46 for reach location map). The restoration ranking for these six reaches is shown in Figure 39, and the protection rankings in Figure 40. From Figure 40 we can interpret that these reaches currently only support redband trout; and from Figure 39 we can see that only reach #1 historically had Spring Chinook; bull trout historically did not use this watershed.

In terms of restoration the high ratings for reaches #3, #4, and #5 (Swam/E. Swamp, Coleman, Crane/Little Crane/Alder Creeks; Figure 39) indicate that restoration of these streams would be highly beneficial to redband trout at the subbasin level. The high protection rating for Granite/Big Granite Creek (Figure 40) indicates that this stream currently provides relatively high quality redband habitat in a watershed that is relatively lacking in quality habitat.

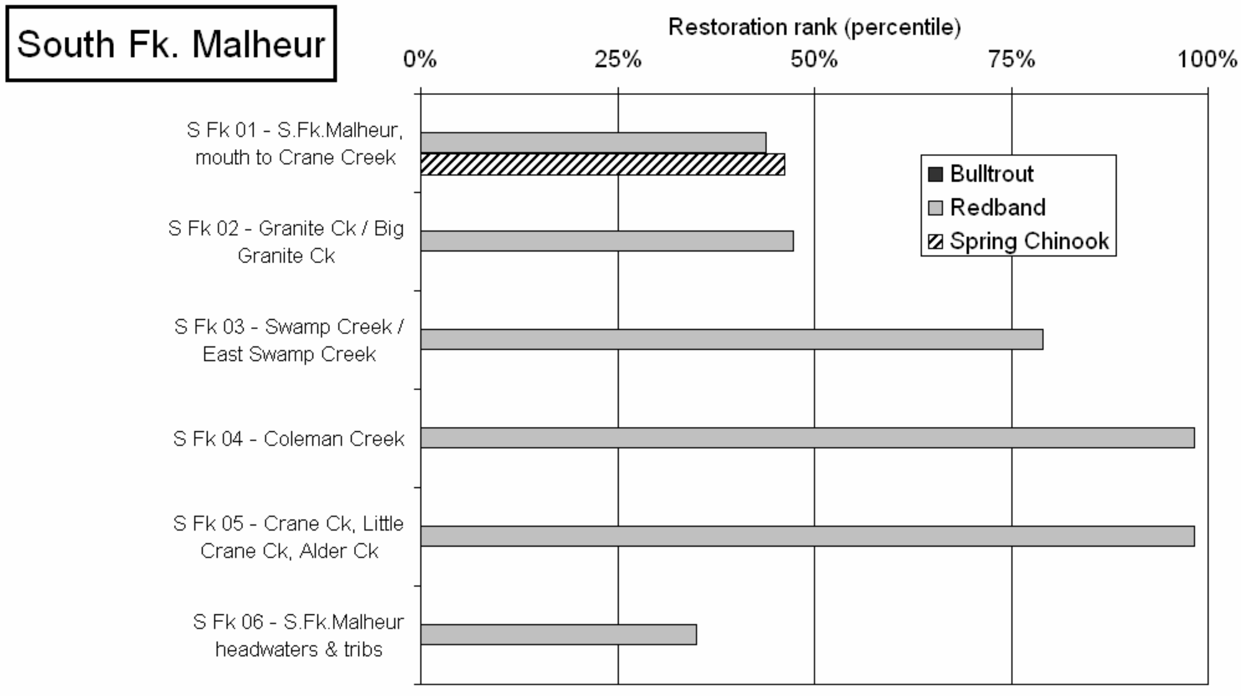


Figure 39. QHA restoration ranking for reaches within the South Fork Malheur Watershed.

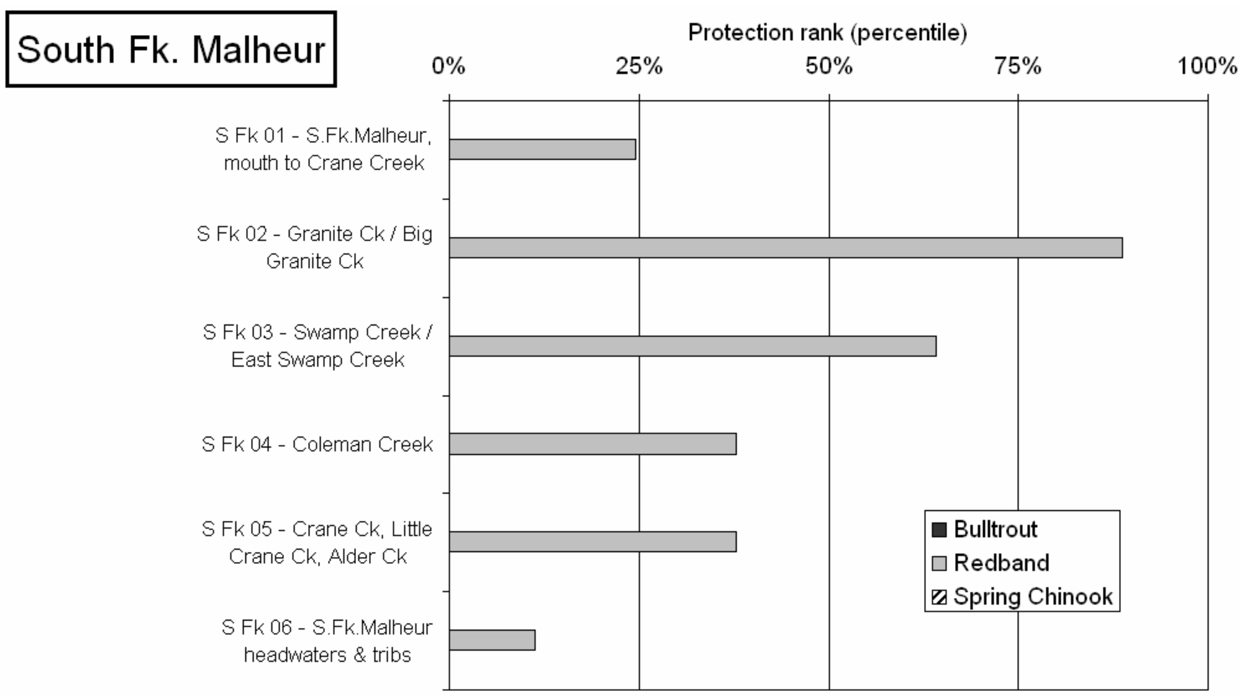


Figure 40. QHA protection ranking for reaches within the South Fork Malheur Watershed.

4 AQUATIC BIOLOGICAL OBJECTIVES

The aquatic assessment described in section 3 above sets the stage for development of the aquatic biological objectives. The summary of limiting factors (section 3.6) identifies four primary habitat attributes (channel conditions, riparian conditions, low flow conditions, and obstructions) that limit the abundance of the three focal species in the subbasin, and also identifies the primary management related activities that result in these limitations. Furthermore, section 3.7 offers a first approximation of how we might proceed in prioritizing the implementation of restoration and protection actions. The purpose of this current section is to outline the overall biological objectives for each of these limiting factors.

In assembling these biological objectives we have been mindful of the need to steer clear of the pitfall of developing static habitat target values, or "one size fits all" solutions. The Independent Science Advisory Board (ISAB, Bilby et al. 2003) recognizes the need to take a spatially variable and temporally dynamic approach to setting biological objective by noting that:

> *"In many cases the application of environmental standards and performance thresholds will divert attention from the real issue – managing watersheds in such a way that ecological processes supporting aquatic productivity and diversity are restored and conserved. Habitat standards have often failed….because they are taken as fixed and do not focus on dynamic processes that create and maintain ecologically complex and resilient watersheds…"*

The ISAB goes on to note that:

> *"This approach* [of setting fixed standards] *is inappropriate because the general trend is to homogenize habitat rather than maintain the complexity of conditions that support biological diversity at multiple scales"*

In outlining our biological objectives for the Malheur subbasin we have tried to incorporate these guidelines. The result is a road map of how to arrive at the "dynamically stable" future condition that will support the full spectrum of aquatic species. The detailed and spatially explicit information needed to implement these objectives (e.g., the current and potential distribution of Rosgen channel types, and the appropriate range of channel conditions that should be represented within those channel types) constitute and important data gap that should be a high priority for evaluation.

The following discussion is organized around the primary limiting factors identified in the QHA analysis.

4.1 Channel Conditions

Simply stated, the biological objective for future channel condition is:

> To have both a 1) distribution of channel types (e.g., Rosgen (1996) channel types[8]), as well as 2) a distribution of habitat conditions within those channel types, that are as close as possible to the historic distribution of these two variables within the subbasin.

By "as close as possible" we are recognizing that there are human institutions, and infrastructure that supports those institutions, that may result in a difference between the historic and potential future condition.

In section 3.5 we presented a simple approach to describing the current and historic distribution of channel types (e.g., Figure 4) based on a simple channel gradient and valley confinement approach (Figure 3). This channel classification is too coarse to provide the resolution that we would require at the reach or finer scales to implement these objectives. Consequently, a more detailed analysis (e.g., OWRD, 1999) will be needed to identify the current, historic, and potential future distribution of channel types. This approach must also incorporate the concepts of the evolutionary stages of channel adjustment outlined by Rosgen (1996) that channels will proceed through as they adjust to natural disturbances (e.g., wildfire and flooding).

Once the distribution of channel types is known we can then evaluate the appropriate habitat characteristics (e.g., width/depth ratios, entrenchment, pool frequency, etc.) within these channel types. Again, it is important not to think of these as static values within a given channel type, but also to consider the range of values and how that would be distributed across the landscape. Generic reference values (and ranges of values) could be used (e.g., those found in Rosgen 1996), however, it would be more appropriate to use information from the local management agencies (BLM, USFS, etc.) in developing a set of conditions appropriate to the local area.

[8] The Rosgen classification system is used in this discussion, given it's ubiquity and usefulness in the interior west, however, other classification systems may be equally appropriate

4.2 Riparian Conditions

The biological objective for future riparian conditions follows a similar line of reasoning as for channel conditions:

> To have a distribution of riparian communities having 1) a species composition, 2) size, and 3) structure that is appropriate for the channel type and ecoregion, recognizing that the distribution will also vary in time in response to natural disturbance factors.

In section 3.5 we presented an assessment of historic riparian communities that varied around the subbasin by EPA level III and IV ecoregion (Table 13), and channel type. The values given in Table 13 are for only a portion of the subbasin (the Blue Mountains level III ecoregion), however, similar descriptions could be developed for streams in other ecoregions within the subbasin. The recognition that the potential riparian communities will vary with varying channel conditions ties this biological objective to the previous. For example, restoration of a stream that presently flows through a channelized former-wet meadow will require not only restoration of the plant community, but restoration of the channel to restore the hydrology and soil conditions under which the potential plant community can develop.

The recognition that certain human institutions, and infrastructure that supports those institutions, exists that may result in a difference between the historic and potential future riparian condition is implicit, given the between the potential riparian community and the potential channel type.

The recognition that natural disturbance factors (e.g., wildfire, flooding, etc.) will influence the potential community both in space (different portions of the subbasin will be more or less susceptible to these disturbances) and time (disturbance has a probability and distribution associated with it) requires us to think of restoration not in terms of fixed target conditions, but as an improving trend in conditions, a trend that may at times experience set backs, across a broader landscape.

4.3 Low Flow Conditions

Unlike the previous two biological objectives, which can (in our opinion) be achieved while sustaining the economic concerns of the human community, the limiting factors that result from low-flow related impacts is a much less tractable problem. Human use of water in the arid west comes at the direct cost to aquatic species, and any attempt to retain more water instream will come at the expense of existing water-dependent practices (i.e., irrigated farming). However, this reality not withstanding, there are activities that can occur that soften the blow to either the human or the aquatic communities. These include things such as the more efficient use of water, or the voluntary (and fully compensated) transfer of water rights to instream uses, such as is done under the auspices of the Oregon Water Trust (http://www.owt.org).

Fortunately, from the perspective of restoring the health of the focal species in the Malheur subbasin, low flows are not the primary limiting factor among the assessment reaches. Consequently, moderate improvements in the existing low flow situation (through technological advances as well as voluntary reductions in use), coupled with improvements in channel and riparian conditions, will result in substantial benefits to the aquatic community. In light of this we propose the following biological objective with respect to low flows in the Malheur subbasin:

> To enhance low flow conditions such that they mimic the natural hydrograph to the extent possible, given the limitations posed by agriculturally dependent water use in the region.

The practical implication of this objective is that we will seek to reduce irrigation impacts to the extent possible, through both technological innovation and voluntary reductions in water use, however our focus will be on the non-consumptive factors that also affect low flows such as 1) lower effective summertime flows due to poor channel conditions that result in flow going sub-surface, 2) dam operations and irrigation infrastructure changes that can keep more water in the stream at the times and in the places that it is needed, and 3) restoration of natural storage pathways within the subbasin such as beaver dam/meadow complexes, and channel/floodplain connectivity.

4.4 Obstructions

4.4.1 Within-subbasin obstructions:

The limiting factors posed by obstructions are confined to only a small portion of the subbasin; 75% of the total reach length having no or only minor impacts from obstructions. However, the impacts to focal species posed by obstructions are significant. Happily, most of the causal agents for these impacts can be remedied by technological means (e.g., irrigation galleries) simple and well-accepted solutions (e.g., culvert removal or replacement), or will be remedied by addressing some of the other concerns discussed above (e.g., improved channel conditions that eliminate sub-surface flow problems). Consequently, the biological objective with respect to within-subbasin obstructions is:

> Eliminate, to the extent possible, all human-related obstructions to the movement of the aquatic focal species within the Malheur subbasin.

Again, the term "to the extent possible" is meant to recognize that there are human institutions, and infrastructure that supports those institutions, that may make it impractical to eliminate certain obstructions.

4.4.2 Out of subbasin obstructions:

The QHA does not do an adequate job in addressing the limitations presented by out-of-subbasin factors on focal species populations. In particular, the effects of mainstem Columbia and Snake River dams on anadromous species are not addressed. The following objective recognizes that mainstem dams have (at least for the time being) extirpated anadromous fish from the Malheur Subbasin, consequently, we can only protect and enhance the ecosystem that remains. Therefore, the biological objective with respect to out of subbasin obstructions is:

> Mitigate for the loss of anadromous fish species in the Malheur Subbasin through substitution programs that emphasize the long-term sustainability of native resident fish in native habitats wherever possible.

Substitution is appropriate for lost salmon and steelhead in areas that previously had anadromous fish but where anadromous fish access is now blocked by hydropower development and where in-kind mitigation cannot occur. Resident fish substitution for anadromous fish losses should occur in the vicinity of the salmon and steelhead losses being addressed, but substitution and mitigation measures may occur on or off-site. For substitution purposes, resident fish may include landlocked anadromous fish (e.g., white sturgeon, kokanee and coho) as well as traditionally defined resident fish species (e.g. largemouth bass).

4.5 Other Attributes

As discussed in section 3 above, the primary limiting factors among the streams in the Malheur subbasin are the four habitat attributes described above. Furthermore, the additional habitat attributes can be considered as being either dependent on these "big four" factors, and therefore remedied by the objectives discussed above, or of relatively local and/or minor concern. However, for the sake of completeness, we will explicitly state the biological objectives for these other attributes here:

- Habitat diversity shall be restored as near as possible to historic conditions, as a result of restoring channel conditions (section 4.1 above) and riparian conditions (section 4.2),

- Fine sediment and high flow related impacts are expected to be reduced as ongoing best management practices are implemented that will reduce sediment inputs across the landscape, and as a result of restoring channel conditions (section 4.1 above) that will reduce sediment deposition problems. as a more natural Sediment Load Amount of fine sediment within the stream, especially in spawning riffles

- High and low water temperatures and dissolved oxygen conditions shall be restored as near as possible to historic conditions, as a result of restoring channel conditions (section 4.1 above), riparian conditions (section 4.2), and improving low flow conditions (section 4.3),

- Localized impacts due to Pollutants are expected to be reduced as ongoing best management practices are implemented that will reduce inputs of pollutants across the landscape.

5 AQUATIC SUBBASIN-WIDE HYPOTHESES AND ASSUMPTIONS

The purpose of this final section of the assessment is to bring together the primary assumptions and working hypotheses that, collectively, makeup the aquatic assessment. In the broadest sense the working hypotheses consist of all of the data, professional judgments, assumptions, model relationships, and analytical results that are contained in the preceding sections. However, for the purpose of this summary we have focused on the most important limiting factors and estimated population performance. These hypotheses and assumptions set the framework for evaluating the inventory (i.e., it provides a gap analysis of what has and is being done to address the limiting factors) and developing the management plan, which contains strategies to address the identified gaps. The primary assumptions and working hypotheses are:

- **The aquatic technical team has adequately interpreted and synthesized the known data regarding current and reference habitat conditions within the subbasin**. We are confident in this assumption, given the presence on the team of individuals with long experience in the subbasin, and considering the breadth of agency involvement.

- **The Qualitative Habitat Assessment (QHA) model adequately represents the complex relationships between the focal species and their environments**. The QHA is an expert system, and as such provides a somewhat more structured and better-documented approach to evaluating limiting factors then expert opinion alone. However, unlike the more sophisticated Ecosystem Diagnostics and Treatment (EDT) model, from which QHA is descendent, there is no explicit way to evaluate the validity of the outcome (i.e., no estimates of population size are generated).

- **The species-specific hypotheses are correct and adequately represent how focal species use the subbasin**. In sections 3.2 and 3.4 we summarize the aquatic technical teams understanding of how the three focal species use the various reaches within the subbasin, and what habitat attributes are most important to the focal species under both current and reference conditions. Given the aquatic technical teams expertise within the subbasin we feel that these hypotheses are reasonable.

- **Of the eleven habitat attributes considered in this analysis the following four factors are the most limiting, and adequately illustrate the concerns with respect to the focal species**:

  - **Channel conditions**: Channel condition (the condition of the channel in regard to its ability to move laterally and vertically and to form a "normal" sequence of stream unit types) is a primary determinant of the success of all three focal species. Classification of channels allows a mechanism to adequately capture the expected condition of the channel with respect to habitat quality, and can be used to evaluate the potential of a given stream reach. Caveats to this hypothesis are that 1) a systematic subbasin-wide understanding of reference and current channel types does not currently exist, but could be assembled fairly easily using existing methodologies (e.g., Rosgen, 1996; OWEB, 1999); 2) local metrics describing the range of appropriate habitat characteristics by channel type does not currently exist, but could be assembled from existing data and expertise; and 3) in evaluating the current health of the channel system we must consider variability due to stochastic disturbance events. A final hypotheses is that the management-related activities that have contributed to currently degraded channel conditions can be reversed relatively easy with only limited impacts to the social and economic fabric of local communities.

- **Riparian Conditions**: Riparian conditions are also a primary determinant of the success of all three focal species, although the effect varies by species due to the different life stage hypotheses referenced above. Appropriate riparian conditions vary with respect to ecoregion, as well as with channel condition. Consequently, riparian enhancement is tied in many areas to channel restoration. As with channel condition natural disturbance factors influence the potential riparian community both in space and time. Consequently, restoration is best thought of in terms of trend across a broader landscape. As with channel conditions an additional hypothesis is that the management-related activities that have contributed to currently degraded riparian conditions can be reversed relatively easy with only limited impacts to the social and economic fabric of local communities.

- **Low flows**: Unlike the previous two biological objectives, which can (in our opinion) be achieved while sustaining the economic concerns of the human community, the limiting factors that result from low-flow related impacts is a much less tractable problem. However, low flows are not the primary limiting factor among the assessment reaches, and moderate improvements in the existing low flow situation, coupled with improvements in channel and riparian conditions, will result in substantial benefits to the aquatic community.

- **Obstructions**: The limiting factors posed by obstructions are confined to only a small portion of the subbasin, however, the impacts to focal species posed by obstructions are significant. Most of the impacts can be remedied by technological means or relatively simple and well-accepted solutions, and many will be remedied by addressing the channel, riparian and low flow concerns discussed above.

- **In the big picture the other limiting factors (in addition to the four described previously) can be mostly ignored**. Additional habitat attributes are either dependent on the "big four" factors identified above, or are of relatively local and/or minor concern.

- **Prioritization of restoration and protection can be first approximated using QHA, but must consider additional factors**. The QHA methodology produces a prioritization approach for reach-scale restoration and protection (see section 3.7). However, this first cut must be tempered with additional considerations, such as the additional factors described below.

- **Additional factors are not adequately addressed in QHA, and must be dealt with in a more qualitative fashion**. As discussed in section 3.1.1 at least three additional factors (large dams within the subbasin, exotic species interactions, and out of subbasin effects - primarily dams that block anadromous fish access) are not adequately addressed within

QHA. Consequently, these must be highlighted in the management plan as areas of special concern.

- **Static, "one size fits all" biological objectives are inadequate for outlining a restoration strategy and management plan for the Malheur subbasin**. As noted by the ISAB, and as discussed in section 4, biological objectives must be developed with consideration given to inherent variability both in space (among the reaches in various parts of the watershed, and within the reaches themselves), and over time in response to natural disturbance and channel evolutionary response. The biological objectives, particularly for channel and riparian condition, have been outlined with this in mind.

- **Many, if not most, of the likely strategies derived from these biological objectives are already being implemented within the subbasin**. The products from the aquatic assessment do not implicate a change in direction for the various land management agencies, individuals, or other entities (e.g., watershed council) within the subbasin. Rather, the products here will (hopefully) help direct and prioritize ths ongoing activities at the watershed scale.

- **Population performance is the ultimate arbiter of habitat protection/restoration activities, and must be incorporated into monitoring and evaluation plans**. The underlying assumption of the work presented here is that it is appropriate to focus on habitat, and the focal species response will follow (i.e., "if you build it they will come"). However, this assumption must be borne about by thorough and systematic monitoring programs, many of which are already in place (e.g., ongoing Burns Paiute monitoring in the Logan Valley area).

6 REFERENCES

All references are included in a separate document

7 ATTACHMENTS

Attachment 1 - Stream reach maps

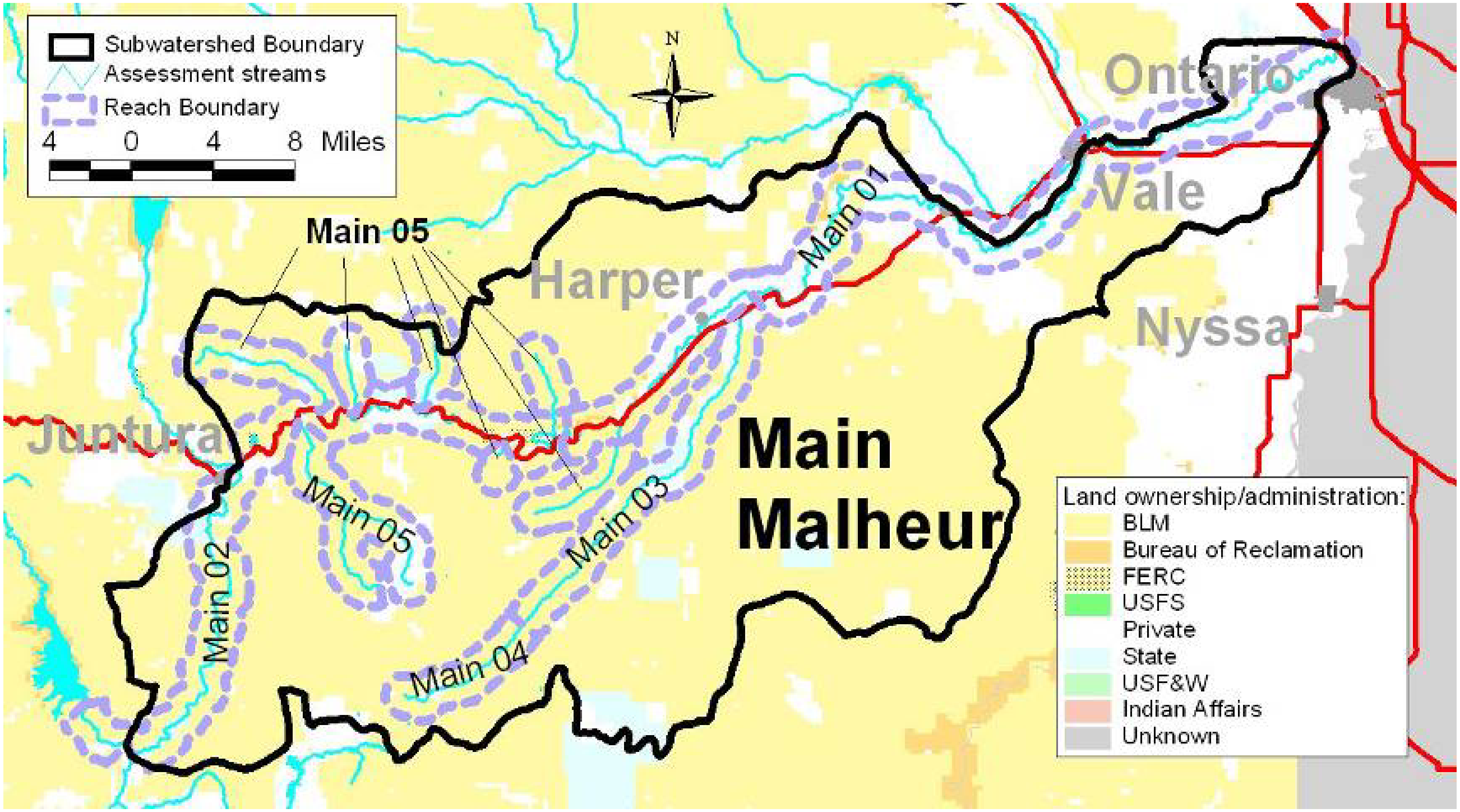


Figure 41. Main Malheur watershed, showing the reaches defined for this assessment.

Attachment 1 (continued) - Stream reach maps.

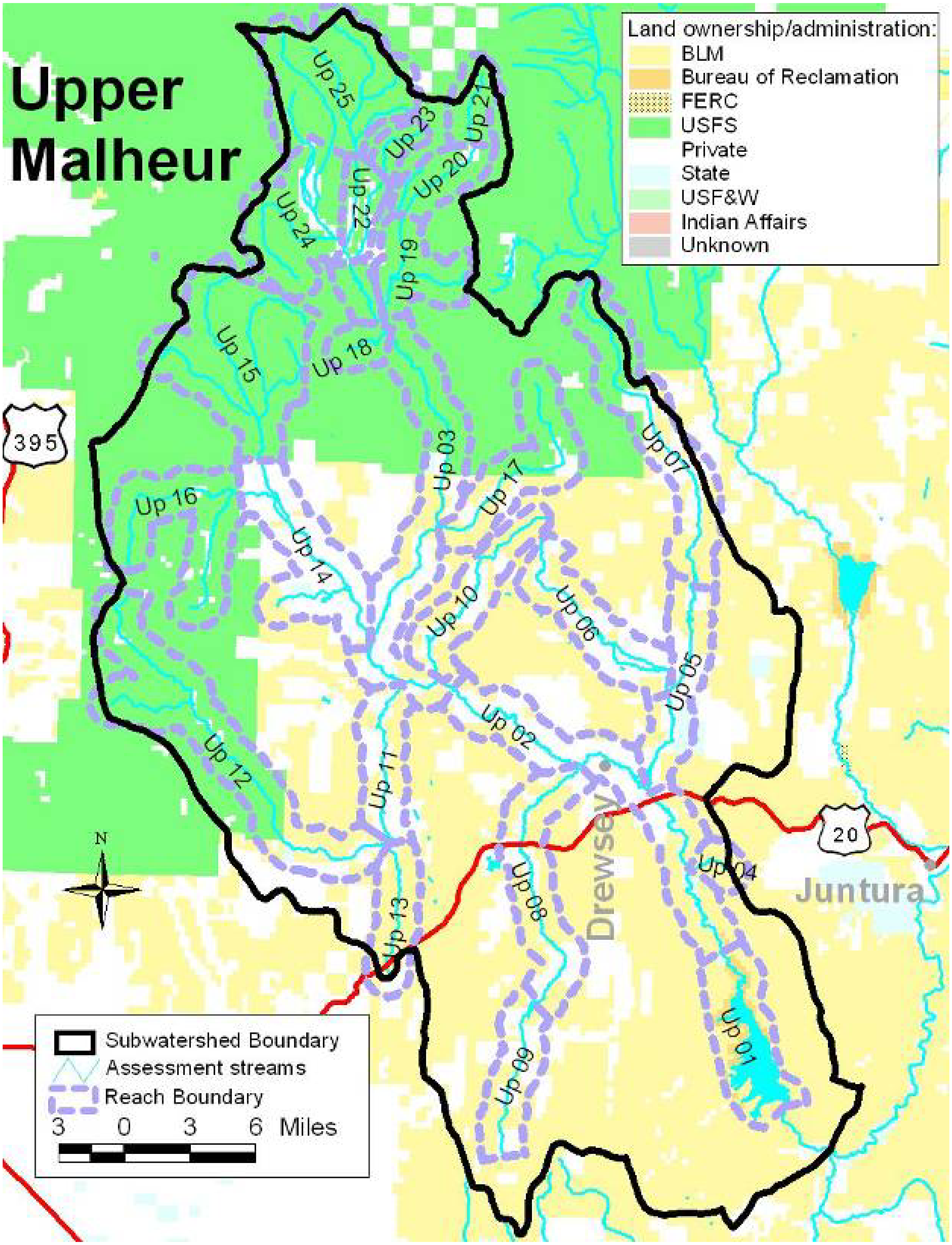


Figure 42. Upper Malheur watershed, showing the reaches defined for this assessment.

Attachment 1 (continued) - Stream reach maps.

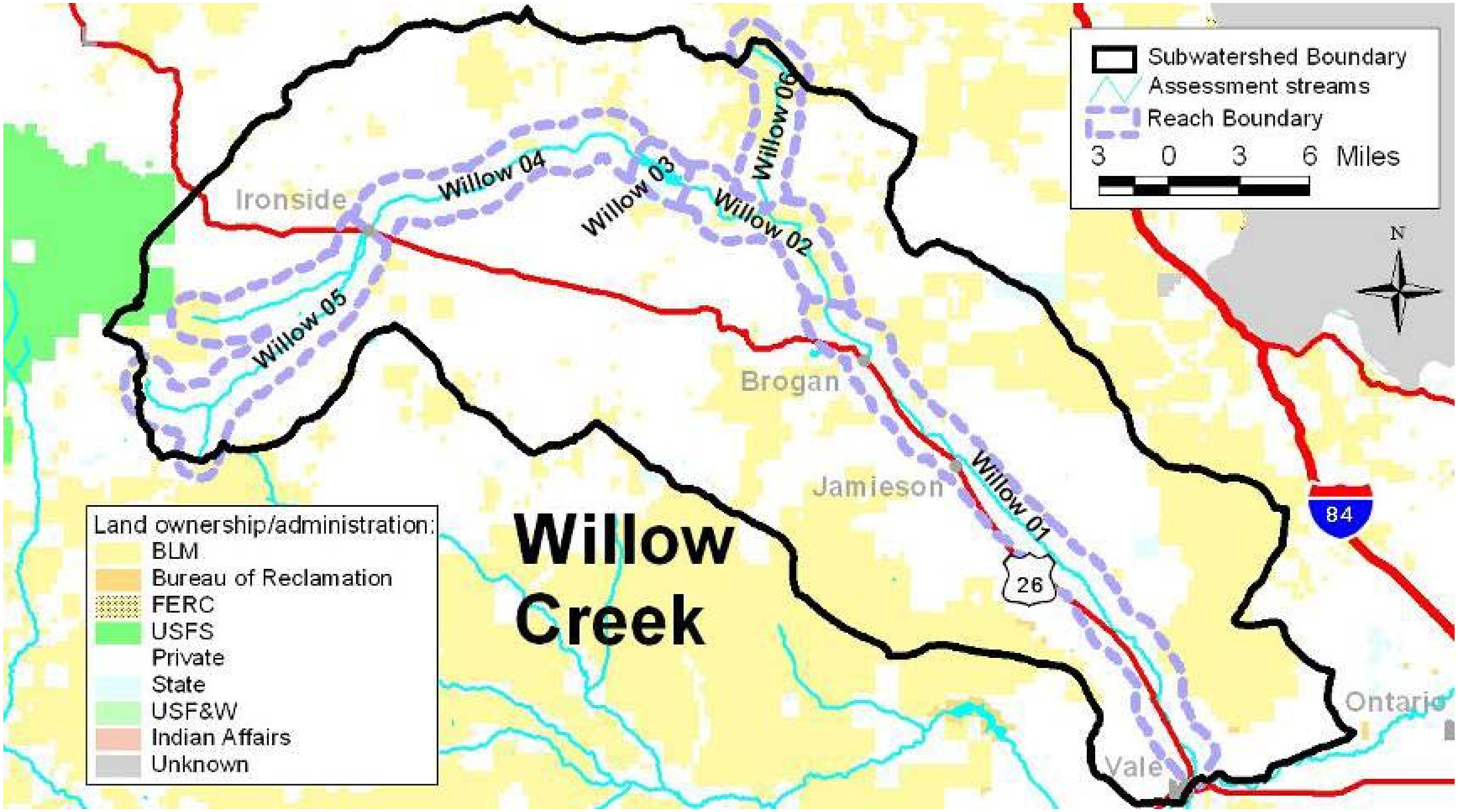


Figure 43. Willow Creek watershed, showing the reaches defined for this assessment

Attachment 1 (continued) - Stream reach maps.

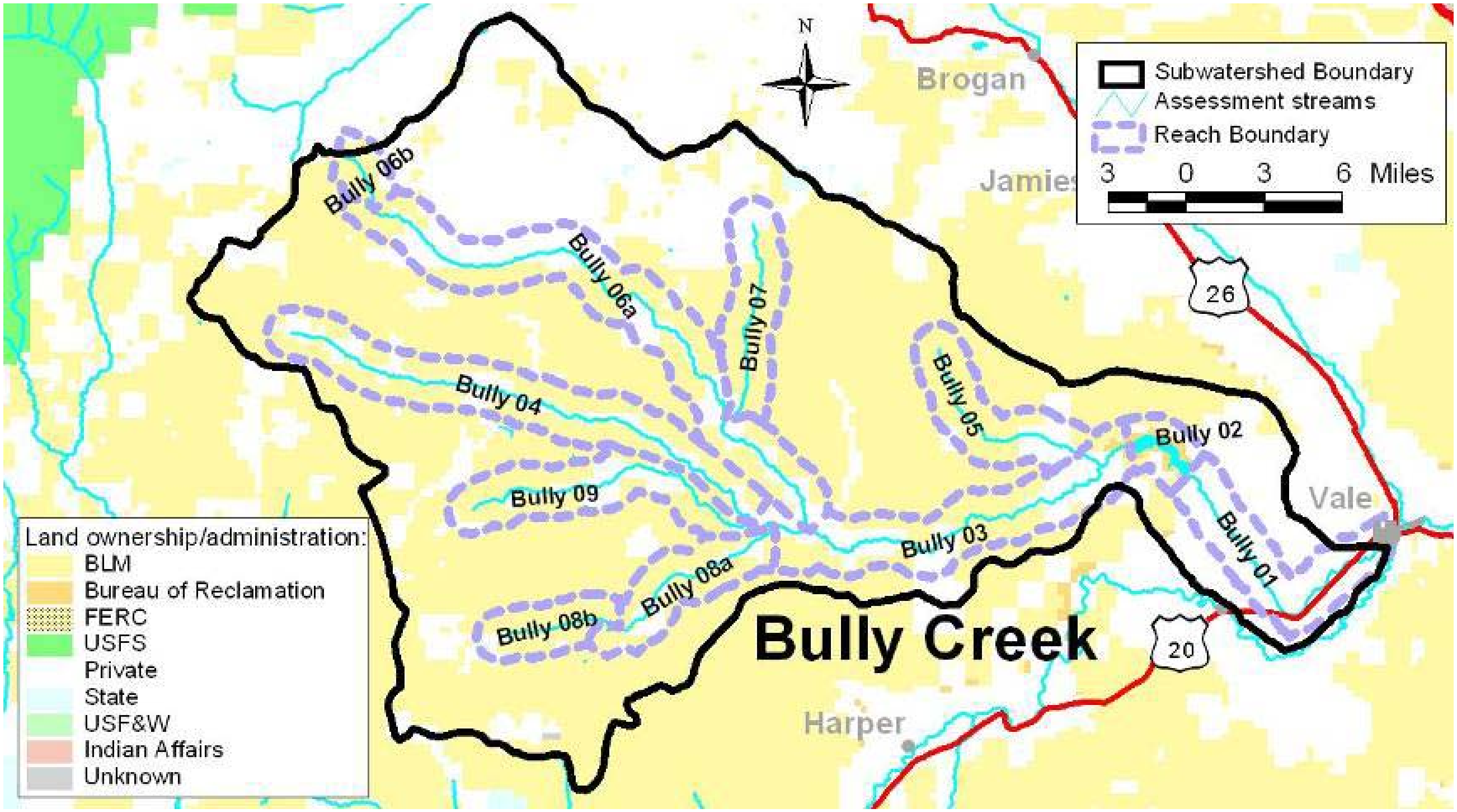
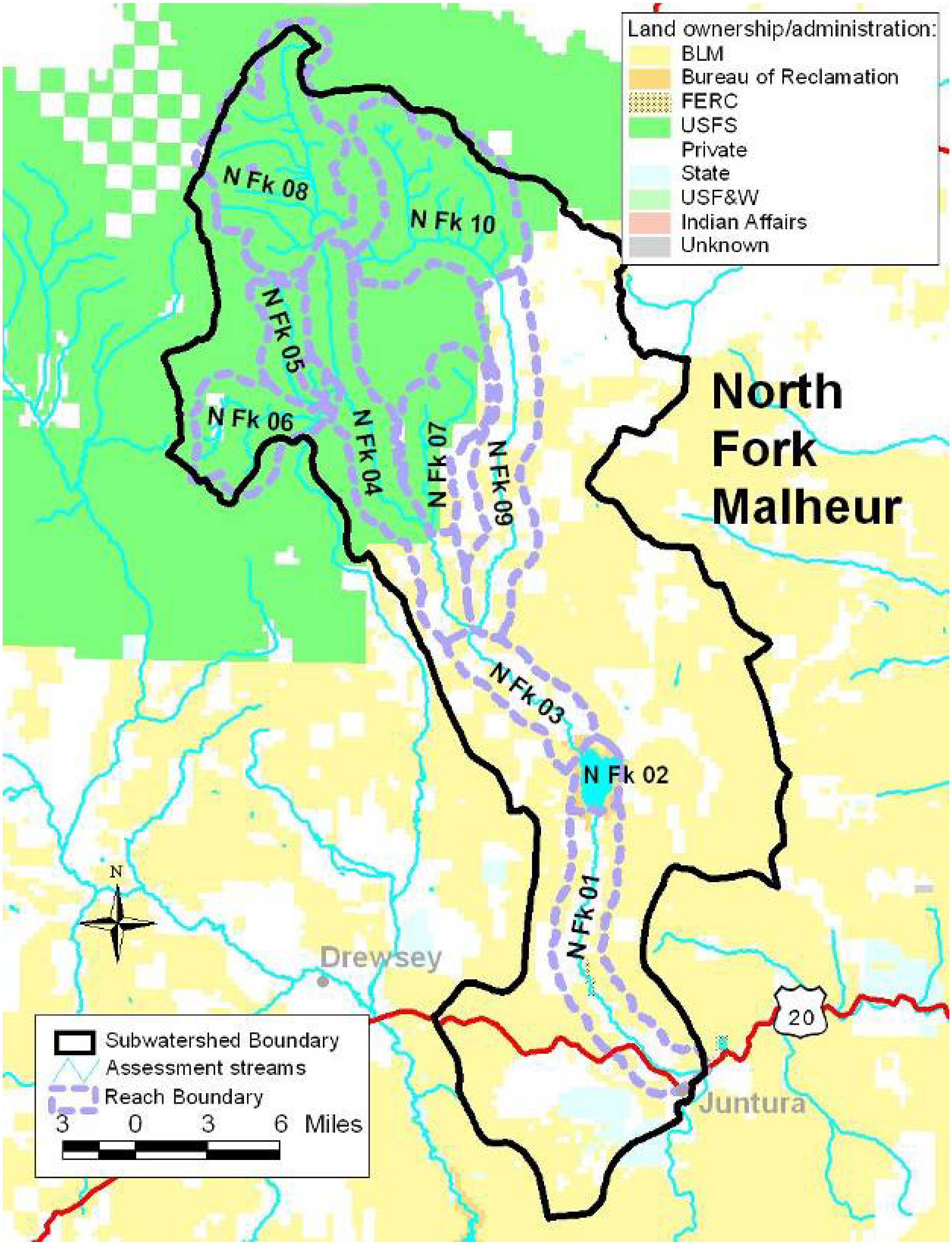


Figure 44. Bully Creek watershed, showing the reaches defined for this assessment.

Attachment 1 (continued) - Stream reach maps.



Attachment 1 (continued) - Stream reach maps.

Figure 45. North Fork Malheur watershed, showing the reaches defined for this assessment.

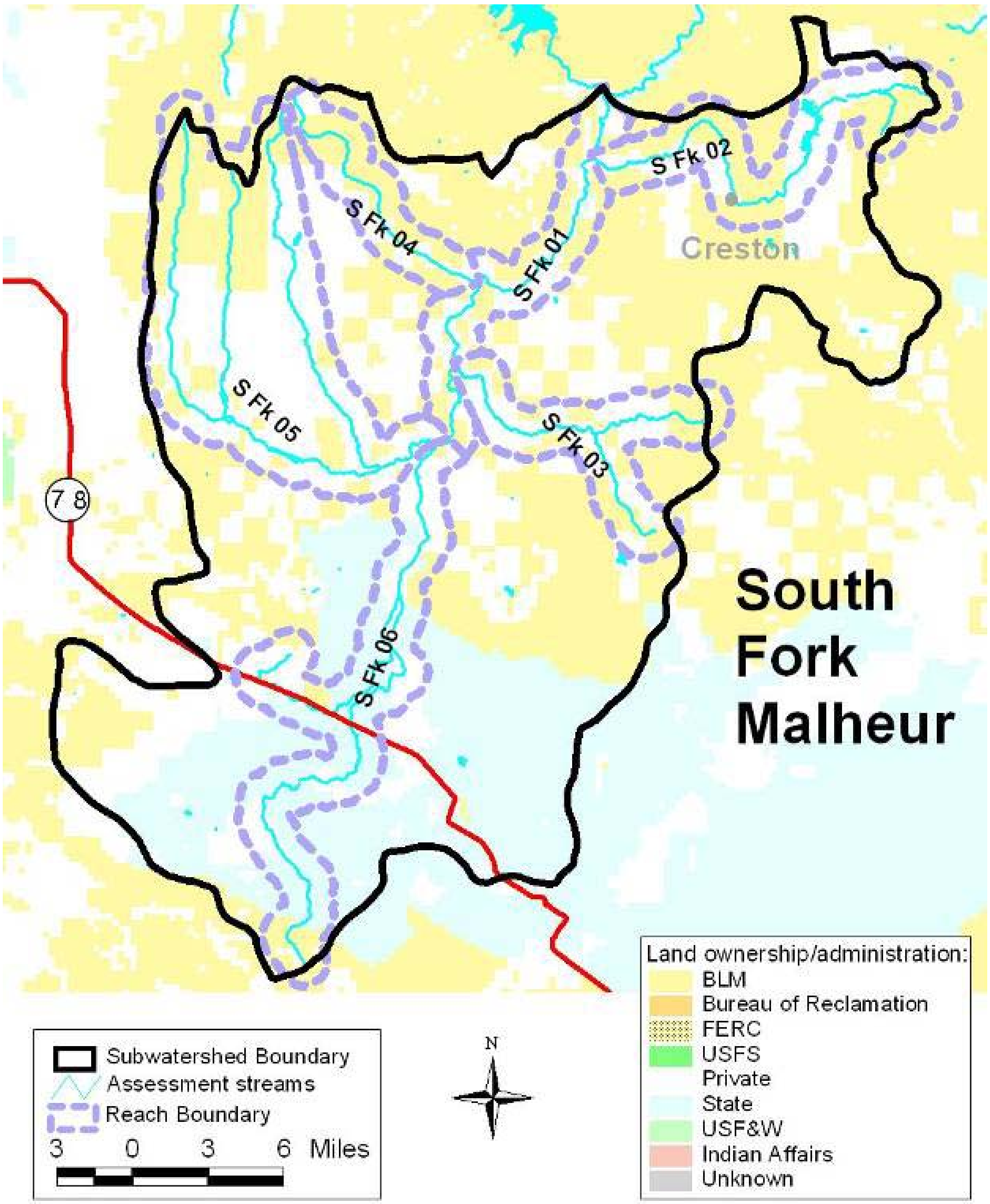


Figure 46. South Fork Malheur watershed, showing the reaches defined for this assessment.

Attachment 2 - General Assessment reach characteristics and focal species use by reach

Reach Name	Reach Description	Reach Length (miles)	Percent reach utilization by focal species				
			Redband (current)	*Redband (historic)*	*Spring Chinook (historic)*	*Bull Trout (current)*	*Bull Trout ("historic")*
Main 01 - Malheur R., Mouth to Namorf	Malheur River - Mouth to Namorf	66.1	25 %	100 %	100 %	-	100 %
Main 02 - Malheur R., Namorf to Warm Spr.	Malheur River - Namorf to Warm Springs Dam	53.9	100 %	100 %	100 %	-	100 %
Main 03 - Cottonwood Ck #1 (lower)	Lower Cottonwood Creek (Main Malheur subbasin)	22.0	100 %	100 %	-	-	-
Main 04 - Cottonwood Ck #1 (upper)	Upper Cottonwood Creek (Main Malheur subbasin)	7.7	100 %	100 %	-	-	-
Main 05 - Other Main Malheur tribs	Other Main Malheur tribs (Black Canyon, Calf Ck, Canyon Ck, Gold Ck, Hog Ck, Hunter Ck, North Fork Squaw Ck, Pole Ck, Squaw Ck)	47.6	100 %	100 %	-	-	-
Up 01 - Warm Springs reservoir	Malheur River - Warm Springs Dam to upstream end of innundation area	8.6	-	100 %	100 %	-	100 %
Up 02 - Malheur R., WS Res ~ Griffin Ck	Malheur River - Upstream end of Warm Springs Dam innundation area to near Griffin Ck	27.4	50 %	100 %	100 %	-	100 %
Up 03 - Malheur R., ~Griffin Ck ~Bosonburg Ck	Malheur River - Near Griffin Ck to near Bosonburg Creek	29.0	100 %	100 %	100 %	35 %	100 %
Up 04 - Cottonwood Ck #2	Cottonwood Ck (Upper Malheur subbasin) near Warm Springs Res	2.4	100 %	100 %	-	-	-
Up 05 - Otis Ck (lower)/Cottonwood Ck #3 (lower)	Lower Otis Creek / Lower Cottonwood Creek	12.6	50 %	100 %	-	-	-
Up 06 - Otis Ck (upper)	Upper Otis Creek	12.6	100 %	100 %	-	-	-
Up 07 - Cottonwood Ck #3 (upper)	Upper Cottonwood Creek (Otis Ck trib)	18.4	100 %	100 %	-	-	-
Up 08 - Stinkingwater Ck (downstream of res)	Stinkingwater Ck, downstream of reservoir	15.9	100 %	100 %	-	-	-

Attachment 2 (continued)- General Assessment reach characteristics and focal species use by reach.

Reach Name	Reach Description	Reach Length (miles)	Percent reach utilization by focal species				
			Redband (current)	*Redband (historic)*	*Spring Chinook (historic)*	*Bull Trout (current)*	*Bull Trout ("historic")*
Up 09 - Stinkingwater Ck (res. & upstream)	Stinkingwater Ck, reservoir and upstream	8.2	100 %	100 %	-	-	-
Up 10 - Griffin Creek	Griffin Creek	11.8	100 %	100 %	-	-	-
Up 11 - Lower Pine Creek	Lower Pine Creek	9.6	100 %	100 %	-	-	-
Up 12 - Upper Pine Ck / W Fk Pine Ck	Upper Pine Creek / W Fk Pine Creek	26.3	100 %	100 %	-	-	-
Up 13 - Little Pine Ck	Little Pine Creek	6.7	-	-	-	-	-
Up 14 - Wolf Ck (lower/little), Calamity Ck (lower)	Lower Wolf Ck, Little Wolf Ck, Lower Calamity Ck	20.2	100 %	100 %	-	-	-
Up 15 - Upper Wolf Ck and tribs	Wolf Ck, Middle Fork Wolf Ck, West Fork Wolf Ck, Magpie Ck	30.5	100 %	100 %	-	-	-
Up 16 - Calamity Ck (upper), Gunbarrel Ck	Upper Calamity Ck, Gunbarrel Ck	15.7	100 %	100 %	-	-	-
Up 17 – Bluebucket Creek	Bluebucket Creek	12.1	100 %	100 %	-	-	-
Up 18 - Dollar Basin Creek	Dollar Basin Creek	2.7	100 %	100 %	-	-	-
Up 19 - Lower Summit Ck, Larch Ck	Lower Summit Ck, Larch Ck	10.1	100 %	100 %	24 %	-	81 %
Up 20 - Mid-Summit Ck, Little Logan Ck	Mid-Summit Ck, Little Logan Ck	7.6	100 %	100 %	-	-	64 %
Up 21 - Upper Summit Ck	Upper Summit Ck	3.6	100 %	100 %	-	-	100 %
Up 22 - Logan Valley East (Malh., Boson.& Big)	Logan Valley East (Upper extent of Malheur R., lower Bosonberg Ck, lower Big Ck)	9.9	100 %	100 %	83 %	54 %	100 %
Up 23 - Upper Bosonberg Ck	Upper Bosonberg Ck	3.6	-	100 %	-	-	100 %
Up 24 - Logan Valley West (Lake, Crooked, McCoy)	Logan Valley West (lower Lake Ck, Crooked Ck, lower McCoy Ck)	17.9	100 %	100 %	28 %	69 %	69 %
Up 25 - Malheur Headwaters	Malheur Headwaters (upper Lake Ck, upper McCoy Ck, upper Big Ck, Corral Basin Ck, Meadow Fork, Snowshoe Ck)	26.0	100 %	100 %	10 %	76 %	90 %
Willow 01 - Willow Ck, mouth to near Brogan	Willow Ck - Confluence with Malheur River to near Brogan	29.7	-	100 %	-	-	-
Willow 02 - Willow Ck, near Brogan to Malheur Res	Willow Ck - Near Brogan to Malheur Reservoir outlet	10.5	25 %	100 %	-	-	-

Attachment 2 (continued)- General Assessment reach characteristics and focal species use by reach.

Reach Name	Reach Description	Reach Length (miles)	Percent reach utilization by focal species				
			Redband (current)	*Redband (historic)*	*Spring Chinook (historic)*	*Bull Trout (current)*	*Bull Trout ("historic")*
Willow 03 – Malheur Reservoir	Malheur Reservoir	2.4	-	100 %	-	-	-
Willow 04 - Willow Ck, Malheur Res to Ironside	Willow Ck - Upstream end of Malheur Reservoir to Ironside	15.2	100 %	100 %	-	-	-
Willow 05 - S.Willow, Dutch John, Bridge Cks	South Willow Ck, Dutch John Ck, Bridge Ck	26.6	100 %	100 %	-	-	-
Willow 06 - Basin Creek	Basin Creek	8.8	100 %	100 %	-	-	-
Bully 01 - Bully Ck, mouth to Bully Ck Res	Bully Ck - Confluence with Malheur River to Bully Ck Reservoir outlet	13.1	-	100 %	-	-	-
Bully 02 - Bully Ck Reservoir	Bully Ck Reservoir	3.0	-	100 %	-	-	-
Bully 03 - Bully Ck, Res to S.Fk Indian Ck	Bully Ck - Upstream end of Bully Ck Reservoir to South Fork Indian Ck	19.2	25 %	100 %	-	-	-
Bully 04 - Bully Ck, Upstream of S.Fork Indian Ck	Bully Ck - Upstream of confluence with South Fork Indian Ck	21.6	100 %	100 %	-	-	-
Bully 05 - Cottonwood Ck #4	Cottonwood Creek (north side of Bully Ck drainage)	9.3	100 %	100 %	-	-	-
Bully 06a - Clover Creek	Clover Creek	26.0	100 %	100 %	-	-	-
Bully 06b - Rail Canyon	Rail Canyon	2.8	100 %	100 %	-	-	-
Bully 07 - Reds Creek	Reds Creek	8.5	100 %	100 %	-	-	-
Bully 08a - Cottonwood Ck #5	Cottonwood Creek (south side of Bully Ck drainage)	8.5	-	100 %	-	-	-
Bully 08b - W.Fk Cottonwood	West Fork Cottonwood	4.8	100 %	100 %	-	-	-
Bully 09 - S.Fk Indian Ck	South Fork Indian Ck	13.2	100 %	100 %	-	-	-
N Fk 01 - N.Fk.Malheur, mouth to Beulah Res.	N. Fk. Malheur River - Confluence with Malheur River to Agency Valley Dam	18.0	100 %	100 %	100 %	-	100 %
N Fk 02 - Beulah Res.	Beulah Reservoir	2.7	100 %	100 %	100 %	100 %	100 %
N Fk 03 - N.Fk.Malheur, Beulah to Little Malheur	N. Fk. Malheur River - Upstream end Beulah Reservoir to Little Malheur River	8.5	100 %	100 %	100 %	100 %	100 %
N Fk 04 - N.Fk.Malheur, Little Malheur to Elk Ck	N. Fk. Malheur River - Upstream of Little Malheur River to Elk Ck	20.4	100 %	100 %	84 %	100 %	100 %
N Fk 05 - Lower Crane Ck / Little Crane Ck	Lower Crane Ck / Little Crane Ck	8.0	100 %	100 %	83 %	100 %	100 %

Attachment 2 (continued)- General Assessment reach characteristics and focal species use by reach.

Reach Name	Reach Description	Reach Length (miles)	Percent reach utilization by focal species				
			Redband (current)	*Redband (historic)*	*Spring Chinook (historic)*	*Bull Trout (current)*	*Bull Trout ("historic")*
N Fk 06 - Crane Ck Tribs	Crane Ck Tribs	16.6	100 %	100 %	-	0 %	50 %
N Fk 07 - Bear Creek / Kate Creek	Bear Creek / Kate Creek	10.8	100 %	100 %	-	-	-
N Fk 08 - N.Fk.Malheur headwaters & tribs	N. Fk. Malheur River - Upstream of Elk Ck, and Upper tribs	34.4	100 %	100 %	-	75 %	75 %
N Fk 09 - Little Malheur, mouth to USFS boundary	Little Malheur R - Confluence with N. Fk. Malheur River to USFS boundary	17.5	100 %	100 %	-	-	-
N Fk 10 - Little Malheur headwaters & tribs	Little Malheur R and tribs upstream of USFS boundary	29.3	100 %	100 %	-	-	-
S Fk 01 - S.Fk.Malheur, mouth to Crane Creek	S. Fk. Malheur River - Confluence with Malheur River to Crane Creek	21.5	100 %	100 %	100 %	-	-
S Fk 02 - Granite Ck / Big Granite Ck	Granite Ck / Big Granite Ck	23.7	100 %	100 %	-	-	-
S Fk 03 - Swamp Creek / East Swamp Creek	Swamp Creek / East Swamp Creek	19.6	100 %	100 %	-	-	-
S Fk 04 - Coleman Creek	Coleman Creek	12.8	100 %	100 %	-	-	-
S Fk 05 - Crane Ck, Little Crane Ck, Alder Ck	Crane Ck, Little Crane Ck, Alder Ck	56.6	100 %	100 %	-	-	-
S Fk 06 - S.Fk.Malheur headwaters & tribs	S. Fk. Malheur River upstream of Crane Creek, Camp Creek	42.0	100 %	100 %	-	-	-

Attachment 3 - Current Aquatic Habitat Attributes

Current conditions are displayed for each reach in the Malheur subbasin as a series of bar charts. The attributes referenced include Channel stability, Riparian Condition, Habitat Diversity, Fine Sediment, High Flow, Low Flow, Oxygen, Low Temperature, High Temperature, Pollutants, and Obstructions. Note that these summary bar charts are color coded as follows:

0 - 1: Bar is red

>1 - 2: Bar is orange

>2 - 3: Bar is green

>3: Bar is blue

Attachment 3 (continued) - Current Aquatic Habitat Attributes

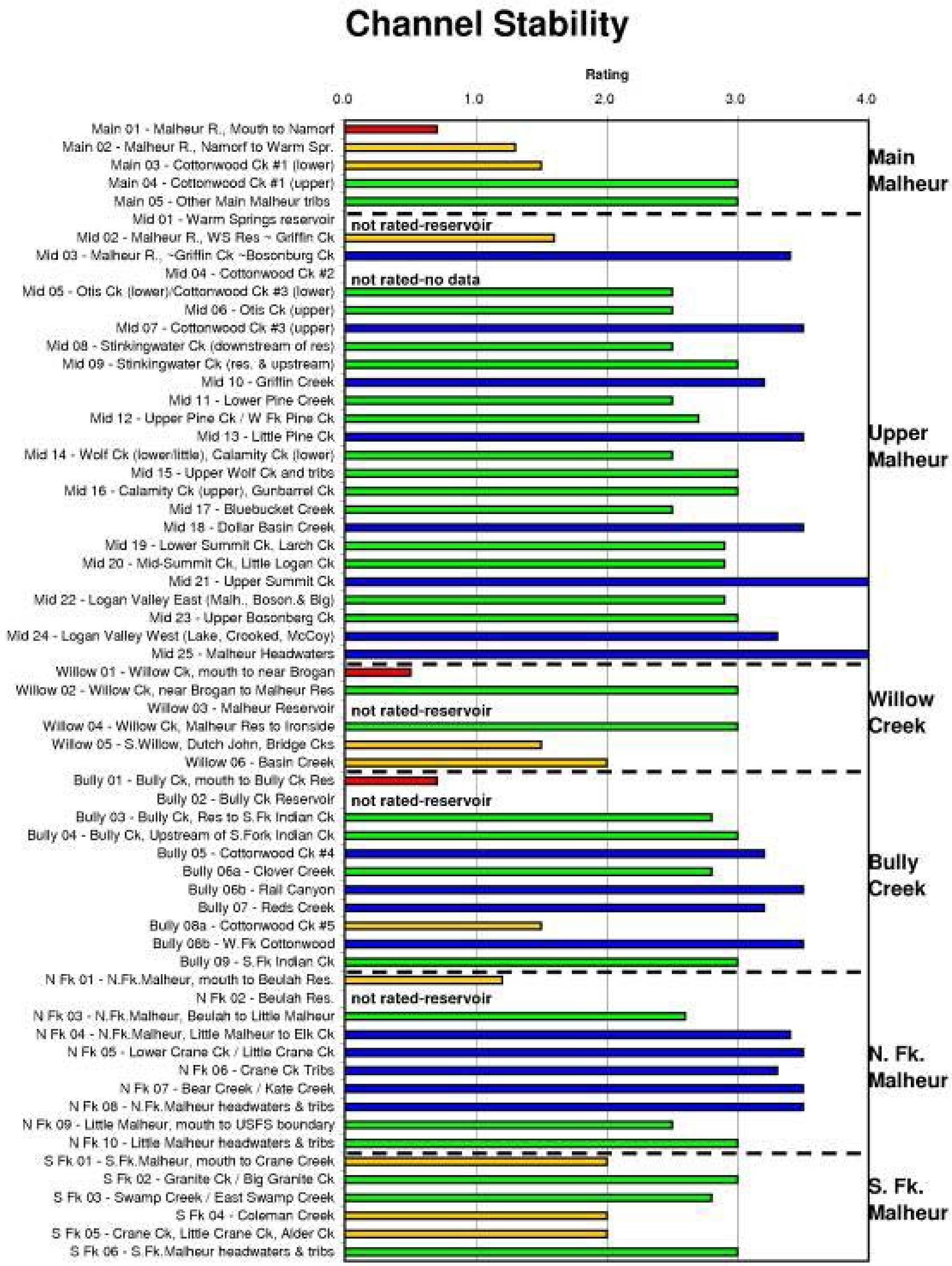


Figure 47. Channel stability bar chart.

Attachment 3 (continued) - Current Aquatic Habitat Attributes

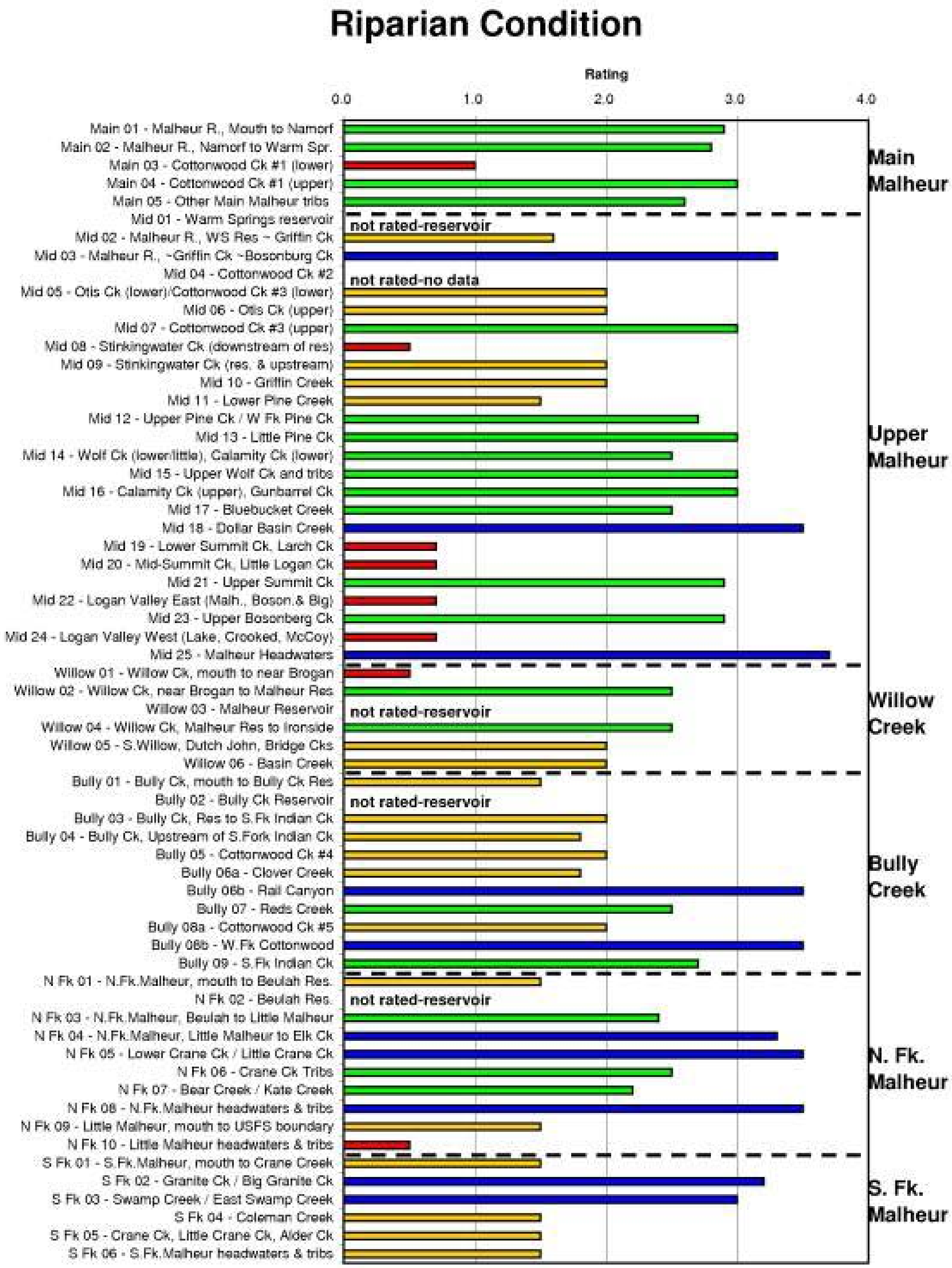


Figure 48. Riparian condition bar chart.

Attachment 3 (continued) - Current Aquatic Habitat Attributes

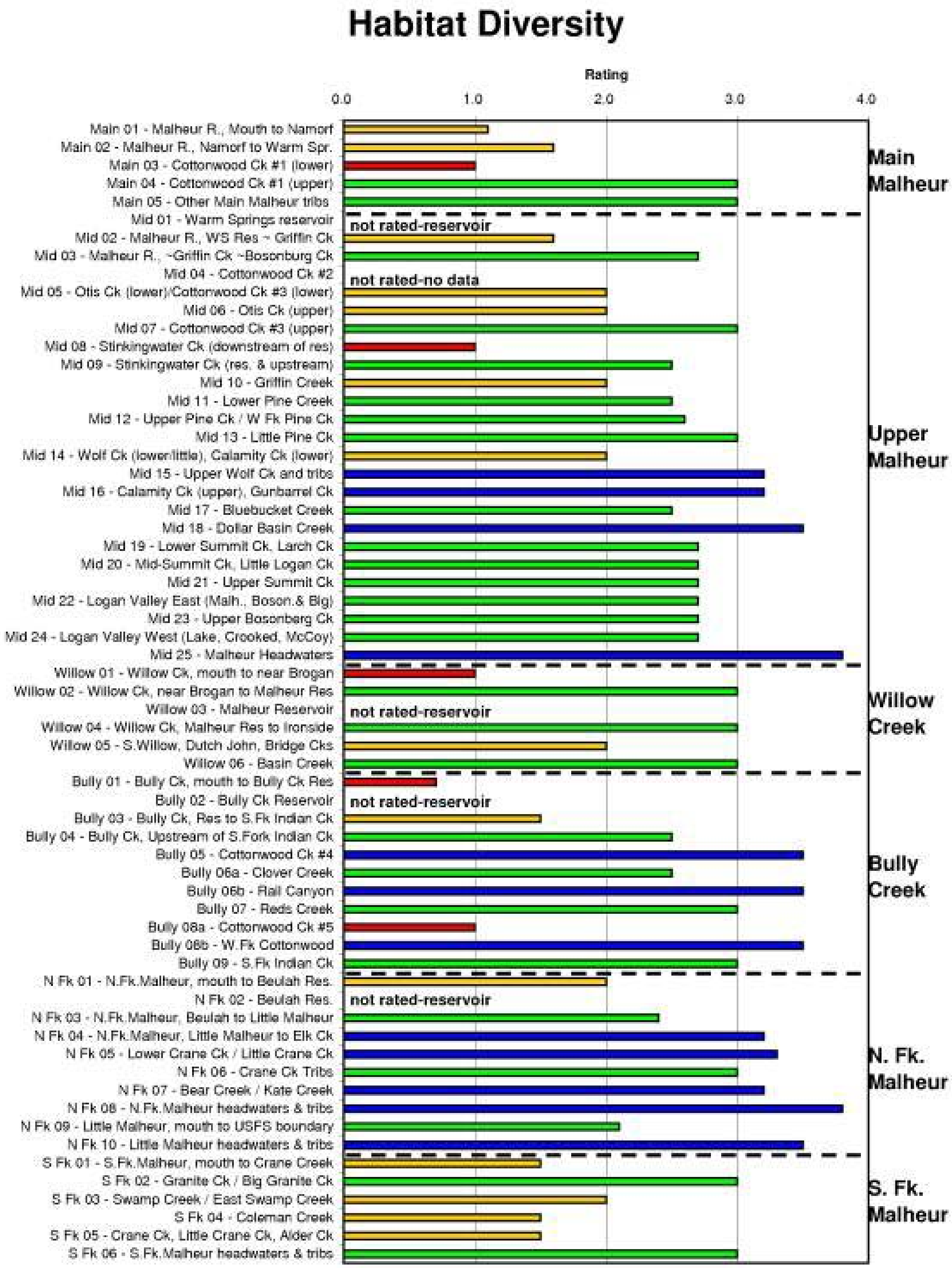


Figure 49. Habitat diversity bar chart.

Attachment 3 (continued) - Current Aquatic Habitat Attributes

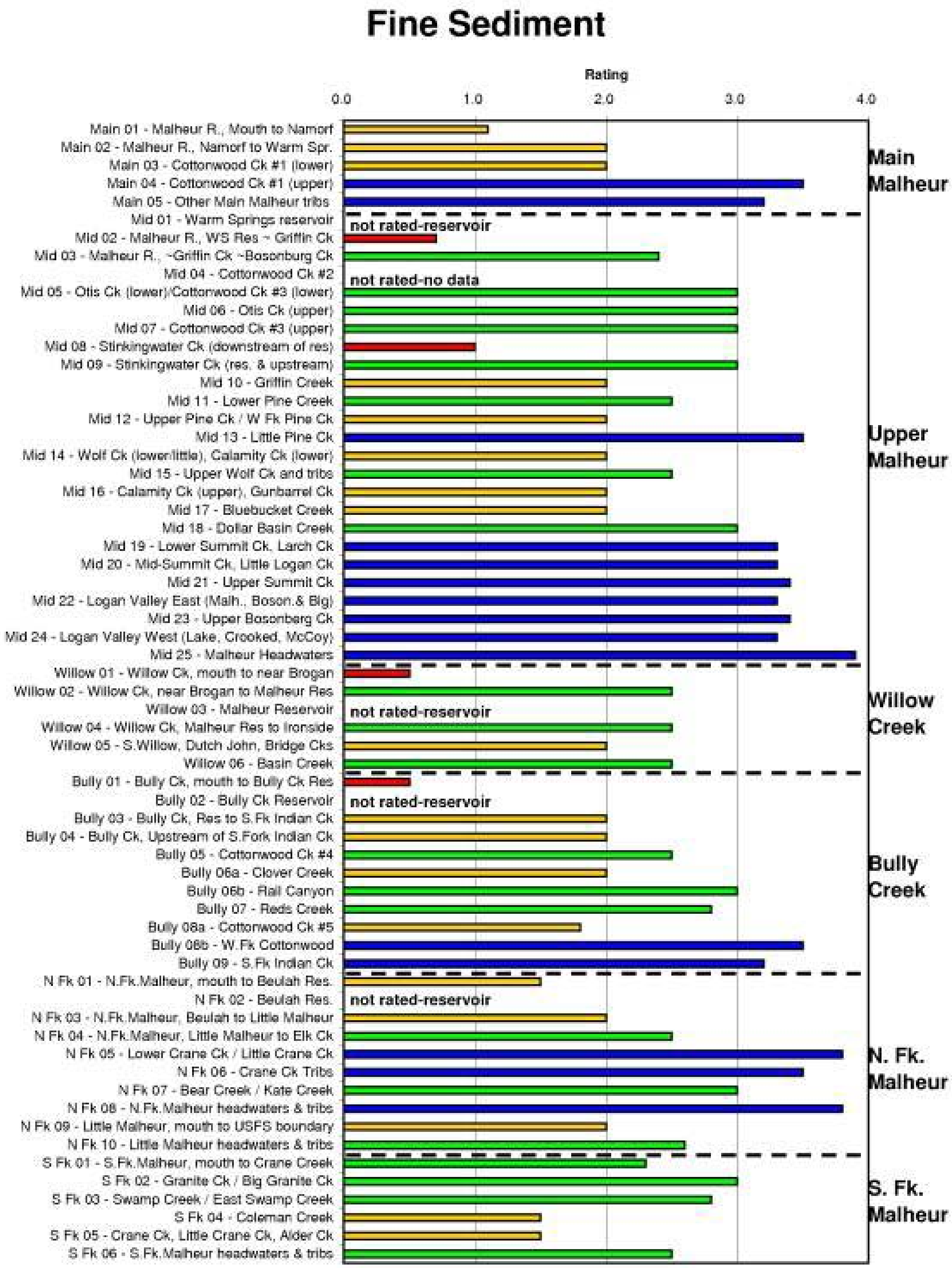


Figure 50. Fine sediment bar chart.

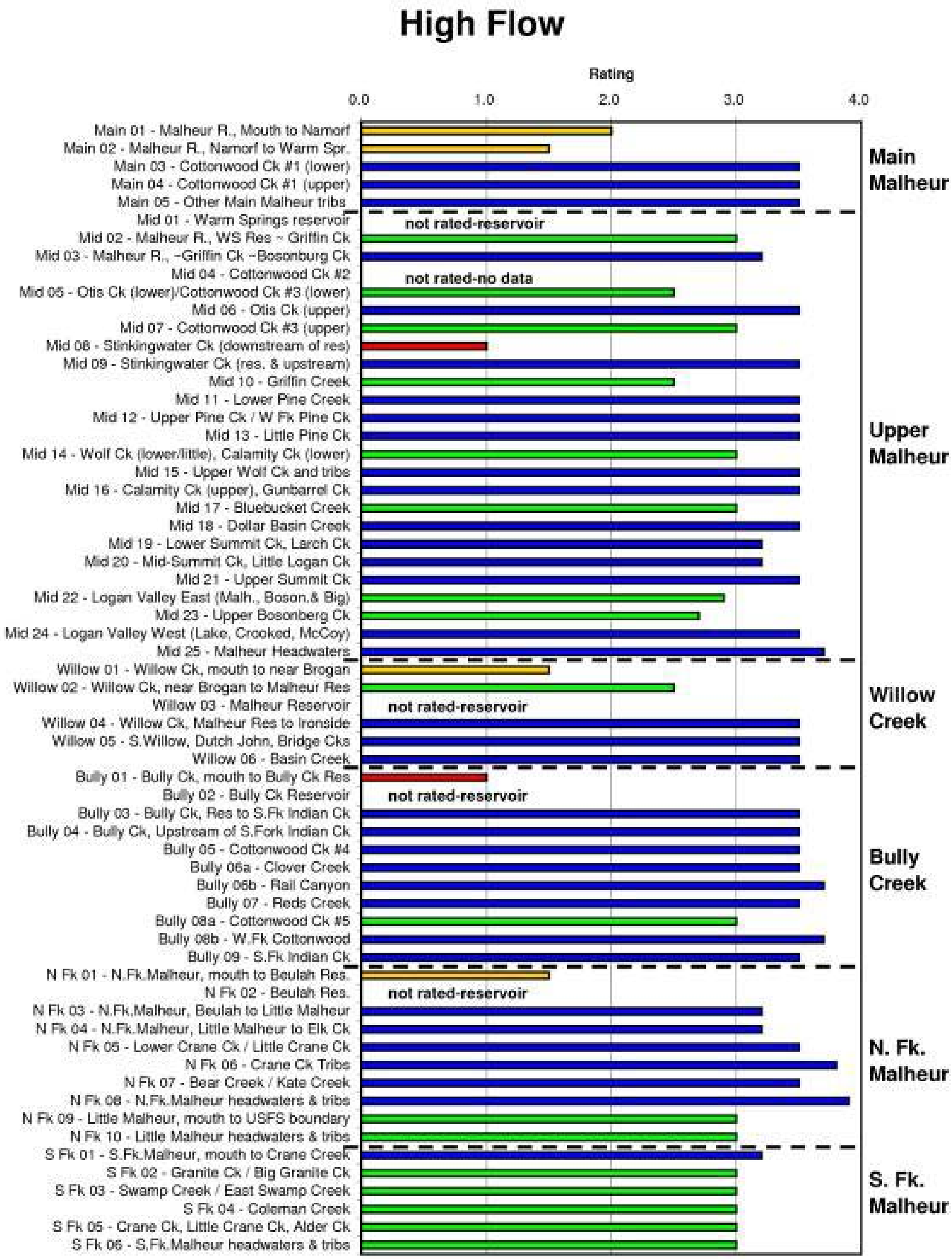


Figure 51. High flow bar chart.

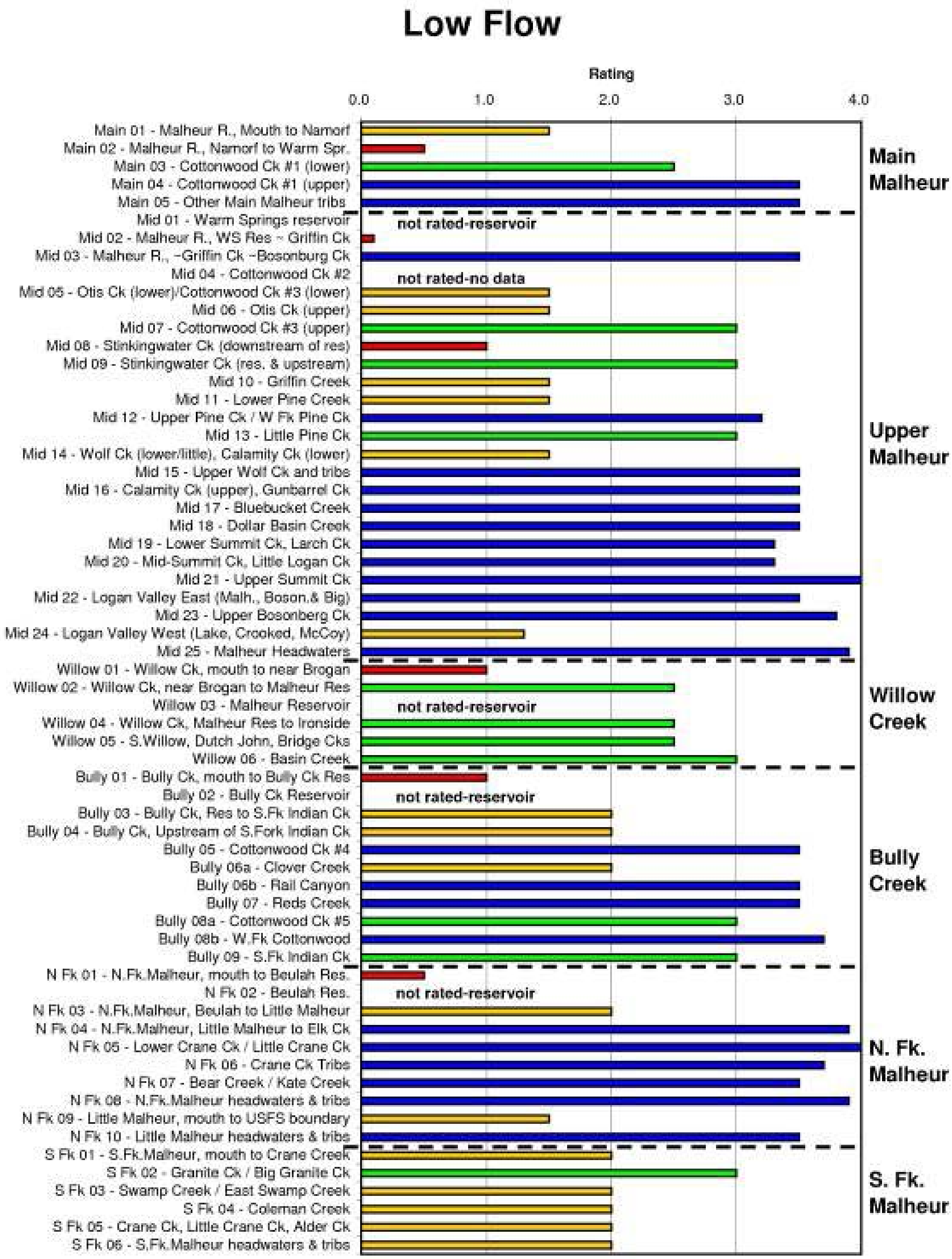


Figure 52. Low flow bar chart.

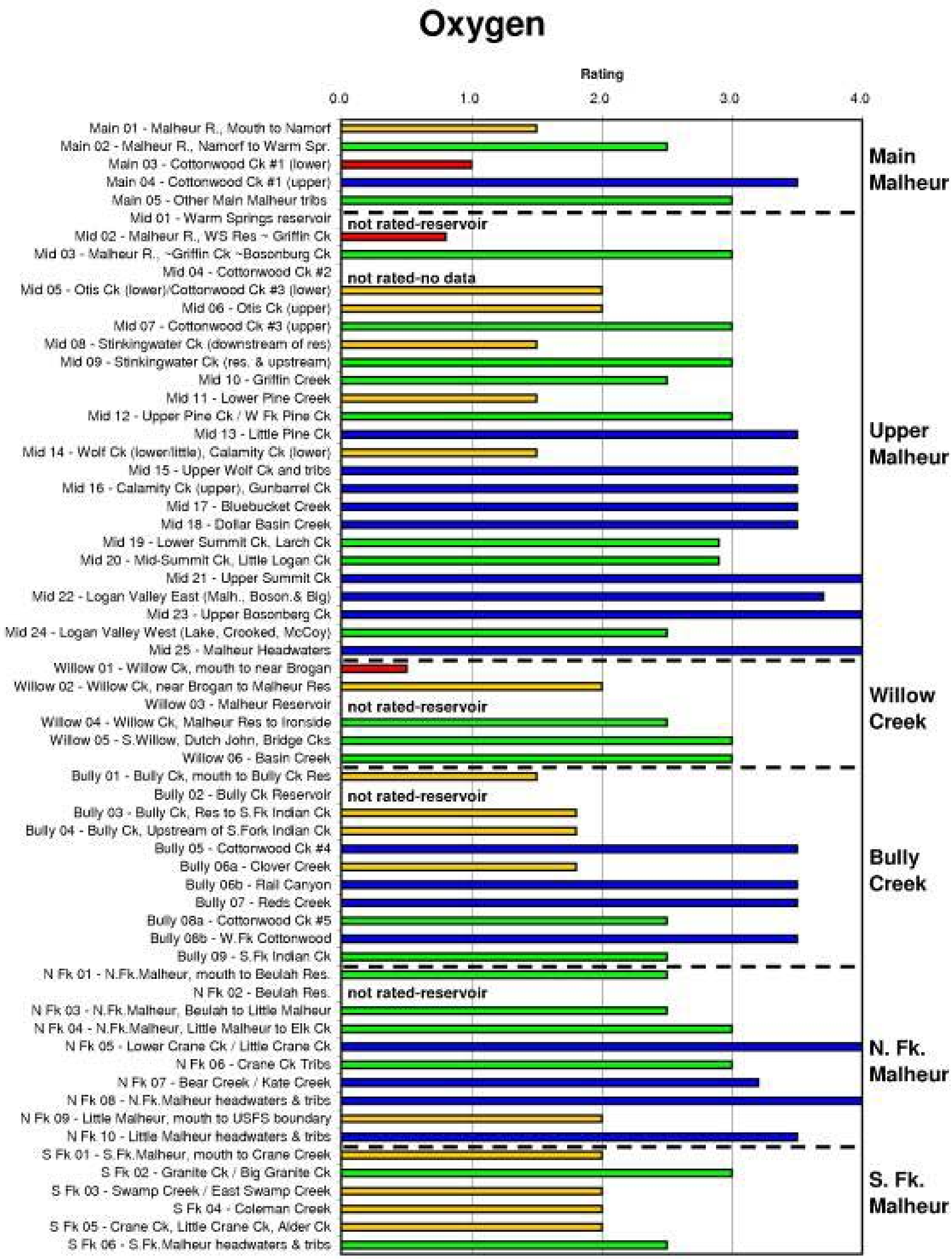


Figure 53. Oxygen bar chart.

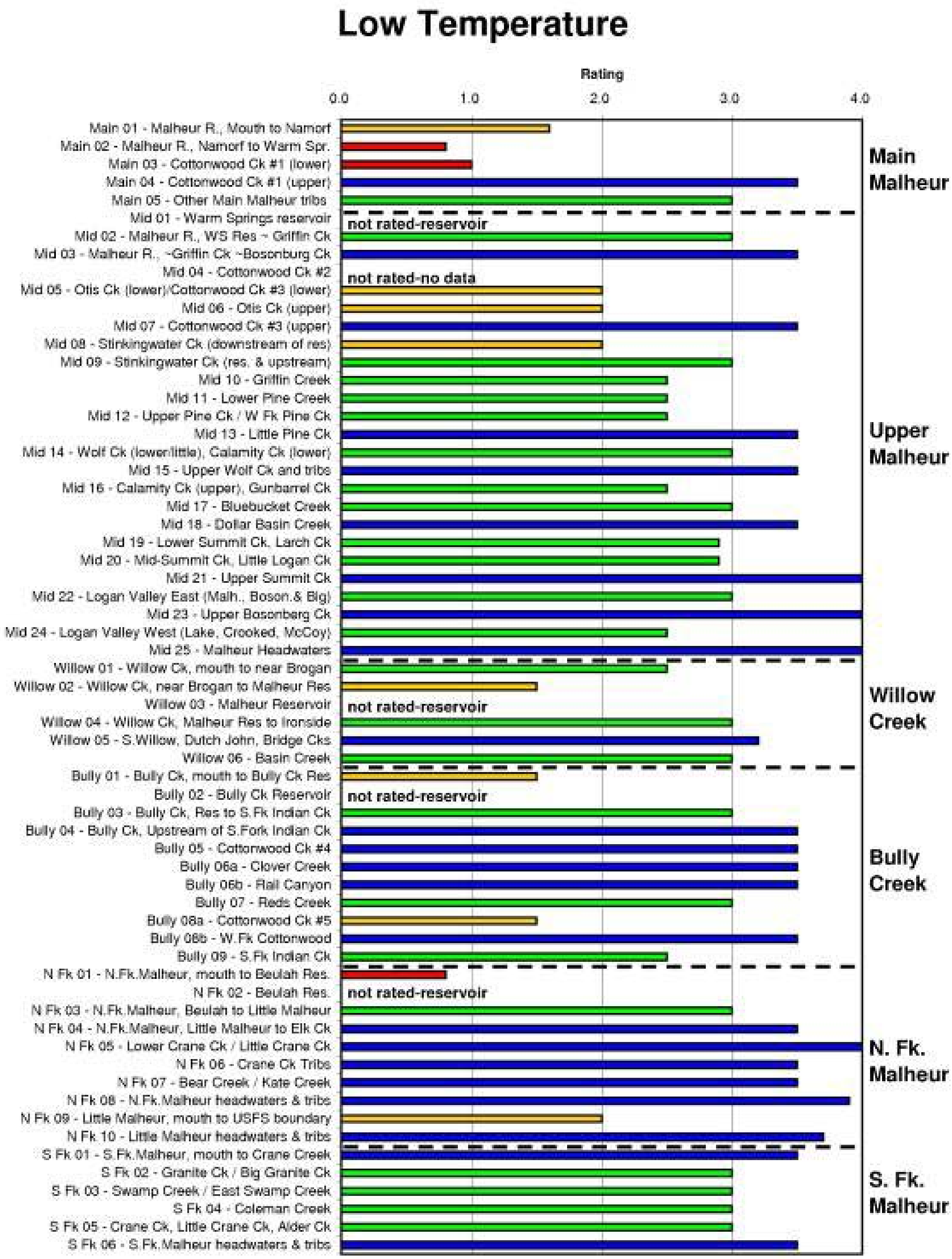


Figure 54. Low temperature bar chart.

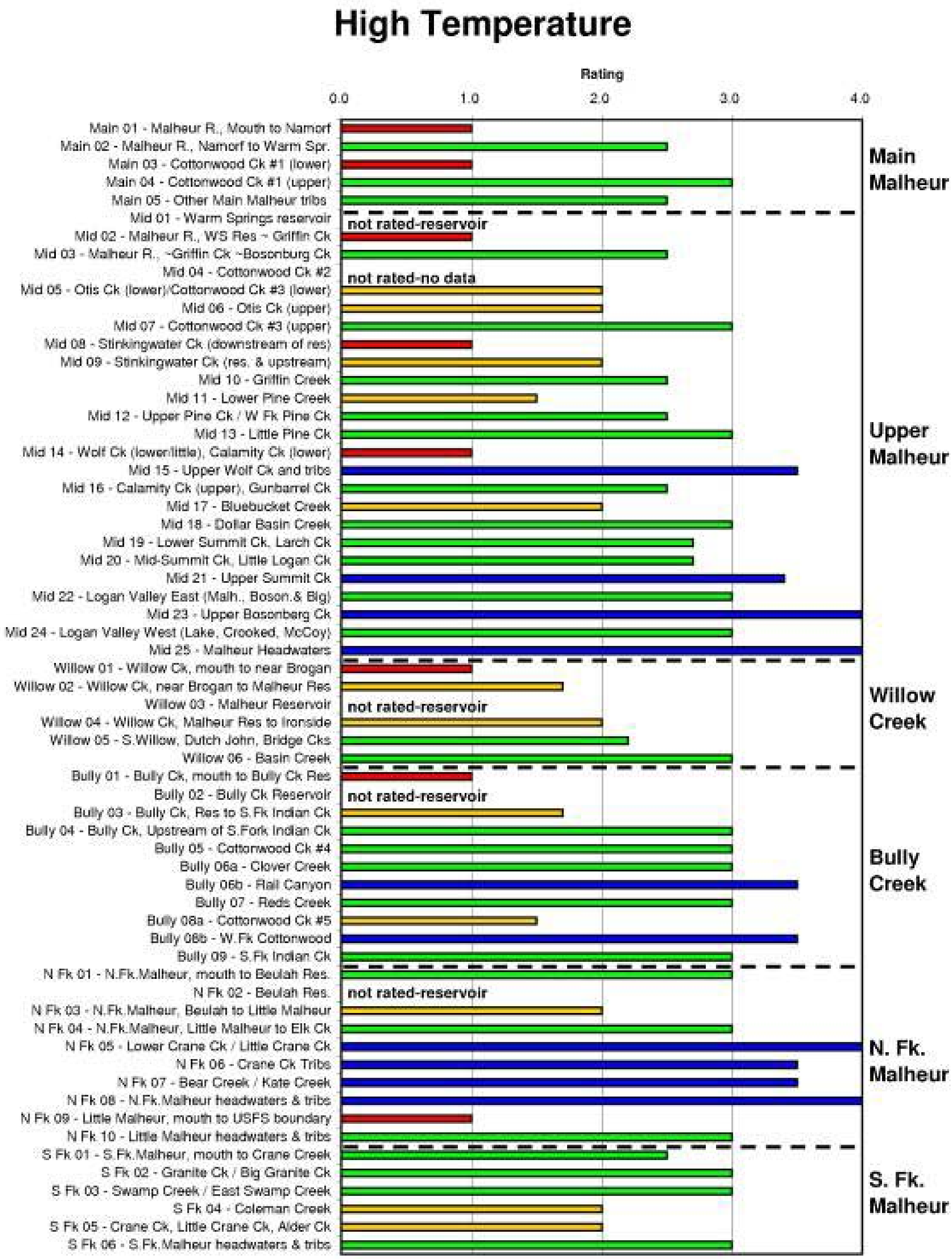


Figure 55. High temperature bar chart.

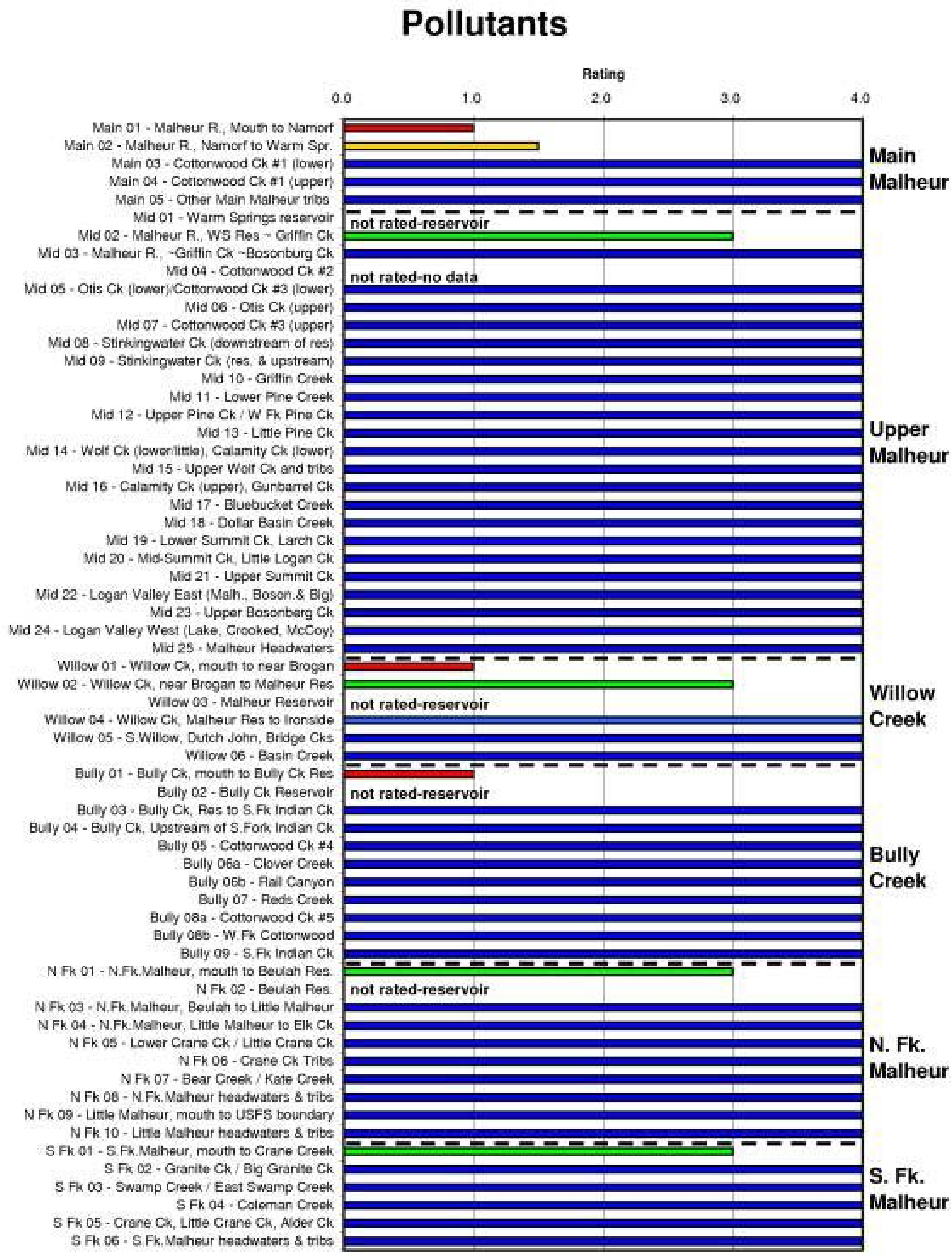


Figure 56. Pollutants bar chart.

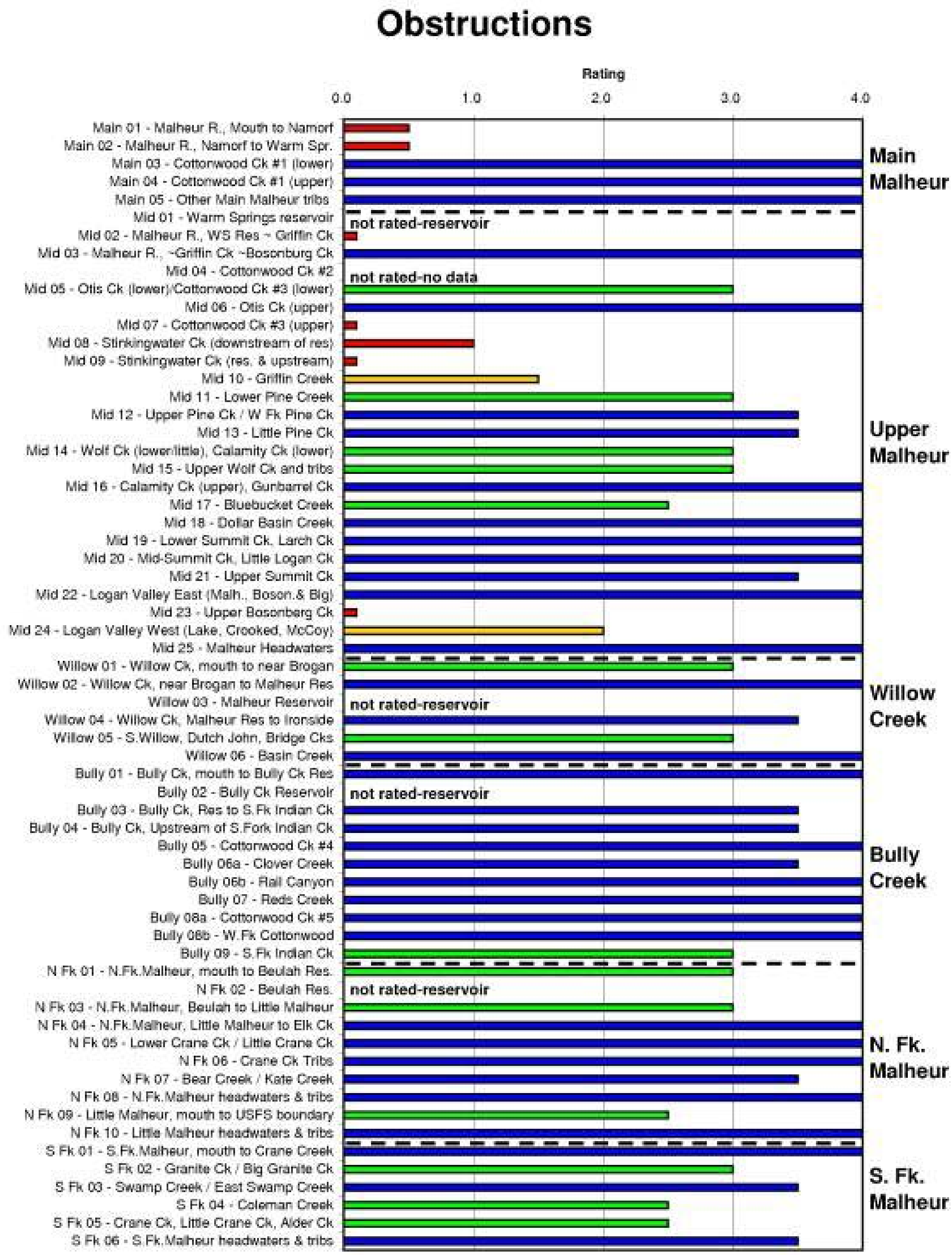


Figure 57. Obstructions bar chart.

Attachment 4 - Documentation Matrix

Table 14. Documentation Matrix: Main & Upper Malheur Watersheds.

Main & Upper Malheur Watersheds	Main 01 - Malheur R., Mouth to Namorf	Main 02 - Malheur R., Namorf to Warm Spr.	Main 03 - Cottonwood Ck #1 (lower)	Main 04 - Cottonwood Ck #1 (upper)	Main 05 - Other Main Malheur tribs	Up 01 - Warm Springs reservoir	Up 02 - Malheur R., WS Res ~ Griffin Ck	Up 03 - Malheur R., ~Griffin Ck to ~Bosonburg Ck	Up 04 - Cottonwood Ck #2	Up 05 - Otis Ck (lower)/ Cottonwood Ck #3 (lower)	Up 06 - Otis Ck (upper)	Up 07 - Cottonwood Ck #3 (upper)	Up 08 - Stinkingwater Ck (downstream of res)	Up 09 - Stinkingwater Ck (res. & upstream)	Up 10 - Griffin Creek	Up 11 - Lower Pine Creek	Up 12 - Upper Pine Ck / W Fk Pine Ck	Up 13 - Little Pine Ck	Up 14 - Wolf Ck (lower/little), Calamity Ck (lower)	Up 15 - Upper Wolf Ck and tribs	Up 16 - Calamity Ck (upper), Gunbarrel Ck	Up 17 - Bluebucket Creek	Up 18 - Dollar Basin Creek	Up 19 - Lower Summit Ck, Larch Ck	Up 20 - Mid-Summit Ck, Little Logan Ck	Up 21 - Upper Summit Ck	Up 22 - Logan Valley East (Malh., Boson.& Big)	Up 23 - Upper Bosonberg Ck	Up 24 - Logan Valley West (Lake, Crooked, McCoy)	Up 25 - Malheur Headwaters
Expert opinion of aquatic technical team	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
BLM Proper Functioning Cindition (PFC) assessments		2001								X			?	?	?			X				X								
BLM riparian photopoints			c.1990 - present	c.1990 - present	X					X		X	?	?	?			X				X								
BLM riparian surveys																														
BLM stream surveys		1979-1985	1979-1985	1979-1985	1979-1985		c.1978	c.1978														1998								
BLM water temperature data				1996-97	1994-2000									?				X				X								
BLM upland range trend monitoring			X																											
BLM electrophoresis sampling																														

Attachment 4 (continued) - Documentation Matrix.

Main & Upper Malheur Watersheds	Main 01 - Malheur R., Mouth to Namorf	Main 02 - Malheur R., Namorf to Warm Spr.	Main 03 - Cottonwood Ck #1 (lower)	Main 04 - Cottonwood Ck #1 (upper)	Main 05 - Other Main Malheur tribs	Up 01 - Warm Springs reservoir	Up 02 - Malheur R., WS Res ~ Griffin Ck	Up 03 - Malheur R., ~Griffin Ck to ~Bosonburg Ck	Up 04 - Cottonwood Ck #2	Up 05 - Otis Ck (lower)/ Cottonwood Ck #3 (lower)	Up 06 - Otis Ck (upper)	Up 07 - Cottonwood Ck #3 (upper)	Up 08 - Stinkingwater Ck (downstream of res)	Up 09 - Stinkingwater Ck (res. & upstream)	Up 10 - Griffin Creek
BLM redband genetics study					2001										
BLM Macroinvertebrate data															
BPT fish surveys															
BPT flood irrigation monitoring															
BPT genetic research												X		?	
BPT HEP for riparian habitat		2001													
BPT Rosgen level II surveys															
BPT snorkle surveys								2002							
BPT stream survey								1997-present							

Main & Upper Malheur Watersheds	Up 11 - Lower Pine Creek	Up 12 - Upper Pine Ck / W Fk Pine Ck	Up 13 - Little Pine Ck	Up 14 - Wolf Ck (lower/little), Calamity Ck (lower)	Up 15 - Upper Wolf Ck and tribs	Up 16 - Calamity Ck (upper), Gunbarrel Ck	Up 17 - Bluebucket Creek	Up 18 - Dollar Basin Creek	Up 19 - Lower Summit Ck, Larch Ck	Up 20 - Mid-Summit Ck, Little Logan Ck	Up 21 - Upper Summit Ck	Up 22 - Logan Valley East (Malh., Boson.& Big)	Up 23 - Upper Bosonberg Ck	Up 24 - Logan Valley West (Lake, Crooked, McCoy)	Up 25 - Malheur Headwaters
BLM redband genetics study															
BLM Macroinvertebrate data							X								
BPT fish surveys									2001	2001	2001		2001	2003	2003
BPT flood irrigation monitoring														2000-present	
BPT genetic research						X	X	X			2003				2003
BPT HEP for riparian habitat															
BPT Rosgen level II surveys												2003		2003	
BPT snorkle surveys															
BPT stream survey					X				1997	1997	1997	1997-present		1997-present	

Attachment 4 (continued) - Documentation Matrix.

Main & Upper Malheur Watersheds	Main 01 - Malheur R., Mouth to Namorf	Main 02 - Malheur R., Namorf to Warm Spr.	Main 03 - Cottonwood Ck #1 (lower)	Main 04 - Cottonwood Ck #1 (upper)	Main 05 - Other Main Malheur tribs	Up 01 - Warm Springs reservoir	Up 02 - Malheur R., WS Res ~ Griffin Ck	Up 03 - Malheur R., ~Griffin Ck to ~Bosonburg Ck	Up 04 - Cottonwood Ck #2	Up 05 - Otis Ck (lower)/ Cottonwood Ck #3 (lower)	Up 06 - Otis Ck (upper)	Up 07 - Cottonwood Ck #3 (upper)	Up 08 - Stinkingwater Ck (downstream of res)	Up 09 - Stinkingwater Ck (res. & upstream)	Up 10 - Griffin Creek	Up 11 - Lower Pine Creek	Up 12 - Upper Pine Ck / W Fk Pine Ck	Up 13 - Little Pine Ck	Up 14 - Wolf Ck (lower/little), Calamity Ck (lower)	Up 15 - Upper Wolf Ck and tribs	Up 16 - Calamity Ck (upper), Gunbarrel Ck	Up 17 - Bluebucket Creek	Up 18 - Dollar Basin Creek	Up 19 - Lower Summit Ck, Larch Ck	Up 20 - Mid-Summit Ck, Little Logan Ck	Up 21 - Upper Summit Ck	Up 22 - Logan Valley East (Malh., Boson.& Big)	Up 23 - Upper Bosonberg Ck	Up 24 - Logan Valley West (Lake, Crooked, McCoy)	Up 25 - Malheur Headwaters
BPT telemetry studies								2000-2001																		2000-2001	2000-2001		2000-2001	2000-2001
BPT water temperature data								2000-present																			2000-present		2000-present	
BPT willow monitoring																											2000-present		2000-present	
ODFW stream surveys	1966, 1978		c.1975, 2002	c.1975, 2002				1982-83											1974	1997-98		2003		1969	1969	1969, 1982-83, 1989, 1994	1982-83, 1989, 1994	1989	1982-83, 1989, 1994	1982-83, 1989, 1994
ODFW fish surveys	1978	1973-present			c.1975, 1997		1982-83	1982-83								1973-79	1973-79		1973-79	1973-79	1973-79	1973-79, 1998		1969	1969	1969, 1994	1986, 1994	1986, 1989	1986, 1989, 1994	1986, 1989, 1994
ODFW electrophoresis sampling			1989	1989	1988														1981	1981										
ODFW bull trout																										1998-present	1998-present	1998-present	1998-present	1998-present

Attachment 4 (continued) - Documentation Matrix.

Main & Upper Malheur Watersheds	Main 01 - Malheur R., Mouth to Namorf	Main 02 - Malheur R., Namorf to Warm Spr.	Main 03 - Cottonwood Ck #1 (lower)	Main 04 - Cottonwood Ck #1 (upper)	Main 05 - Other Main Malheur tribs	Up 01 - Warm Springs reservoir	Up 02 - Malheur R., WS Res ~ Griffin Ck	Up 03 - Malheur R., ~Griffin Ck to ~Bosonburg Ck	Up 04 - Cottonwood Ck #2	Up 05 - Otis Ck (lower)/ Cottonwood Ck #3 (lower)	Up 06 - Otis Ck (upper)	Up 07 - Cottonwood Ck #3 (upper)	Up 08 - Stinkingwater Ck (downstream of res)	Up 09 - Stinkingwater Ck (res. & upstream)	Up 10 - Griffin Creek	Up 11 - Lower Pine Creek	Up 12 - Upper Pine Ck / W Fk Pine Ck	Up 13 - Little Pine Ck	Up 14 - Wolf Ck (lower/little), Calamity Ck (lower)	Up 15 - Upper Wolf Ck and tribs	Up 16 - Calamity Ck (upper), Gunbarrel Ck	Up 17 - Bluebucket Creek	Up 18 - Dollar Basin Creek	Up 19 - Lower Summit Ck, Larch Ck	Up 20 - Mid-Summit Ck, Little Logan Ck	Up 21 - Upper Summit Ck	Up 22 - Logan Valley East (Malh., Boson.& Big)	Up 23 - Upper Bosonberg Ck	Up 24 - Logan Valley West (Lake, Crooked, McCoy)	Up 25 - Malheur Headwaters
ODFW water temperature data	1996	1996						1996-present																1996-present	1996-present	1996-present	1996-present		1996-present	1996-present
ODFW Basin Reports																														
ODFW Photo points																														
USBR & USGS Bull trout suitability study																														
USBR Hydromet data	X	X				X	X																							
USFS water temperature data																								X	X		1991-present	1991-present		
USFS Snowshoe Fire evaluation																										X		X		
USFS Stream surveys								1989				1989					?			1997-98	?	1989	?							
USFS watershed analyses (get names)												X					?			?	?		?	X	X	X	X		X	X
ODEQ Water quality data	X																													

Attachment 4 (continued) - Documentation Matrix.

Main & Upper Malheur Watersheds	Main 01 - Malheur R., Mouth to Namorf	Main 02 - Malheur R., Namorf to Warm Spr.	Main 03 - Cottonwood Ck #1 (lower)	Main 04 - Cottonwood Ck #1 (upper)	Main 05 - Other Main Malheur tribs	Up 01 - Warm Springs reservoir	Up 02 - Malheur R., WS Res ~ Griffin Ck	Up 03 - Malheur R., ~Griffin Ck to ~Bosonburg Ck	Up 04 - Cottonwood Ck #2	Up 05 - Otis Ck (lower)/ Cottonwood Ck #3 (lower)	Up 06 - Otis Ck (upper)	Up 07 - Cottonwood Ck #3 (upper)	Up 08 - Stinkingwater Ck (downstream of res)	Up 09 - Stinkingwater Ck (res. & upstream)	Up 10 - Griffin Creek	Up 11 - Lower Pine Creek	Up 12 - Upper Pine Ck / W Fk Pine Ck	Up 13 - Little Pine Ck	Up 14 - Wolf Ck (lower/little), Calamity Ck (lower)	Up 15 - Upper Wolf Ck and tribs	Up 16 - Calamity Ck (upper), Gunbarrel Ck	Up 17 - Bluebucket Creek	Up 18 - Dollar Basin Creek	Up 19 - Lower Summit Ck, Larch Ck	Up 20 - Mid-Summit Ck, Little Logan Ck	Up 21 - Upper Summit Ck	Up 22 - Logan Valley East (Malh., Boson.& Big)	Up 23 - Upper Bosonberg Ck	Up 24 - Logan Valley West (Lake, Crooked, McCoy)	Up 25 - Malheur Headwaters
Agency?? FLIR data																														
MWC water temperature data																														
Harney County (Watershed Council?)																?														
NRCS Farm Plans																														
USGS daily flow data	1890-present	1909-present	1926-30				1926-present					1967-91		1968-78																
USGS peak flow data	1903-present	1913-present					1920-present					1967-91		1968-78																

Attachment 4 (continued) - Documentation Matrix.

Table 15. Documentation Matrix: Willow Creek, Bully Creek, North Fork Malheur, and South Fork Malheur watersheds.

Willow Creek, Bully Creek, N.Fk Malheur and S. Fk. Malheur Watersheds	Willow 01 - Willow Ck, mouth to near Brogan	Willow 02 - Willow Ck, near Brogan to Malheur Res	Willow 03 - Malheur Reservoir	Willow 04 - Willow Ck, Malheur Res to Ironside	Willow 05 - S.Willow, Dutch John, Bridge Cks	Willow 06 - Basin Creek	Bully 01 - Bully Ck, mouth to Bully Ck Res	Bully 02 - Bully Ck Reservoir	Bully 03 - Bully Ck, Res to S.Fk Indian Ck	Bully 04 - Bully Ck, Upstream of S.Fork Indian Ck	Bully 05 - Cottonwood Ck #4	Bully 06a - Clover Creek	Bully 06b - Rail Canyon	Bully 07 - Reds Creek	Bully 08a - Cottonwood Ck #5	Bully 08b - W.Fk Cottonwood	Bully 09 - S.Fk Indian Ck	N Fk 01 - N.Fk.Malheur, mouth to Beulah Res.	N Fk 02 - Beulah Res.	N Fk 03 - N.Fk.Malheur, Beulah to Little Malheur	N Fk 04 - N.Fk.Malheur, Little Malheur to Elk Ck	N Fk 05 - Lower Crane Ck / Little Crane Ck	N Fk 06 - Crane Ck Tribs	N Fk 07 - Bear Creek / Kate Creek	N Fk 08 - N.Fk.Malheur headwaters & tribs	N Fk 09 - Little Malheur, mouth to USFS boundary	N Fk 10 - Little Malheur headwaters & tribs	S Fk 01 - S.Fk.Malheur, mouth to Crane Creek	S Fk 02 - Granite Ck / Big Granite Ck	S Fk 03 - Swamp Creek / East Swamp Creek	S Fk 04 - Coleman Creek	S Fk 05 - Crane Ck, Little Crane Ck, Alder Ck	S Fk 06 - S.Fk.Malheur headwaters & tribs
Expert opinion of aquatic technical team	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
BLM Proper Functioning Cindition (PFC) assessments									X	X	X	X	X	X	X	X	X				1999					X					X	X	
BLM riparian photopoints		X				X					X	X	X	X	X	X	X				1980-present					X			X	X	X	X	
BLM riparian surveys																					1979												
BLM stream surveys									1980	1980	1980	1980, 1999	1980, 1999	1980	1980	1980	1980			c.1978	c.1978, 1998					c.1978			c.1976	c.1976	c.1976	c.1976	
BLM water temperature data													X					1994-present		1994-present	1994-present					X							
BLM upland range trend monitoring																													X	X			
BLM electrophoresis sampling															1988		1989																

Attachment 4 (continued) - Documentation Matrix.

Willow Creek, Bully Creek, N.Fk Malheur and S. Fk. Malheur Watersheds	Willow 01 - Willow Ck, mouth to near Brogan	Willow 02 - Willow Ck, near Brogan to Malheur Res	Willow 03 - Malheur Reservoir	Willow 04 - Willow Ck, Malheur Res to Ironside	Willow 05 - S.Willow, Dutch John, Bridge Cks	Willow 06 - Basin Creek	Bully 01 - Bully Ck, mouth to Bully Ck Res	Bully 02 - Bully Ck Reservoir	Bully 03 - Bully Ck, Res to S.Fk Indian Ck	Bully 04 - Bully Ck, Upstream of S.Fork Indian Ck	Bully 05 - Cottonwood Ck #4	Bully 06a - Clover Creek	Bully 06b - Rail Canyon	Bully 07 - Reds Creek	Bully 08a - Cottonwood Ck #5	Bully 08b - W.Fk Cottonwood	Bully 09 - S.Fk Indian Ck	N Fk 01 - N.Fk.Malheur, mouth to Beulah Res.	N Fk 02 - Beulah Res.	N Fk 03 - N.Fk.Malheur, Beulah to Little Malheur	N Fk 04 - N.Fk.Malheur, Little Malheur to Elk Ck	N Fk 05 - Lower Crane Ck / Little Crane Ck	N Fk 06 - Crane Ck Tribs	N Fk 07 - Bear Creek / Kate Creek	N Fk 08 - N.Fk.Malheur headwaters & tribs	N Fk 09 - Little Malheur, mouth to USFS boundary	N Fk 10 - Little Malheur headwaters & tribs	S Fk 01 - S.Fk.Malheur, mouth to Crane Creek	S Fk 02 - Granite Ck / Big Granite Ck	S Fk 03 - Swamp Creek / East Swamp Creek	S Fk 04 - Coleman Creek	S Fk 05 - Crane Ck, Little Crane Ck, Alder Ck	S Fk 06 - S.Fk.Malheur headwaters & tribs
BLM redband genetics study											1994				1994		1994																
BLM Macroinvertebrate data													X																				
BPT fish surveys																																	
BPT flood irrigation monitoring																																	
BPT genetic research																								2001			X						
BPT HEP for riparian habitat																																	
BPT Rosgen level II surveys																																	
BPT snorkle surveys																					1999												
BPT stream survey																					2001	2001	2001		2001								
BPT telemetry studies																		1998-99, 2002-03	1998-99, 2001-02	1998-99, 2002-03	1998-99, 2002-03	1998-99, 2002-03	1998-99, 2002-03		1998-99, 2002-03								

Attachment 4 (continued) - Documentation Matrix.

Willow Creek, Bully Creek, N.Fk Malheur and S. Fk. Malheur Watersheds	Willow 01 - Willow Ck, mouth to near Brogan	Willow 02 - Willow Ck, near Brogan to Malheur Res	Willow 03 - Malheur Reservoir	Willow 04 - Willow Ck, Malheur Res to Ironside	Willow 05 - S.Willow, Dutch John, Bridge Cks	Willow 06 - Basin Creek	Bully 01 - Bully Ck, mouth to Bully Ck Res	Bully 02 - Bully Ck Reservoir	Bully 03 - Bully Ck, Res to S.Fk Indian Ck	Bully 04 - Bully Ck, Upstream of S.Fork Indian Ck	Bully 05 - Cottonwood Ck #4
BPT water temperature data											
BPT willow monitoring											
ODFW stream surveys											
ODFW fish surveys							1961	1961	1961	1961	1961
ODFW electrophoresis sampling											
ODFW bull trout											

Willow Creek, Bully Creek, N.Fk Malheur and S. Fk. Malheur Watersheds	Bully 06a - Clover Creek	Bully 06b - Rail Canyon	Bully 07 - Reds Creek	Bully 08a - Cottonwood Ck #5	Bully 08b - W.Fk Cottonwood	Bully 09 - S.Fk Indian Ck	N Fk 01 - N.Fk.Malheur, mouth to Beulah Res.	N Fk 02 - Beulah Res.	N Fk 03 - N.Fk.Malheur, Beulah to Little Malheur	N Fk 04 - N.Fk.Malheur, Little Malheur to Elk Ck	N Fk 05 - Lower Crane Ck / Little Crane Ck
BPT water temperature data											
BPT willow monitoring											
ODFW stream surveys										1972, 1982-83, 1989, 1992-1993	1972, 1989, 1992
ODFW fish surveys	1961	1961	1961	1961	1961	1961	1970-present	1951-present	1982-83, 1989		1970-present
ODFW electrophoresis sampling											
ODFW bull trout										1998-present	

Willow Creek, Bully Creek, N.Fk Malheur and S. Fk. Malheur Watersheds	N Fk 06 - Crane Ck Tribs	N Fk 07 - Bear Creek / Kate Creek	N Fk 08 - N.Fk.Malheur headwaters & tribs	N Fk 09 - Little Malheur, mouth to USFS boundary	N Fk 10 - Little Malheur headwaters & tribs	S Fk 01 - S.Fk.Malheur, mouth to Crane Creek	S Fk 02 - Granite Ck / Big Granite Ck	S Fk 03 - Swamp Creek / East Swamp Creek	S Fk 04 - Coleman Creek	S Fk 05 - Crane Ck, Little Crane Ck, Alder Ck	S Fk 06 - S.Fk.Malheur headwaters & tribs
BPT water temperature data											
BPT willow monitoring											
ODFW stream surveys	1989	1972	1972, 1989, 1992								
ODFW fish surveys	1989	1980	1970-present		1990	1984					
ODFW electrophoresis sampling		1981									
ODFW bull trout											

Attachment 4 (continued) - Documentation Matrix.

Willow Creek, Bully Creek, N.Fk Malheur and S. Fk. Malheur Watersheds	Willow 01 - Willow Ck, mouth to near Brogan	Willow 02 - Willow Ck, near Brogan to Malheur Res	Willow 03 - Malheur Reservoir	Willow 04 - Willow Ck, Malheur Res to Ironside	Willow 05 - S.Willow, Dutch John, Bridge Cks	Willow 06 - Basin Creek	Bully 01 - Bully Ck, mouth to Bully Ck Res	Bully 02 - Bully Ck Reservoir	Bully 03 - Bully Ck, Res to S.Fk Indian Ck	Bully [illegible] - Bully Ck, Upstream of S.Fork Indian Ck	Bully 05 - Cottonwood Ck #4	Bully 06a - Clover Creek	Bully 06b - Rail Canyon	Bully 07 - Reds Creek	Bully 08a - Cottonwood Ck #5	Bully 08b - W.Fk Cottonwood	Bully 09 - S.Fk Indian Ck	N Fk 01 - N.Fk.Malheur, mouth to Beulah Res.	N Fk 02 - Beulah Res.	N Fk 03 - N.Fk.Malheur, Beulah to Little Malheur	N Fk 04 - N.Fk.Malheur, Little Malheur to Elk Ck	N Fk 05 - Lower Crane Ck / Little Crane Ck	N Fk 06 - Crane Ck Tribs	N Fk 07 - Bear Creek / Kate Creek	N Fk 08 - N.Fk.Malheur headwaters & tribs	N Fk 09 - Little Malheur, mouth to USFS boundary	N Fk 10 - Little Malheur headwaters & tribs	S Fk 01 - S.Fk.Malheur, mouth to Crane Creek	S Fk 02 - Granite Ck / Big Granite Ck	S Fk 03 - Swamp Creek / East Swamp Creek	S Fk 04 - Coleman Creek	S Fk 05 - Crane Ck, Little Crane Ck, Alder Ck	S Fk 06 - S.Fk.Malheur headwaters & tribs
ODFW water temperature data																		1996-present			1996-present	1996-present			1996-present								
ODFW Basin Reports	mid-1960s																																
ODFW Photo points						Late 1980's																											
USBR & USGS Bull trout suitability study																			X														
USBR Hydromet data																		X	X														
USFS water temperature data																					1991-present						X						

Attachment 4 (continued) - Documentation Matrix.

Willow Creek, Bully Creek, N.Fk Malheur and S. Fk. Malheur Watersheds	Willow 01 - Willow Ck, mouth to near Brogan	Willow 02 - Willow Ck, near Brogan to Malheur Res	Willow 03 - Malheur Reservoir	Willow 04 - Willow Ck, Malheur Res to Ironside	Willow 05 - S.Willow, Dutch John, Bridge Cks	Willow 06 - Basin Creek	Bully 01 - Bully Ck, mouth to Bully Ck Res	Bully 02 - Bully Ck Reservoir	Bully 03 - Bully Ck, Res to S.Fk Indian Ck	Bully Ck, Upstream of S.Fork Indian Ck	Bully 05 - Cottonwood Ck #4	Bully 06a - Clover Creek	Bully 06b - Rail Canyon	Bully 07 - Reds Creek	Bully 08a - Cottonwood Ck #5	Bully 08b - W.Fk Cottonwood	Bully 09 - S.Fk Indian Ck	N Fk 01 - N.Fk.Malheur, mouth to Beulah Res.	N Fk 02 - Beulah Res.	N Fk 03 - N.Fk.Malheur, Beulah to Little Malheur	N Fk 04 - N.Fk.Malheur, Little Malheur to Elk Ck	N Fk 05 - Lower Crane Ck / Little Crane Ck	N Fk 06 - Crane Ck Tribs	N Fk 07 - Bear Creek / Kate Creek	N Fk 08 - N.Fk.Malheur headwaters & tribs	N Fk 09 - Little Malheur, mouth to USFS boundary	N Fk 10 - Little Malheur headwaters & tribs	S Fk 01 - S.Fk.Malheur, mouth to Crane Creek	S Fk 02 - Granite Ck / Big Granite Ck	S Fk 03 - Swamp Creek / East Swamp Creek	S Fk 04 - Coleman Creek	S Fk 05 - Crane Ck, Little Crane Ck, Alder Ck	S Fk 06 - S.Fk.Malheur headwaters & tribs
USFS Snowshoe Fire evaluation																																	
USFS Stream surveys																					1989	1989	1989	1989	1989		1989						
USFS watershed analyses (get names)																						X		X	X								
ODEQ Water quality data																																	
Agency?? FLIR data																				X													
MWC water temperature data	X	X		X			X		c.1995	c.1995																							

Attachment 4 (continued) - Documentation Matrix.

Willow Creek, Bully Creek, N.Fk Malheur and S. Fk. Malheur Watersheds	Willow 01 - Willow Ck, mouth to near Brogan	Willow 02 - Willow Ck, near Brogan to Malheur Res	Willow 03 - Malheur Reservoir	Willow 04 - Willow Ck, Malheur Res to Ironside	Willow 05 - S.Willow, Dutch John, Bridge Cks	Willow 06 - Basin Creek	Bully 01 - Bully Ck, mouth to Bully Ck Res	Bully 02 - Bully Ck Reservoir	Bully 03 - Bully Ck, Res to S.Fk Indian Ck	Bully 04 - Bully Ck, Upstream of S.Fork Indian Ck	Bully 05 - Cottonwood Ck #4	Bully 06a - Clover Creek	Bully 06b - Rail Canyon	Bully 07 - Reds Creek	Bully 08a - Cottonwood Ck #5	Bully 08b - W.Fk Cottonwood	Bully 09 - S.Fk Indian Ck	N Fk 01 - N.Fk.Malheur, mouth to Beulah Res.	N Fk 02 - Beulah Res.	N Fk 03 - N.Fk.Malheur, Beulah to Little Malheur	N Fk 04 - N.Fk.Malheur, Little Malheur to Elk Ck	N Fk 05 - Lower Crane Ck / Little Crane Ck	N Fk 06 - Crane Ck Tribs	N Fk 07 - Bear Creek / Kate Creek	N Fk 08 - N.Fk.Malheur headwaters & tribs	N Fk 09 - Little Malheur, mouth to USFS boundary	N Fk 10 - Little Malheur headwaters & tribs	S Fk 01 - S.Fk.Malheur, mouth to Crane Creek	S Fk 02 - Granite Ck / Big Granite Ck	S Fk 03 - Swamp Creek / East Swamp Creek	S Fk 04 - Coleman Creek	S Fk 05 - Crane Ck, Little Crane Ck, Alder Ck	S Fk 06 - S.Fk.Malheur headwaters & tribs
Harney County (Watershed Council?)																																	
NRCS Farm Plans	X																																
USGS daily flow data	1938; 1977-			1925-29			1933-65		1963-86	X		1922-23						1926-present		1914-present								1910-39					
USGS peak flow data		1904-28		1911-27			1933-62		1903-85									1926-present		1994-present								1909-1928					