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North Fork Sprague River Instream Flow

Introduction

In 1990 the State of Oregon began the process of adjudicating water rights within the Klamath River Basin for water users with pre-1909 claims to water. The U.S. Forest Service (USFS) manages three forests within the Klamath Basin; the Fremont, Klamath, and Winema National Forests.

The Water Resources Team, situated on the Winema National Forest, was charged with quantifying the instream flow and consumptive water uses of the Forest Service Pacific Northwest and Pacific Southwest Regions within Oregon. Part of that charge involved development of fisheries claims based on the Multiple-Use Sustained-Yield Act of 1960. Flow, channel morphology, and fisheries data were collected, compiled, and analyzed in preparation of the fisheries water rights claims. The fisheries claims took the form of monthly minimum values as determined using two methods. An incremental flow model (PHABSIM) was used to determine recommended minimum monthly fisheries streamflows. Flows necessary to maintain fisheries habitat, i.e. channel maintenance flows, are superimposed upon the PHABSIM derived values. Quantities for these higher, less frequent, channel maintaining flows were determined through analysis of bedload sediment transport relationships.

The following report is a summarization of the steps taken to determine fisheries habitat flow recommendations for the adjudication process. It has been prepared to disseminate data to resource personnel for use in forest management decisions.

Methods

The North Fork (NF) Sprague River is a 4th order river that drains 71.7 mi^2 and extends 34.2 mi from spring-fed headwaters in the Gearhart Mountain Wilderness to its confluence with the South Fork, forming the main stem Sprague River. Ownership is an alternating pattern of private and Fremont National Forest land. The river has been designated Wild and Scenic from its headwaters to the bottommost USFS boundary at rivermile (RM) 12 (42°30’ N, 121°01’ W). Sixteen of the upper 22 mi of river, which included all the USFS land and excluded all private land, was surveyed in the 1990 Hankin and Reeves USFS Stream Inventory Survey. The lower half of the river on USFS land was characterized as flowing through a narrow V-shaped canyon and having a cobble-boulder substrate, large amounts of woody debris, low sinuosity, and a gradient of 2-4%. The upper half was characterized as a meandering stream with lateral scour pools, minimal riparian cover and unstable banks due at least in part to heavy grazing, and a substrate of gravel and sand; this section of river flows through a wide meadow. There is a hydropower dam at about RM 14 which diverts a large amount of flow and releases it back to the stream about 1 mi downstream.

No known records exist for native fish populations within the NF Sprague River prior to fish stocking by Oregon Department of Fish & Wildlife (ODFW). It is speculated that fluvial bull trout once inhabited the system, as they still exist in Boulder and Dixon Creeks, both of which flow to the NF Sprague River. In 1997, ODFW personnel observed two bull trout in the NF Sprague River at Boulder Creek's confluence at about RM 15.8, and there have been other reports of bull trout in this same area in recent years (Light et al. 1996). ODFW stocking records indicate rainbow trout were stocked from 1928 to 1973 and brook trout were stocked from 1931 to 1941. Presently, brown trout, redband trout, and brook trout occur in the river. Brown trout and redband trout are distributed throughout the system, but their numbers decline toward the upper end. Brook trout dominate the upper end and are the only trout present above RM 33. For habitat modeling, all three trout were modeled at the upper site but only brown and redband trout at the lower site. Marbled sculpin are also present in the lower reaches of USFS land.

The Physical Habitat Simulation System (PHABSIM) was used to model fish habitat in the stream and to make flow recommendations. The protocol for using PHABSIM is described in detail elsewhere (Milhous et al. 1989) and only a brief overview will be made here. The purpose of PHABSIM is to simulate a relationship between streamflow and physical habitat for various species and lifestages of fish. It consists of overlaying hydraulic simulations that represent the physical properties of the stream channel with Habitat Suitability Index (HSI) curves that represent the biological adequacy of these physical properties for a particular species and lifestage. Combining the physical properties with the suitability curves produces the habitat quantity and quality available for use.

In field measurements, each transect is divided into cells in which depth and velocity are measured over a number of discharges. Cell-by-cell depths and velocities are then simulated over a range of flows using standard hydraulic modeling techniques packaged into the PHABSIM computer software [proper PHABSIM modeling and calibration is technically the most difficult step in analyzing instream flows (Milhous et al. 1989), and is too complicated to discuss here]. Substrate is measured once and assumed to not change over the study period of one field season. It is assumed that the worth of a cell for fish habitat is determined by what the suitability of the depth, velocity, and substrate (represented by HSI curves) would be at a particular discharge. HSI curve values vary from zero (unsuitable) to one (optimal) and were developed for each species and lifestage for the Upper Klamath River Basin by a regional panel of experts using published curves, existing data, and professional judgement. Each cell has an overall suitability derived from the product of the suitability for depth, velocity, and substrate. For example, a cell with a depth suitability of 1.0, velocity suitability of 0.5, and substrate suitability of 0.5 would have an overall suitability of 0.25 (i.e., 1.0 x 0.5 x 0.5 = 0.25). The PHABSIM model uses simulated depths and velocities, and recorded substrate, to determine the overall suitability for each individual cell at a given discharge.

The sum of the surface area of each cell that contains fish habitat, called Weighted Usable Area (WUA), is expressed as units of ft^2/1000 feet of stream length. We produced two quantities of habitat. "Total Weighted Usable Area" is all available habitat, regardless of the overall suitability of each individual cell. Therefore any cell with any suitability (i.e., overall suitability greater than zero) is included in the summation of usable surface area. Cells with overall suitability of 0.75 or greater is included in ">75% Weighted Usable Area". "Total WUA" is therefore defined as the total amount of habitat available for use, whether the quality is high or low, whereas ">75% WUA" is that amount of the total habitat that ranks as optimal habitat.

Discharge, water temperature, and instream flow quantification data were collected from two locations in the NF Sprague River, at about RM 12.4 near The Elbow, and at about RM 22.8 below Sandhill Crossing Campground and within the Gearhart Mountain Wilderness (Figure 1). Water temperature was measured at The Elbow (elevation 4560') from 1990-1995 and at Sandhill Crossing (elevation 6045') from 1992-1997. Discharge was continuously recorded at Sandhill Crossing and a hydrograph (Figure 2) was developed for water years 1993-1995 and 3-year monthly median discharge values were calculated. Using a regional predictive model developed by P. Bakke of the Winema National Forest's Water Resources Team (unpublished data), these 3-year monthly medians were used to predict long-term (30-year) monthly medians for NF Sprague River at Sandhill Crossing. Discharge at The Elbow was measured periodically from 1993-1995 and was compared to discharge simultaneously recorded at Sandhill Crossing. The relationship between the two discharges was used to transform long-term median monthly discharge from Sandhill Crossing into long-term values for The Elbow. The long-term monthly values provided a starting point from which to recommend monthly values for fish habitat at each location. Based on the amount of discharge present for a particular month, we analyzed how much total and optimal habitat would be available for all lifestages present during that month, and adjusted our flow recommendations to maximize fish habitat. We rarely recommended a minimum flow of more water than is available, according to the long-term monthly prediction. Other anecdotal data (e.g., water temperature, upstream diversions) were also considered when selecting a monthly discharge value. Habitat requirements of threatened/endangered and sensitive fish species that currently exist in the stream were given priority over other species.

Sediment movement data were collected, analyzed, and used to determine a habitat maintenance (channel maintenance) discharge. Flows above the habitat maintenance discharge were determined to be those necessary to maintain a functioning stream channel and thereby maintain the fish habitat. For more information on channel maintenance results, see the corresponding channel maintenance folder for this stream. In instances where the PHABSIM-determined fish habitat discharge value exceeded the fish habitat maintenance discharge value, the habitat maintenance value was used as the monthly recommendation. For example, if 20.0 cfs was determined to provide adequate fish habitat for a given month, and flows of 30.0 cfs and greater were determined to be the flows needed for habitat maintenance, then 20.0 cfs would be the minimum fish flow recommendation. All natural flows between 0 and 20.0 cfs would be defined as necessary for fish habitat. When natural flows exceeded 30 cfs, all water would be defined as necessary for maintaining fish habitat. If the fish habitat maintenance value had been 15 cfs, then 15 cfs would be selected as the final flow recommendation value for that month.

Results/Discussion

Temperatures were warmer at the upstream location than the downstream site (Tables 1 and 2, Figures 3 through 13), due to input from cold tributaries and because of the warming of water as it flows through Lee Thomas Meadow upstream of Sandhill Crossing. At Sandhill Crossing, temperatures dropped to zero during the winter, and exceeded 20°C every summer from 1992-1996 (Table 2, Figures 5, 7, 9, and 11 through 13). At The Elbow, summer temperatures only exceeded 20°C during 1990, and typically ranged from 10-15°C (Table 1, Figures 2 through 4, 6, 8, and 10). Water temperatures at The Elbow in general did not exceed the standard of 17.8°C set for trout by the Oregon Department of Environmental Quality (Boyd and Sturdevant 1996). Temperatures at Sandhill Crossing during the summer were typically above the standard.

Four cross sections, 3 riffles and 1 pool, were established in 1992 at The Elbow and at Sandhill Crossing to represent the fish habitat in each stream reach (Figure 1). Water surface elevations and cell velocities were collected on three occasions at discharges of 46.0, 59.1, and 95.5 cfs at The Elbow (Figures 15 through 18) and at 11.2, 25.1, and 72.7 cfs at Sandhill Crossing (Figures 19 through 22), and were used for PHABSIM model calibration and simulations. The riffle cross sections at The Elbow were shallow (< 2 ft deep at all calibration discharges) and swift, with velocities exceeding 6 ft/s at the highest calibration discharge of 95.5 cfs (Figures 16 through 18). The pool cross section was deeper (over 3 ft deep) but velocities were not reduced (Figure 15). The substrate for all cross sections consisted mainly of boulders. The relationship between cross sections was similar at Sandhill Crossing, where the pool cross section was deeper than the riffle cross sections, but velocities were not slower, and substrate at all cross section was mainly boulders. Generally, the HSI spawning/incubation curves were identical between brown, brook, and redband trout; velocities between 1 and 3 ft/s, depths between 0.5 and 2.0 ft, and substrate of small or large gravel were all considered optimal (Figures 23 through 25). Any substrate was considered optimal for fry, juvenile, and adult lifestages (Figures 23 through 25). Suitable depths and velocities between fry, juvenile, and adult lifestages varied between species, but, in general, velocities less than 2 ft/s, and depths between 0.5 and 2.0 for brook trout and for brown and redband fry and over 1 ft for brown and redband trout juveniles and adults (Figures 23 through 25).

Redband trout, a USFS sensitive species, took precedence over brook trout and brown trout in our flow recommendations. Redband trout are spring spawners, whereas brown and brook trout spawn in the fall but incubation continues until the following spring (Table 3). Fry occur over nearly the same time period for all species, and juvenile and adult lifestages are present all year (Table 3).

Total and optimal fish habitat was simulated for redband and brown trout from 20 to 300 cfs at The Elbow and for redband, brown, and brook trout from 1 to 160 cfs at Sandhill Crossing (Figures 26 through 29). Discharge in the NF Sprague River at Sandhill Crossing during water years 1993-1995 ranged from a high of 360 cfs during spring 1993 to a baseflow of about 10 cfs, though 1994 was a particularly dry year and discharge never exceeded 80 cfs (Figure 2). Long-term monthly median discharges at Sandhill Crossing ranged from about 11 cfs during the latesummer early-fall months to about 160 cfs during runoff in May. Instantaneous discharges at The Elbow were strongly linearly related to those recorded simultaneously at Sandhill Crossing, with $r^2 = 0.98$ (Figure 30). Based on this relationship and on the long-term values at Sandhill Crossing, the long-term monthly median discharge values were calculated to be about 44 cfs during baseflow months and around 290 cfs in May (Table 4).

PHABSIM modeling at The Elbow indicated that total and optimal fry habitat increased as flows receded from 200 to 20 cfs but spawning habitat was reduced over the same range (Figures 26 and 27). Furthermore, spawning habitat at The Elbow had by far the most limited habitat amount of any lifestage for redband and brown trout (Figures 26 and 27). Amounts of habitat for juveniles and adults for brown and redband trout changes little over the range of discharge for which habitat was simulated. Similarly, spawning habitat was limited at Sandhill Crossing and the amount of spawning habitat was reduced as discharge decreases, but the amount of habitat for other lifestages remained relatively unchanged or increased slightly as discharge decreased (Figures 26 and 27). Month by month justification for final fish values for The Elbow and Sandhill Crossing appears in Tables 5 and 6.

References

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