12-4-2009

Ex. 280-US-472

Unknown

South 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 South Fork (SF) Sprague River is a 4th order stream that flows southwest approximately 32 mi from headwaters in the Gearhart Mountain Wilderness to its confluence with the North Fork Sprague River where the main stem Sprague River begins. At the Brownsworth Creek confluence, rivermile (RM) 15.2, SF Sprague River has a watershed area of 62 mi^2. Fifteen miles of stream on Fremont National Forest land were surveyed in 1990 using Hankin and Reeves Level II Stream Survey protocol. The Sprague River Park Recreation Area (42^{o}22’N,120^{o}58’W) is the most downstream boundary (RM 11) of National Forest land on the SF Sprague River system. Below National Forest land, the SF Sprague River and its tributaries, Fishhole Creek and Deming Creek, have been diked and diverted for pasture irrigation. Land ownership above the Sprague River Park Recreation Area is a mixture of USFS, U.S. Timberlands, and private ranches. The stream survey reports that the SF Sprague River within National Forest is dominated by riffle habitat, flowing through a steep, narrow canyon. Substrate is dominated by cobble and small boulders. Although spawning substrate was not measured in the survey, it is available and not thought to be limiting. Riparian vegetation is alder and grasses in the lower reaches, gradually changing to alder and conifer in the uppermost reaches. Large size classes of large woody debris is limited throughout the reaches surveyed, as well as the presence of deep pool habitat. No known records of historic fish populations exist prior to fish stocking influences, however, fluvial populations of bull trout likely occurred as three tributaries to the SF Sprague River (Brownsworth, Deming, and Leonard Creeks) contain resident populations. Migratory populations of redband trout, shortnose sucker, and Lost River sucker may have also occurred. Oregon Department of Fish and Wildlife (ODFW) stocking records indicate hatchery rainbow were introduced from 1928 to 1975 and brook trout were introduced from 1931 to 1945. Sampling to determine fish species composition in 1990-1991 documented brown trout, brook trout, redband trout and lamprey in the SF Sprague River.

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.

Continuous water temperature was collected with a datalogger at river elevation 4540' (RM 15.4) from 1992-to present. The datalogger also recorded continuous water elevation in the creek, from which a hydrograph was developed for water years 1993-1995 (Figure 1) 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 SF Sprague River, providing a starting point from which to recommend monthly values for fish habitat. 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 recommendation 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

Average water temperatures ranged from 1-2^{o}C during the winter months to monthly average highs of 15-19^{o}C (Table 1, Figures 2 through 8). Maximum summer water temperatures exceeded the standards set by the Oregon Department of Environmental Quality (DEQ) for trout of 17.8^{o}C (Boyd and Sturdevant 1996) for at least 4 months every year that data was collected (Tables 1, Figures 2 through 8).

A single pool transect was established by USFS personnel in 1992, upstream of three run transects that had been established in 1990 (Figure 9) by EA Engineering, Science and Technology of Redmond, Washington, under contract to the Bureau of Indian Affairs (BIA). These transects were established to represent habitat in the stream reach. Water surface elevations were measured at the run transects at discharges of 7.4, 27.7, and 186.2 cfs (Figure

10), with velocities measured once at 27.7 cfs. Water surface elevations and velocities were measured at the pool transect at discharges of 11.6, 26.2, and 79.7 cfs (Figure 11). The depth and velocity data from all four transects were combined and used for PHABSIM model calibration and simulations. The run cross sections were shallow and substrate was dominated by cobble and small boulders. Velocities approached 4 ft/s in all three run transects at the calibration discharge of 27.7 cfs (Figure 10). The pool transect was deeper, with depths exceeding 2 ft at 26.2 cfs, compared with 1 to 1.5 ft at the run transects at 27.7 cfs (Figures 10 and 11). Velocities at the pool were slower, remaining below 2.5 ft/s at the comparison discharge, but approached 5 ft/s at the highest calibration discharge of 79.7 cfs. Substrate in the pool was similar to that found in the runs. Generally, the HSI curves ranked velocities of 0.5 to 3 ft/s as suitable for all redband and brook trout lifestages other than fry, and for brown trout spawning/incubation (Figures 12 through 14). Trout fry prefer velocities of less than 1 ft/s, as do brown trout adult and juvenile lifestages (Figures 12 through 14). The suitability of depth varied between species and lifestages, and any substrate was considered suitable for all lifestages except spawning, which generally required small to large gravel to provide suitable habitat (Figures 12 through 14), although redband trout and brown trout will also make use of sand and cobble for spawning.

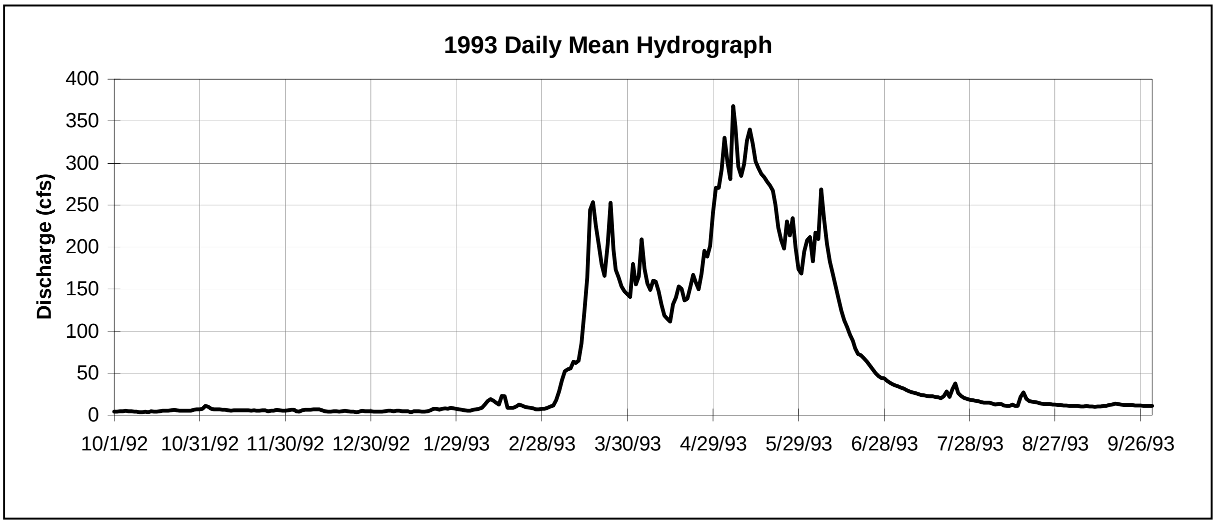
Although bull trout likely occurred in the main stem of the SF Sprague River historically, today they are limited to the headwaters of a few tributaries and were not considered in our analysis. Other fish historically present in the Sprague River drainage may have included shortnose sucker and Lost River sucker, but neither currently exist in the SF Sprague River, and were also not considered in our analysis. Redband trout, a USFS sensitive species and native to SF Sprague River, took precedence over brook trout and brown trout in our flow recommendations. Based on sampling results, brown trout are distributed throughout the system; redband trout are distributed throughout all but the upper few miles of the system; and brook trout appear to be present only in the uppermost reaches. Redband trout spawning period (including incubation) occurs from March to July, whereas brook trout and brown trout spawn in the fall but egg incubation continues until the following spring (Table 2). The period of time that fry occur is similar between species, and juvenile and adult lifestages are present all year for all three species (Table 2).

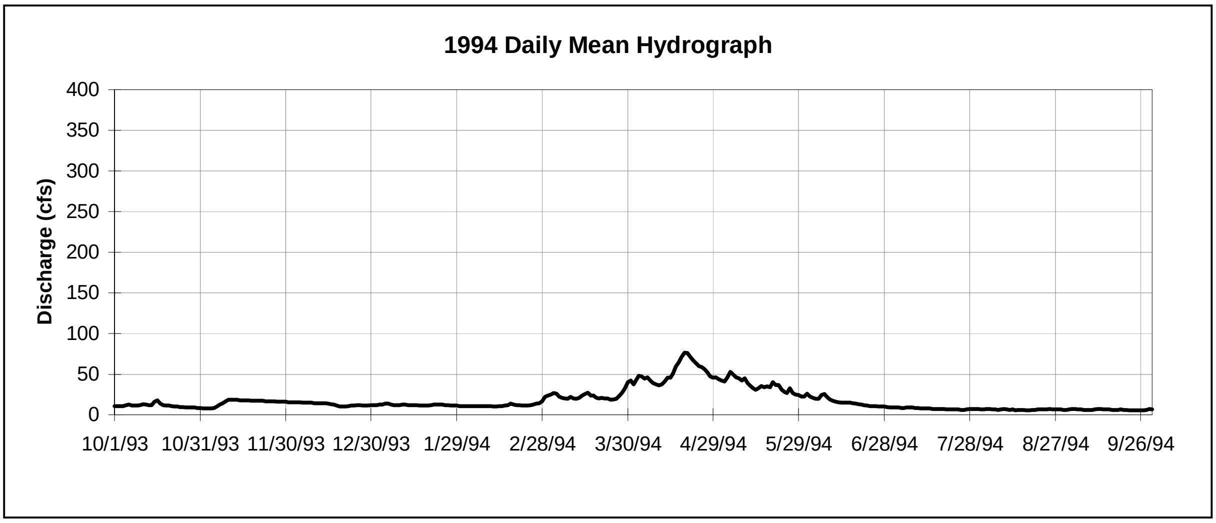
Total and optimal fish habitat was simulated for brook trout, brown trout, and redband trout from 3 to 70 cfs (Figure 15 and 16). The range of simulations was limited to discharges below 70 cfs since the run transect velocities were measured at 27.7 cfs, and upward extrapolation is considered valid up to 2.5 times the calibration flow (Milhous et al. 1989). However, the highest measured flow during this study was 321 cfs in May 1995. Discharge in SF Sprague River generally ranges from a summer baseflow of 10-15 cfs to highs of 300-350 cfs during peak spring runoff, though water year 1994 was a particularly dry year and discharge never exceeded 80 cfs (Figure 1). Long-term median monthly discharges ranged from lows near 10 cfs during the summer to a high of 193 cfs in May (Table 3). Based on PHABSIM modeling, moderate amounts of total habitat exist for all species at flows above about 20 cfs, although available total habitat for spawning is reduced (Figure 15). Redband trout have moderate amounts of available quality habitat for juvenile and adult lifestages, however, quality habitat for redband fry and spawning/incubation is limited (Figure 16). Brown trout and brook trout are both limited in the amount of quality habitat at all flows (Figure 16). Thus, for all months with median discharges of less than 20 cfs, we recommended the monthly median value to provide habitat (Table 3). The exception to this is during summer months, when maximum water temperatures exceeded DEQ standards for trout every year that data was collected. For these months, we selected a flow that was exceeded 20% of the time as our flow recommendation. Month by month justification for final fish values appear in Table 3.

References

Boyd, M., and D. Sturdevant. 1996. The scientific basis for Oregon's stream temperature standard: common questions and straight answers. Oregon Department of Environmental Quality Report.

Milhous, R. T., M. A. Updike, and D. M. Schneider. 1989. Physical habitat simulation system reference manual - version II. Instream Flow Information Paper 26. U.S. Fish & Wildlife Service, Biol. Rep. 89(16).





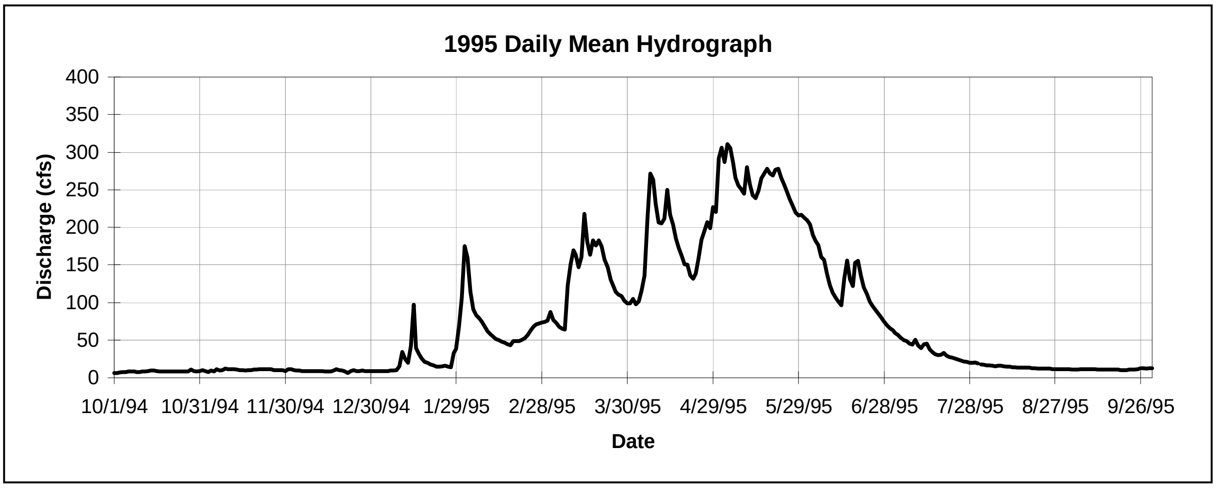


Figure 1. Daily mean discharge for water years 1993-1995 at South Fork Sprague River.

Table 1. Monthly maximum and mean temperature values at the South Fork Sprague River above Brownsworth Creek's confluence.

	Maximum temperature (℃)					
Month	1992	1993	1994	1995	1996	1997
Jan		4.2	3.9	5.6	6.2	4.8
Feb		5.2	6.3	7.0	7.5	4.9
Mar		8.8	11.2	8.5	10.4	8.5
Apr		11.3	13.9	11.8	12.8	11.7
May		14.5	21.0	14.7	13.5	18.3
Jun		20.4	24.5	19.3	19.1	21.4
Jul		21.6	26.7	22.9	22.4	24.0
Aug		23.6		23.6	22.0	23.7
Sep		20.3	19.5	19.3	17.5	19.0
Oct	11.4	14.3	14.4	12.8	14.7	12.9
Nov	8.9	6.8	5.8	9.9	7.1	7.9
Dec	5.0	5.2	2.4	8.2	4.4	4.2

	Average temperature (℃)					
Month	1992	1993	1994	1995	1996	1997
Jan		1.9	1.3	1.5	3.5	1.4
Feb		1.4	1.7	2.7	4.5	2.0
Mar		3.6	4.3	3.3	6.4	4.0
Apr		5.2	6.9	5.0	7.7	5.2
May		8.3	11.5	7.4	9.1	10.2
Jun		11.7	15.5	10.6	12.8	13.6
Jul		15.0	19.3	16.0	17.3	17.2
Aug		15.5		15.8	15.6	16.4
Sep		12.7	12.9	13.4	11.7	12.6
Oct	7.6	8.6	6.7	7.5	7.7	7.2
Nov	3.9	1.9	1.2	5.7	4.2	4.7
Dec	1.9	1.4	0.7	4.2	1.9	1.1

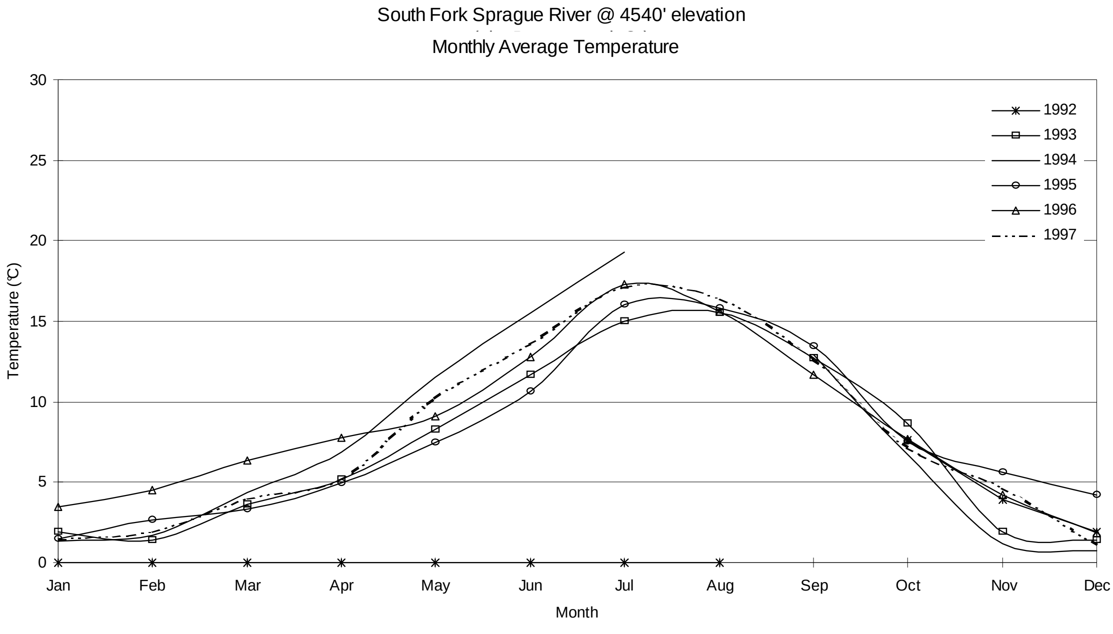


Figure 2. Monthly average temperature at South Fork Sprague River above Brownsworth Creek's confluence.

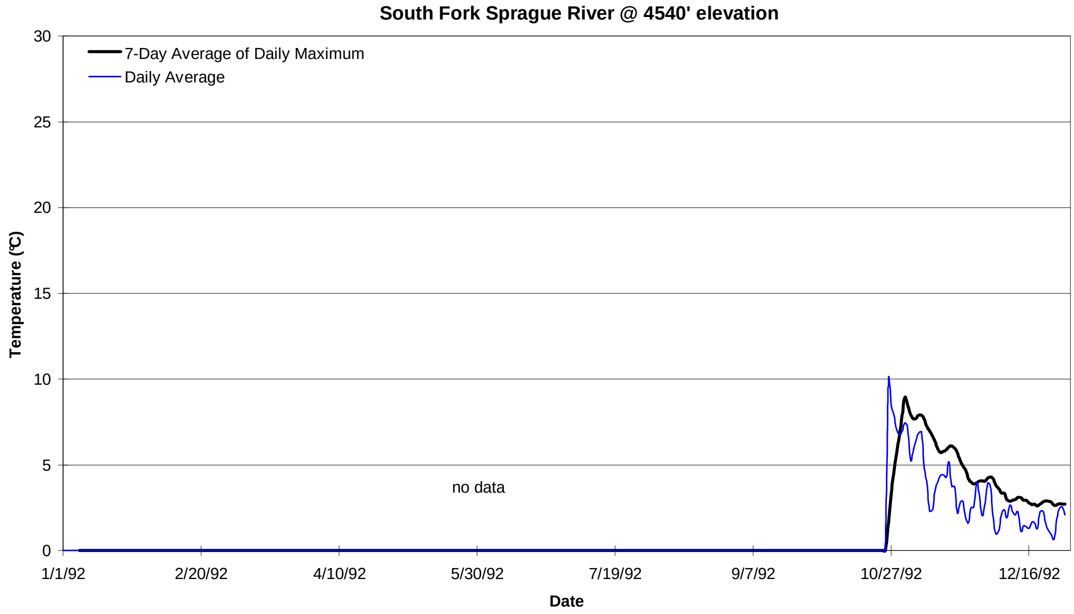


Figure 3. Daily average and 7-day average of the daily maximum temperatures at South Fork Sprague River in 1992.

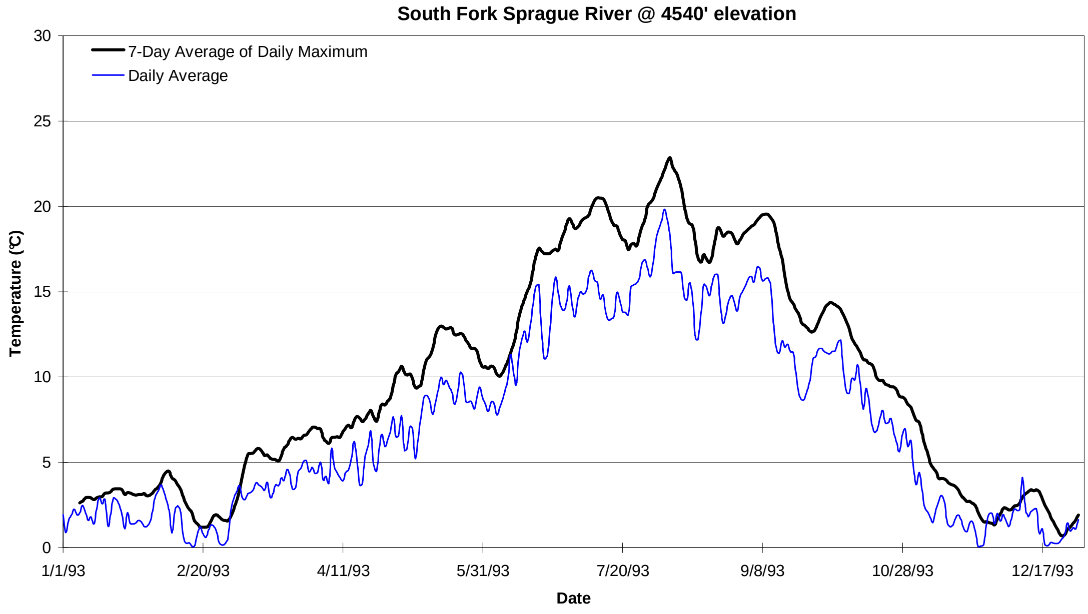


Figure 4. Daily average and 7-day average of the daily maximum temperatures at South Fork Sprague River in 1993.

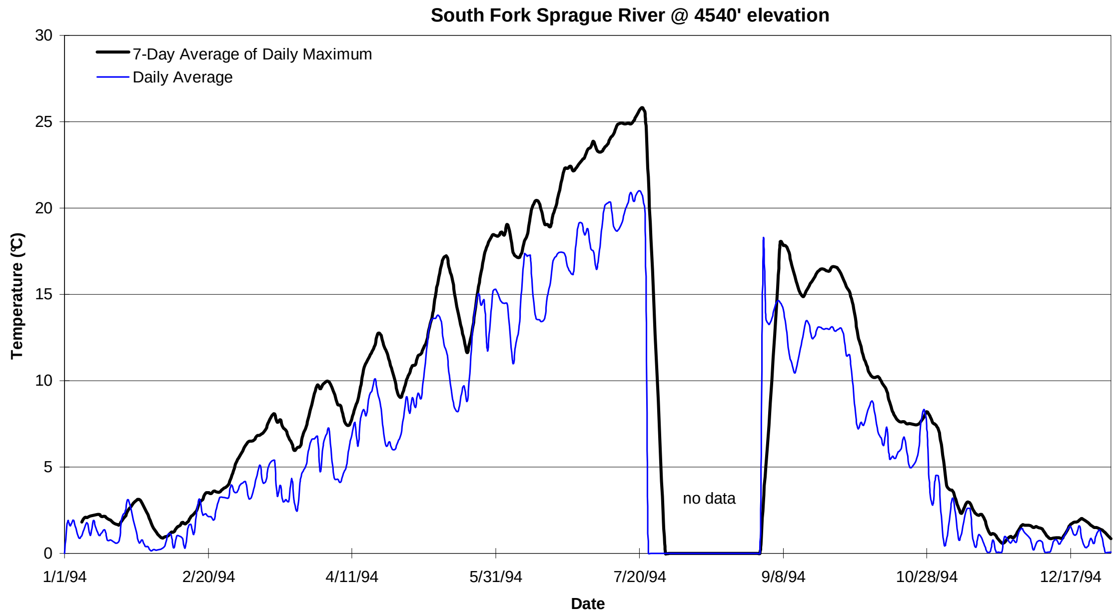


Figure 5. Daily average and 7-day average of the daily maximum temperatures at South Fork Sprague River in 1994.

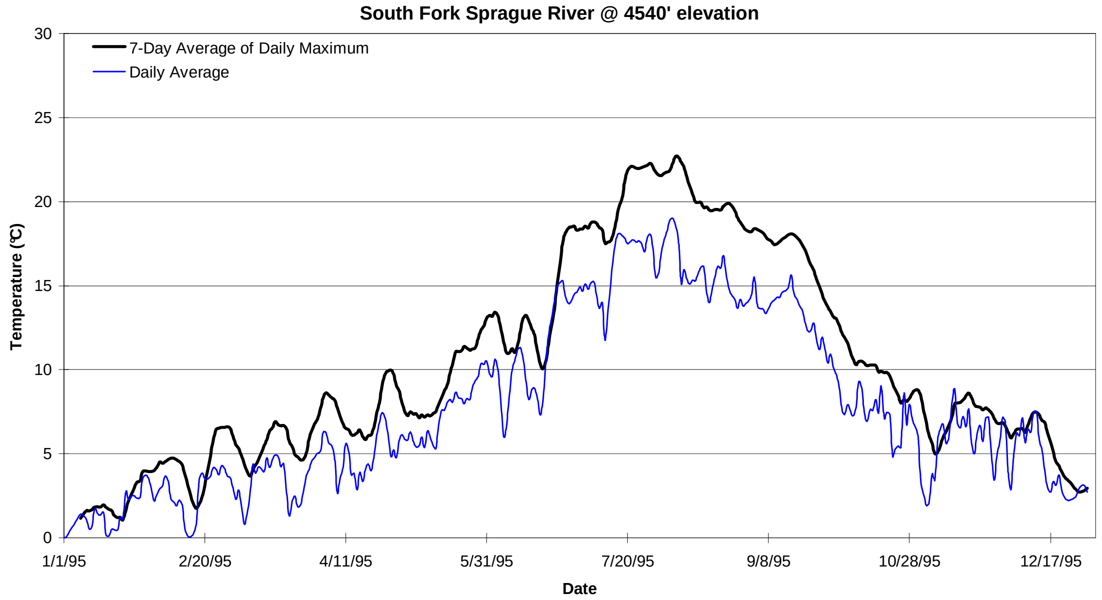


Figure 6. Daily average and 7-day average of the daily maximum temperatures at South Fork Sprague River in 1995.

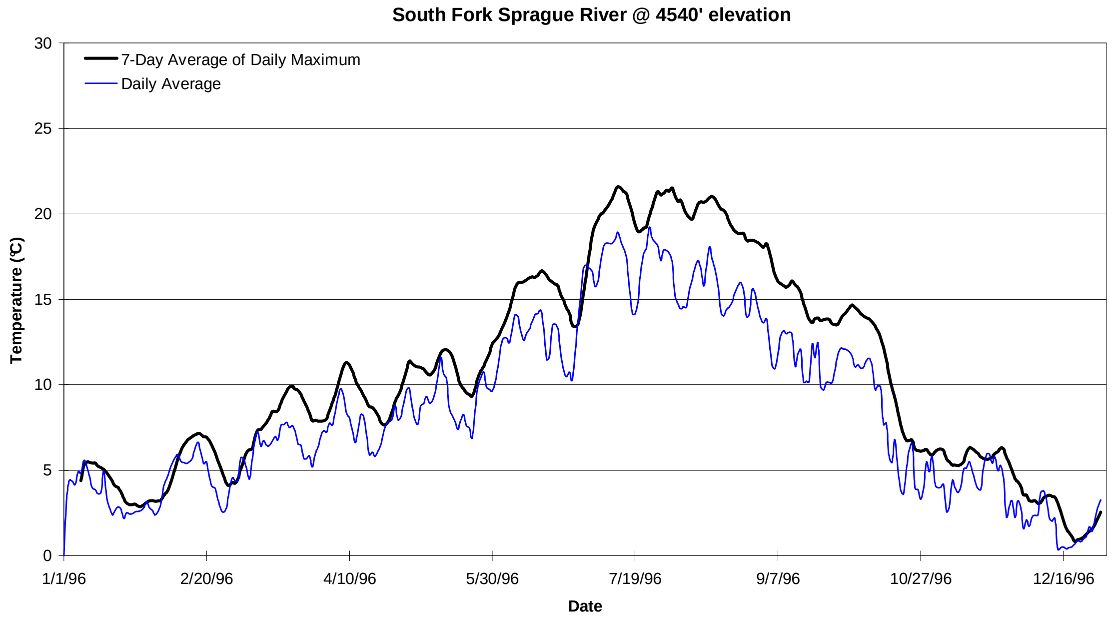


Figure 7. Daily average and 7-day average of the daily maximum temperatures at South Fork Sprague River in 1996.

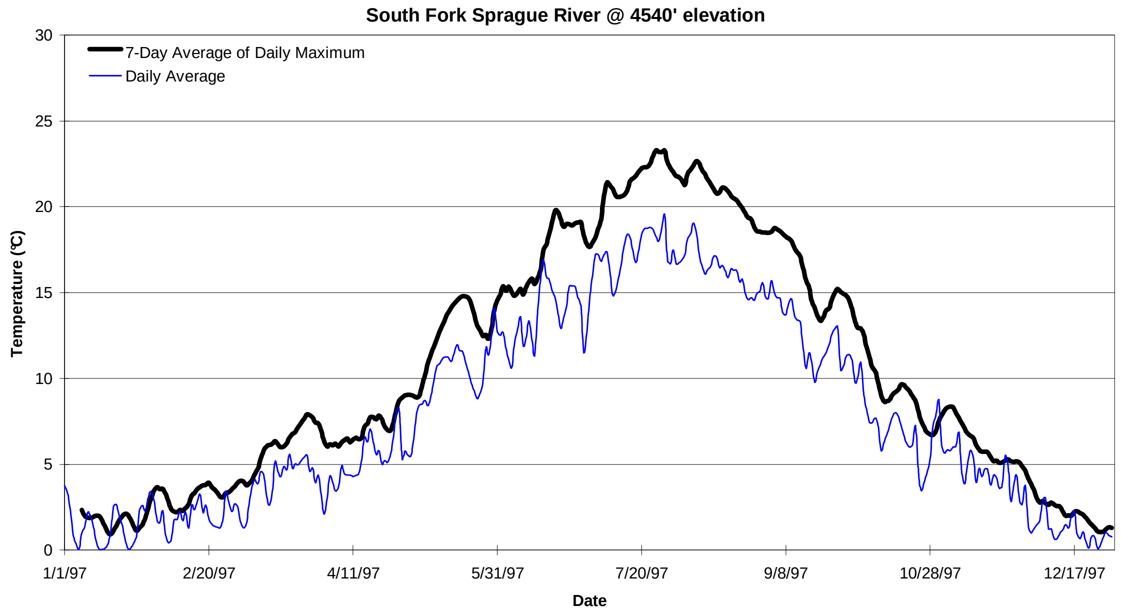


Figure 8. Daily average and 7-day average of the daily maximum temperatures at South Fork Sprague River in 1997.

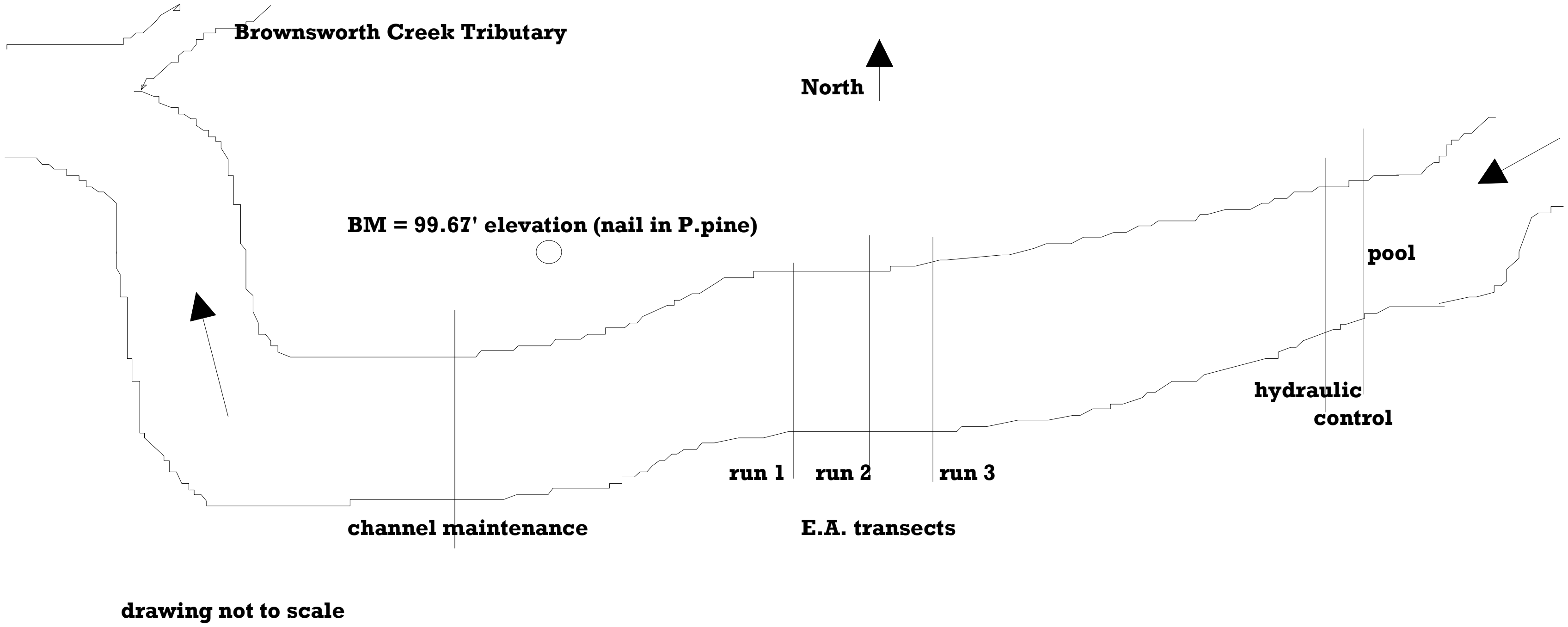
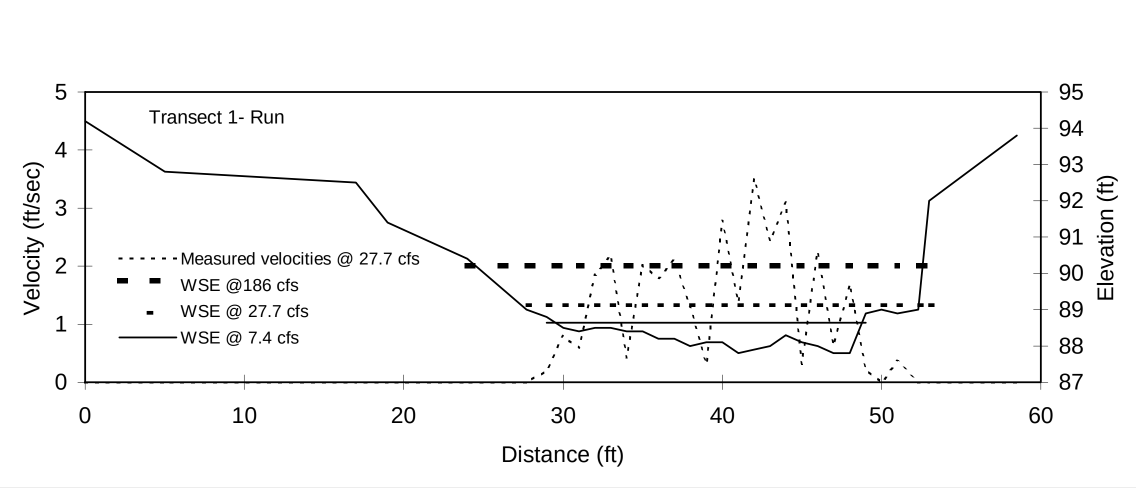
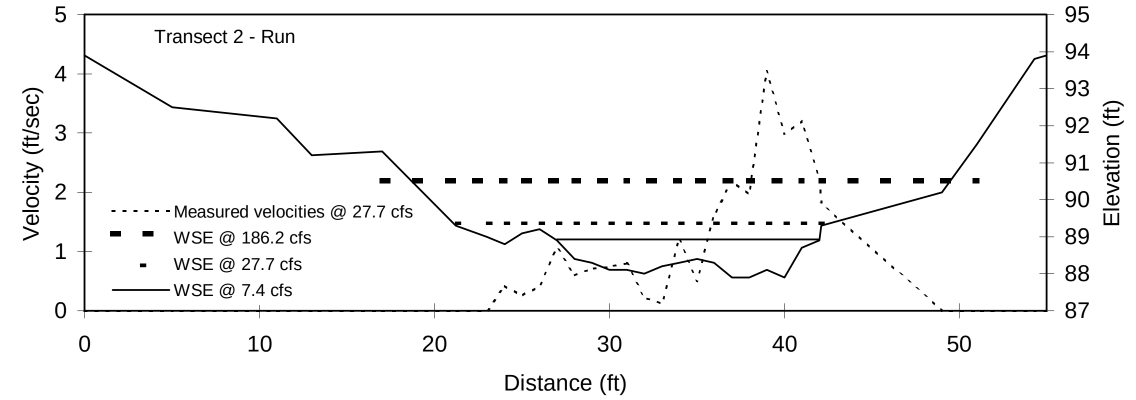


Figure 9. Map of South Fork Sprague River above Brownsworth Creek study site showing the PHABSIM transect layout.





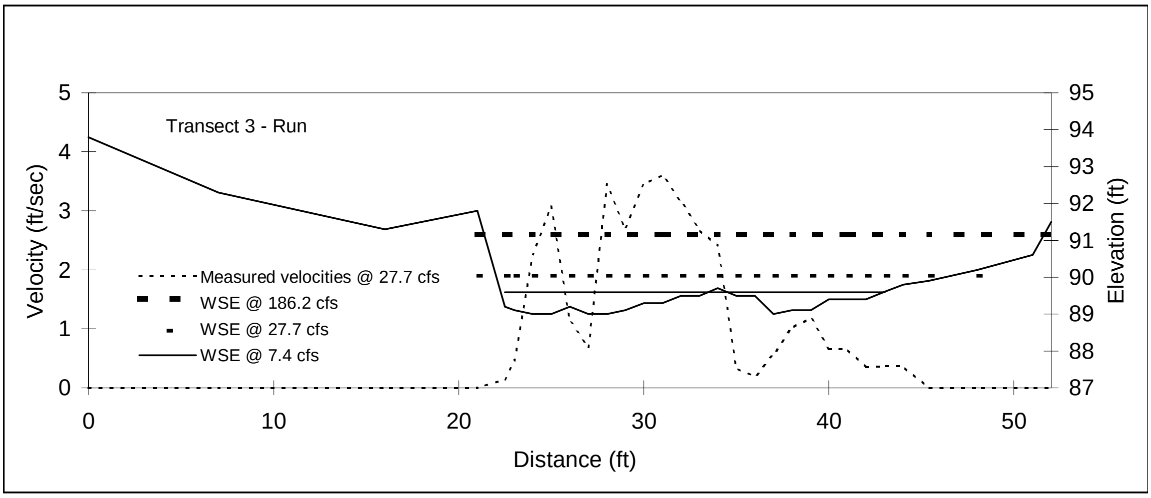


Figure 10. Water Surface Elevation (WSE) and velocities at the run transects established by EA Engineering at South Fork Sprague River. Depths were measured at 7.4, 27.7, and 186.2 cfs; velocities were measured at 27.7 cfs.

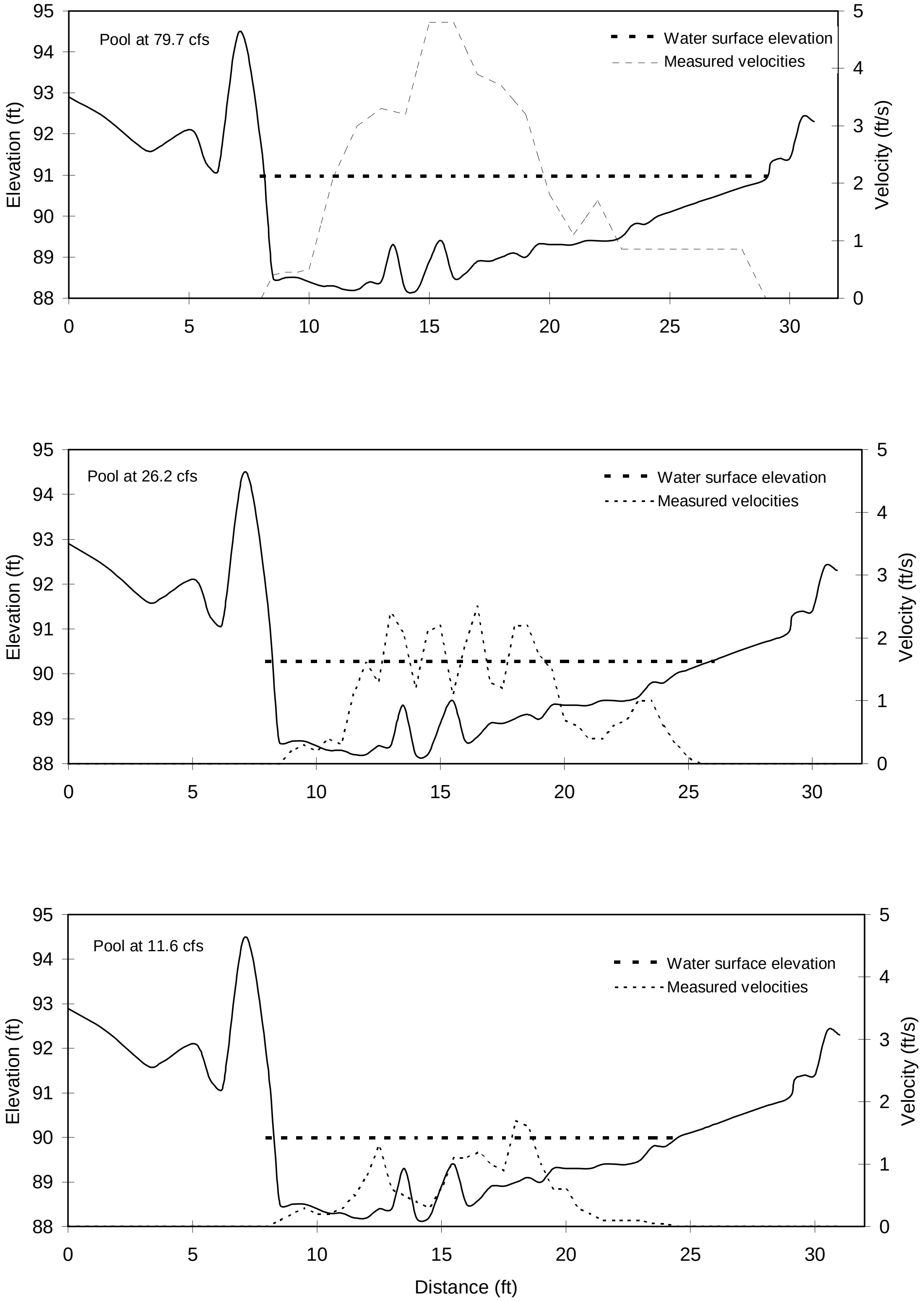


Figure 11. Pool depth and velocities at calibration discharges of 11.6, 26.2, 79.7 cfs at South Fork Sprague River.

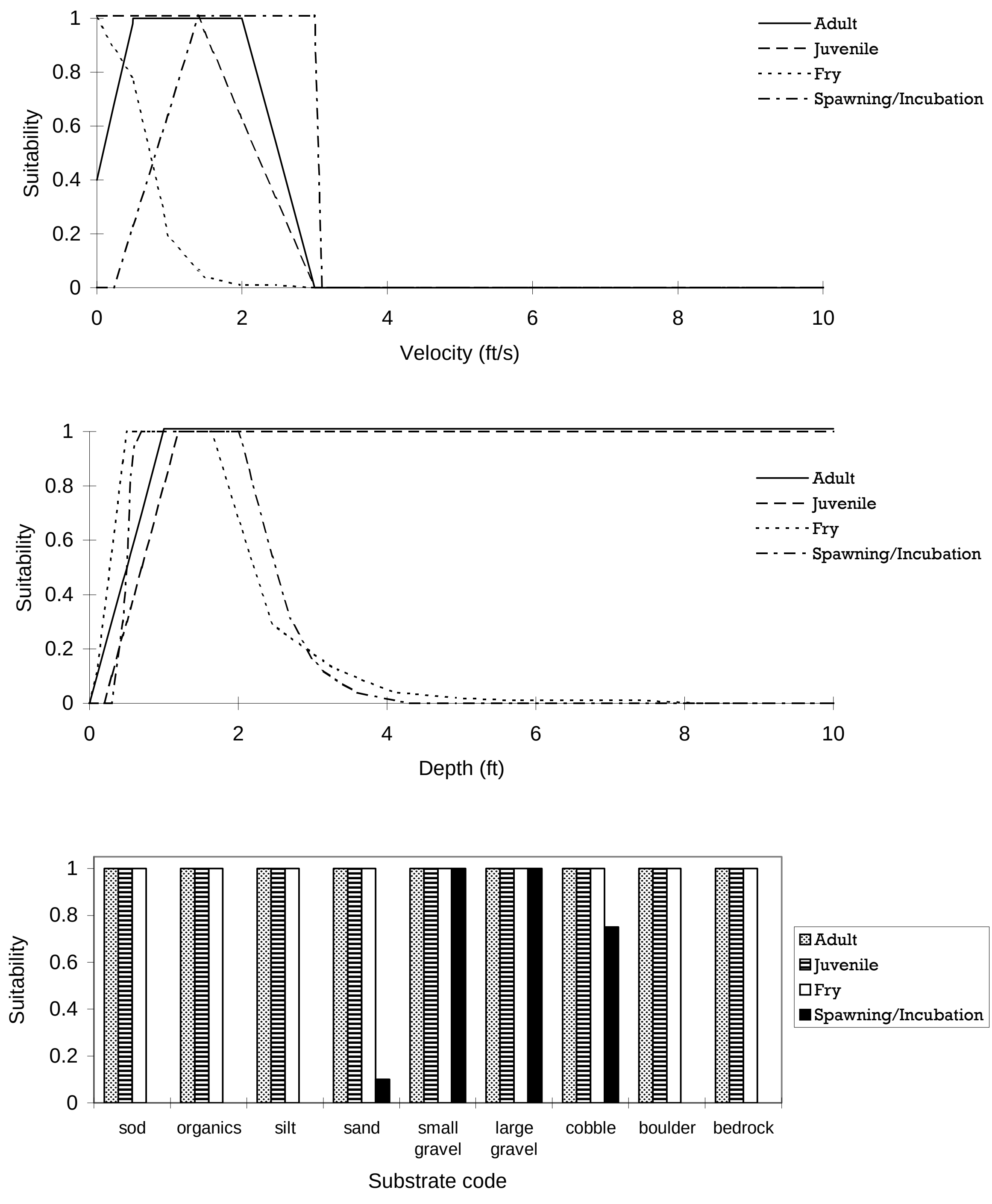


Figure 12. Habitat suitability Index (HSI) curves used for redband trout.

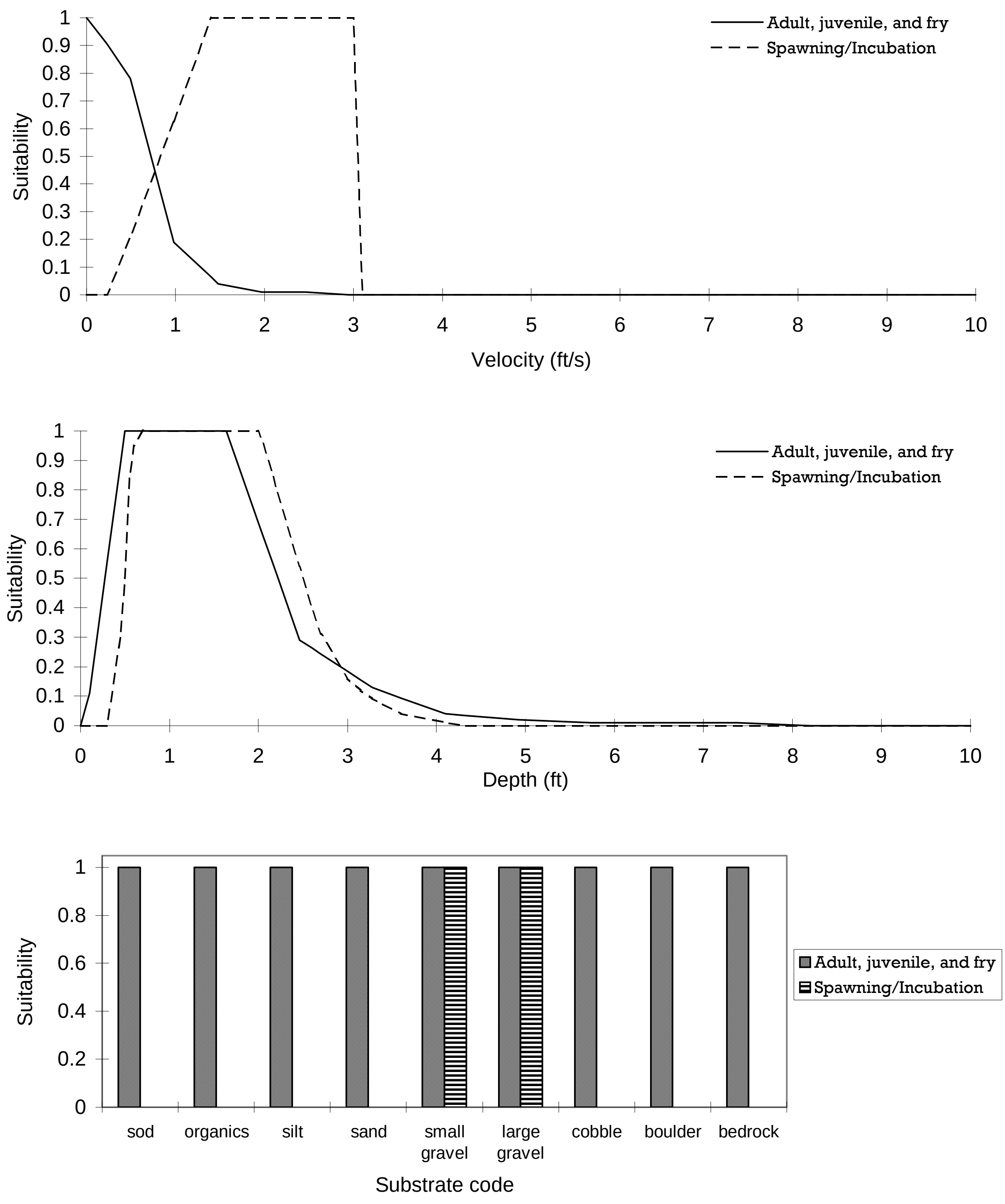


Figure 13. Habitat Suitability Index (HSI) curves used for brook trout.

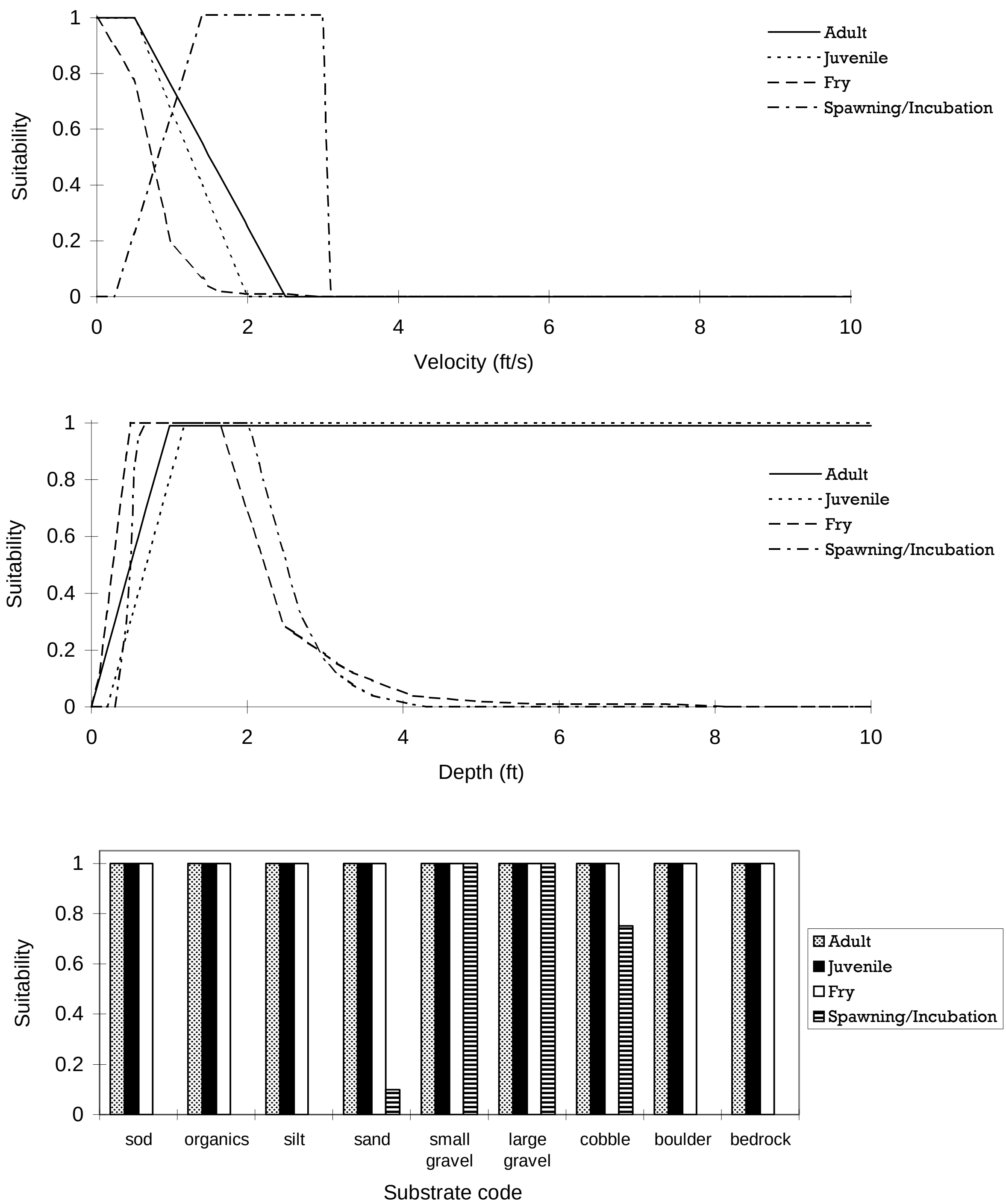
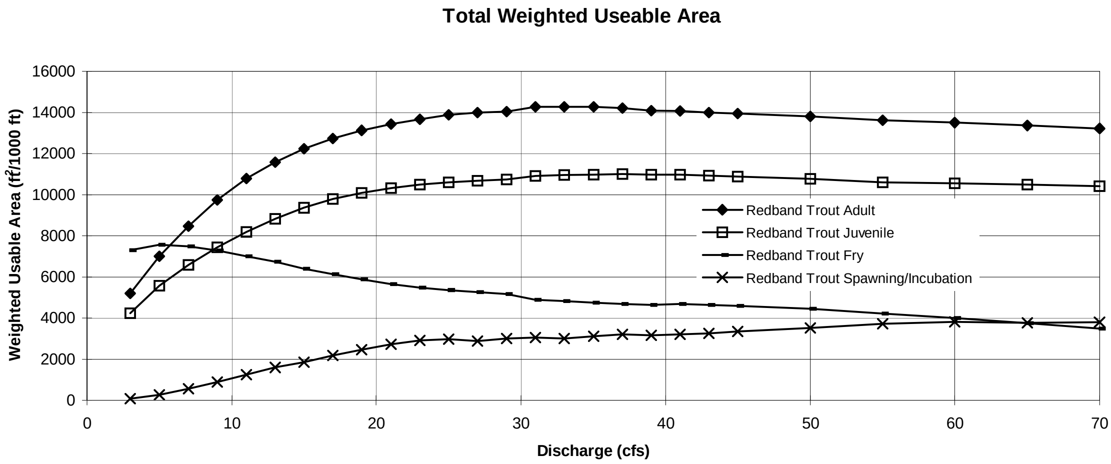
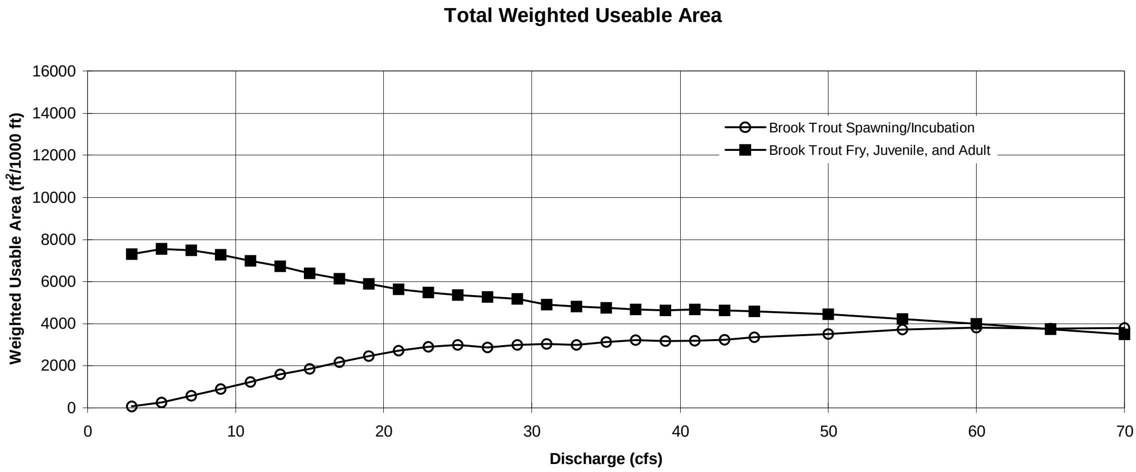


Figure 14. Habitat Suitability Index (HSI) curves used for brown trout.

Table 2. Periodicity chart for brook trout, brown trout, and redband trout in South Fork Sprague River.

Species / Lifestage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Redband Trout Adult	X	X	X	X	X	X	X	X	X	X	X	X
Redband Trout Juvenile	X	X	X	X	X	X	X	X	X	X	X	X
Redband Trout Fry				X	X	X	X	X	X			
Redband Trout Spawning/Incubation			X	X	X	X	X					
Brown Trout Adult	X	X	X	X	X	X	X	X	X	X	X	X
Brown Trout Juvenile	X	X	X	X	X	X	X	X	X	X	X	X
Brown Trout Fry			X	X	X	X						
Brown Trout Spawning/Incubation	X	X	X	X						X	X	X
Brook Trout Spawning/Incubation	X	X	X	X					X	X	X	X
Brook Trout Fry			X	X	X	X						
Brook Trout Juvenile	X	X	X	X	X	X	X	X	X	X	X	X
Brook Trout Adult	X	X	X	X	X	X	X	X	X	X	X	X





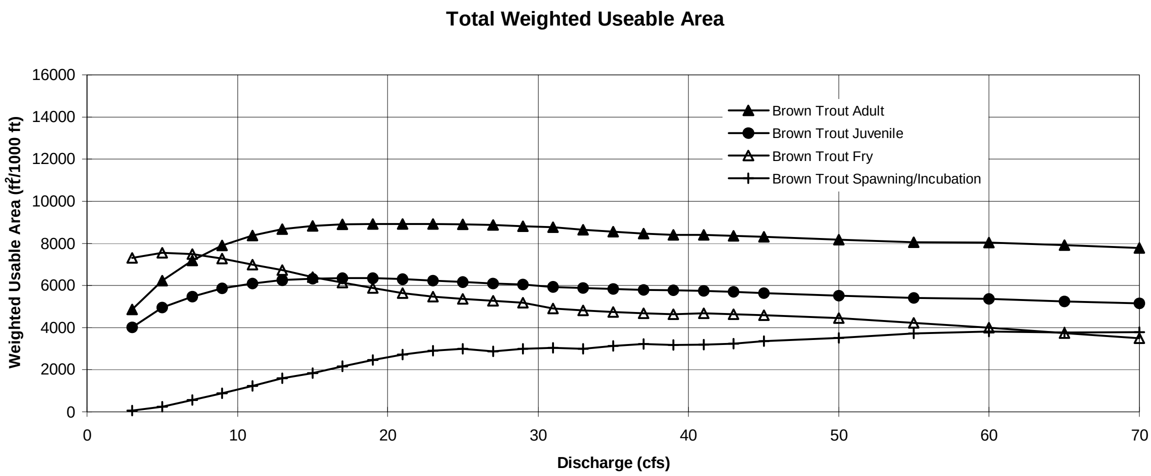


Figure 15. Total weighted useable area vs. discharge for brook trout, brown trout, and redband trout in South Fork Sprague River.

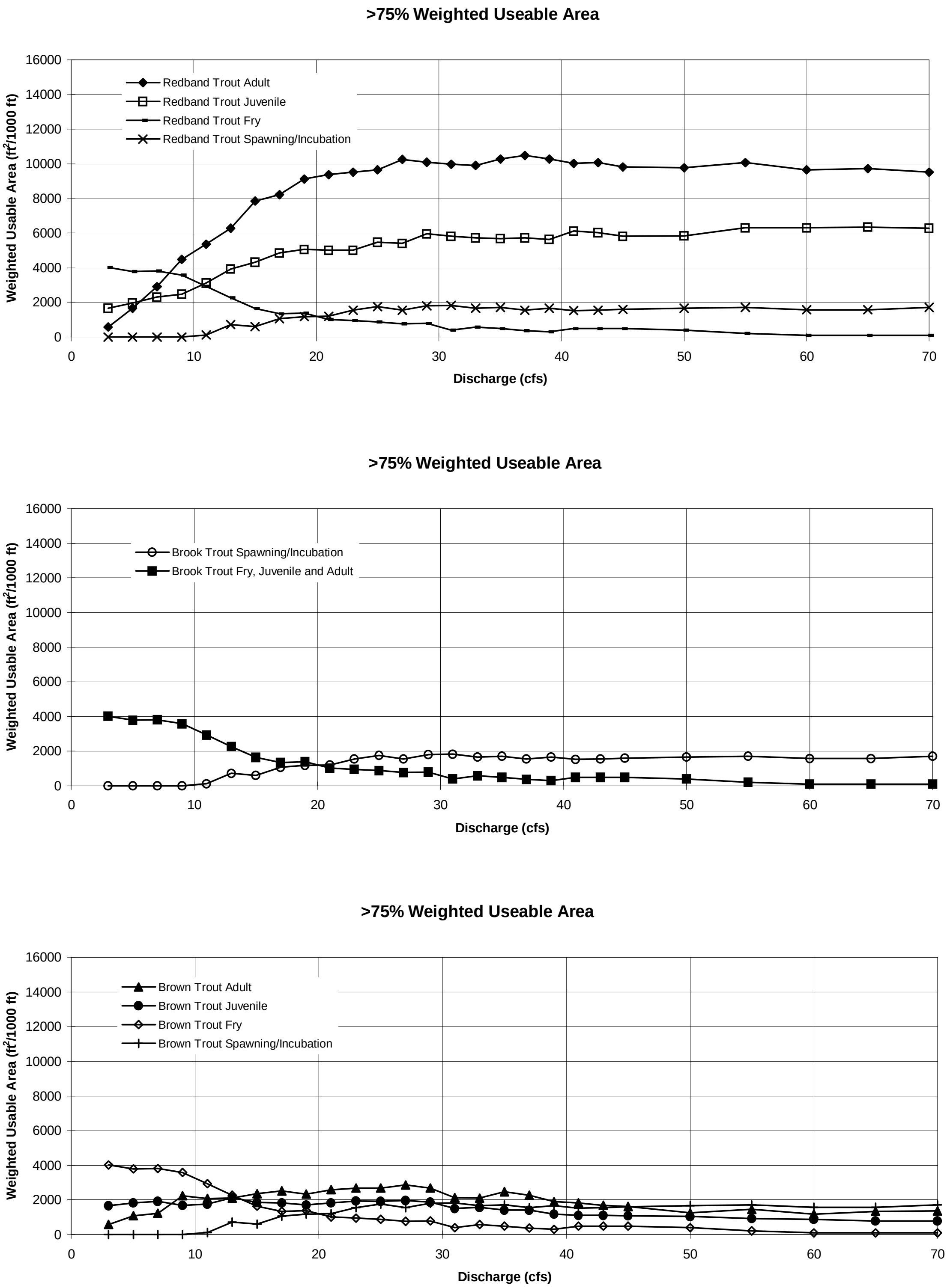


Figure 16. Optimal weighted useable area vs. discharge for brook trout, brown trout, and redband trout in South Fork Sprague River.

Table 3. Summary of rationale for final fish flow recommendations at South Fork Sprague River.

Stream: South Fork Sprague River above Brownsworth Creek confluence | Species present: Redband trout, brown trout, brook trout

Selection crew: K. Meyer, D. Ford, T. Smith

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Long Term Median Discharge	16.8	20.6	74.4	130.8	192.6	63.5	15.8	10.3	10.5	13.6	15.5	13.4
Fish Habitat Recommendation	16.8	20.6	29	29	29	63.5	24	14	10.5	13.6	15.5	13.4
Fish Habitat Maintenance Recommendation	134	134	134	134	134	134	134	134	134	134	134	134
Final Fish Recommendation	17	21	29	29	29	64	24	14	11	14	16	13

Comments:	The highest simulated flow is at 70 cfs so that we could combine USFS and EA transect data. EA measured velocities are at 27.7 cfs and should only be extrapolated up to about 70 cfs.
Jan	Redband adult and juvenile WUA curves decline to below 80% of maximum available habitat below 18 cfs; recommend median monthly.
Feb	Availability of quality habitat increases, but same defense as January, and brook and brown incubation would be reduced at lower flow; recommend monthly median.
Mar	Keeps adult and juvenile redband above 80% of maximum available quality habitat, flows above 29 cfs does not gain habitat for brook trout, which is the only spp. not above 80% of maximum available quality habitat. 29 cfs is apex of redband curves and maintains quality habitat for brown trout; recommend 29 cfs.
Apr	Same as March; recommend 29 cfs.
May	Same as April; recommend 29 cfs.
Jun	Same as April, except temperatures become problematic, reaching 25°C and would probably increase with lower flows (temperature is >20°C even when Q is >120 cfs in 1993); recommend median monthly.
Jul	Water temperatures are high, need flow to improve amount of total and quality habitat; recommend 24 cfs. This flow is estimated to occur 20% of the time during this month.
Aug	Water temperatures are high, need flow to improve amount of total and quality habitat; recommend 14 cfs. This flow is estimated to occur 20% of the time during this month.
Sep	Total and quality habitat declining for all lifestages except fry, water temperatures are not problematic; recommend median monthly.
Oct	Total and quality habitat declining for all lifestages, water temperatures are not problematic; recommend median monthly.
Nov	Availability of habitat declines at flows below median monthly; recommend median monthly.
Dec	Availability of habitat declines at flows below median monthly; recommend median monthly.