IDAHO
DEPARTMENT OF FISH & GAME

Robert L. Salter, Acting Director

INSTREAM FLOW METHODOLOGY EVALUATION, BIOLOGICAL CRITERIA DETERMINATION, AND WATER QUANTITY NEEDS FOR SELECTED IDAHO STREAMS

Stream Evaluation Project -- Phase II
OBS, Western Water Allocation Project
Contract No. 14-16-0001-77090

WILDLIFE & FISHERY RESEARCH

Completion Report

Prepared by

William D. Horton
and
Tim Cochnauer

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ABSTRACT

Methodologies for instream flow assessments are as varied and numerous as the agencies that employ them. This study was initiated to evaluate a non-field methodology and several field methodologies including single cross section and multiple cross section types. The methodologies, IFGI-preferred habitat, IFG Incremental method (WSP), IFG Incremental method (IFG4), Idaho method, and the Montana method were applied on six streams covering a wide range of stream morphologies and habitats. They were evaluated as to cost and manpower requirements, predictive capability, applicability to biological criteria and requirements of methodology improvements.

Computer programs, used with the field methodologies, were adapted to IBM hardware from the CDC system used by the Bureau of Reclamation and the Cooperative Instream Flow Group.

Instream flow recommendations were determined for each methodology from criteria described in this report and cited literature.

CHAPTER I

INTRODUCTION

Chapter I

INTRODUCTION

Regulatory agencies have been charged with assessing instream water quantity needs for fish and wildlife resource for input into overall water development plans of streams. These agencies have employed nearly as many methodologies for determining needs as there are agencies (Anon. 1978). In many cases methodologies have to be adapted to certain flow regimes, unique situations, time restrictions, manpower limits or target fish species under consideration. It is imperative that methodologies be able to stand the test of time if the instream flow recommendations are to be acceptable against increased demand for other uses.

The U.S. Fish and Wildlife Service, Environmental Services, and the Idaho Department of Fish and Game have completed a preliminary project (Phase I) to evaluate stream habitats as critical, high priority, substantial, or limited in terms of their fishery values (USF&WS 1978). The guidelines set up in Phase I provided the basis for establishing priorities and selecting streams on which instream water quantity needs have been assessed in this report.

This project (Phase II) is designed to evaluate several methodologies over a range of stream morphologies and habitats, and to quantify flows required to maintain the values that caused a stream reach to be designated as "critical" in Phase I. The Phase II project is comprised of seven objectives, or tasks, which are listed below and described in the following chapters.

Task I - Selection of stream reaches

Task II - Selection of methodologies

Task III- Biological criteria determination

Task IV - Data collection

Task V - Determination of water needs

Task VI - Evaluation of effectiveness of selected methodologies

Task VII- Completion report

This completion report is provided the U.S. Fish and Wildlife Service to satisfy requirements of the Stream Flow Evaluation Project--Phase II, contract number 14-16-001-77090 and summarizes work conducted from September 1977 to September 1979.

CHAPTER II

TASK I SELECTION OF STREAM REACHES

Chapter II

Task I

SELECTION OF STREAM REACHES

The objectives of this task were to determine those streams on which adequate historical data are available and to select streams on which designated methodologies will be evaluated. Only those streams which were designated as "critical" in Phase I were considered. The selection of streams or stream reaches for methodology evaluation was based on the following criteria:

1. There must be adequate historical discharge data available.

2. The field data must be useful in Idaho's instream flow program.

3. Priority will be given to streams where energy or other development is pending.

4. Stream reaches shall be as representative as possible for the following categories:

   (a) Wadeable cold water stream

   (b) Wadeable cool water stream

   (c) Wadeable warm water stream

   (d) Unwadeable cold water stream

   (e) Unwadeable cool water stream

   (f) Unwadeable warm water stream

Historical flow data were obtained from gage station records listed in U.S.G.S. Water Resource Data for Idaho, Water Year 1977.

FINDINGS

The critical streams on which adequate historical flow data are available are listed in Table 1 and shown in Figures 1-8. The streams for use in methodology evaluations were selected from Table 1 and are as follows:

Wadeable cold water stream - Hayden Creek

Wadeable cool water stream - Big Wood River

Wadeable warm water stream - Boise River

Unwadeable cold water stream - South Fork Clearwater River

Unwadeable cool water stream - Clearwater River

Unwadeable warm water stream - Snake River

Table 1. Critical streams with historical flow data.

Stream/location	Gage Station No.	County	Map	Period of record	Years of record
North Idaho					
Kootenai River at Leonia	12-3050	Boundary	1	1928-1977	49
Clark Fork River near Cabinet	12-3920	Bonner	1	1928-1977	49
Hayden Creek	12-4160	Kootenai	1	1948-1977	18
Coeur d'Alene River near Prichard	12-4110	Shoshone	1	1950-1977	26
Coeur d'Alene River near Enaville	12-4130	Shoshone	1	1911-1977	38
North-central Idaho					
North Fork Clearwater River near Canyon	13-3406	Clearwater	2	1967-1977	10
Selway River near Lowell	13-3365	Idaho	2	1911-1977	48
Lochsa River near Lowell	13-3370	Idaho	2	1910-1977	50
South Fork Clearwater River near Stites	13-3385	Idaho	2	1910-1977	14
Clearwater River at Orofino	13-3400	Clearwater	2	1930-1977	21
Clearwater River near Peck	13-34105	Nez Perce	2	1964-1977	13
Clearwater River at Spalding	13-3425	Nez Perce	2	1910-1977	55
Little Salmon River at Riggins	13-3165	Idaho	2	1951-1977	24
Salmon River at Whitebird	13-3170	Idaho	2	1910-1977	65
Snake River near Anatone, WA	13-3343	Asotin, WA	2	1958-1977	19

Table 1. Critical streams with historical flow data. (continued)

Stream/location	Gage Station No.	County	Map	Period of record	Years of record
West-central Idaho					
Snake River at Hells Canyon Dam	13-29045	Adams	3	1966-1977	12
South Fork Salmon River near Krassel	13-3107	Valley	3	1966-1977	11
Johnson Creek at Yellowpine	13-3130	Valley	3	1928-1977	49
North Fork Payette River at McCall	13-2390	Valley	3	1908-1977	66
South Fork Payette River at Lowman	13-2350	Boise	3	1941-1977	36
Snake River at Weiser	13-2690	Washington	3	1910-1977	67
East-central Idaho					
East Fork Salmon River near Clayton	13-2980	Custer	4	1928-1977	15
Lemhi River near Tendoy	13-3050	Lemhi	4	1938-1977	18
Salmon River at Salmon	13-3025	Lemhi	4	1912-1977	62
Salmon River near Shoup	13-3070	Lemhi	4	1944-1977	33
Southwest Idaho					
South Fork Boise River near Featherville	13-1860	Elmore	5	1945-1977	32
South Fork Boise River at Anderson Ranch Dam	13-1905	Elmore	5	1943-1977	34
Boise River near Twin Springs	13-1850	Boise	5	1911-1977	66
Boise River at Boise	13-2055	Ada	5	1940-1977	23

Table 1. Critical streams with historical flow data. (continued)

Stream/location	Gage Station No.	County	Map	Period of record	Years of record
Southwest Idaho (cont'd)					
Snake River at King Hill	13-1545	Elmore	5	1909-1977	68
Snake River near Murphy	13-1725	Ada	5	1912-1977	64
West Fork Bruneau River near Rowland, Nevada	13-1615	Elko, NV	5	1913-1977	16
Bruneau River near Hot Creek	13-1685	Owyhee	5	1909-1977	39
South Fork Owyhee River near Whiterock, Nevada	13-1778	Elko, NV	5	1955-1977	22
Owyhee River near Owyhee, Nevada	13-1760	Elko, NV	5	1939-1977	38
Owyhee River near Jordan Creek	13-1810	Malheur, OR	5	1949-1977	28
South-central Idaho					
Big Wood River	13-1425	Blaine	6	1912-1977	65
Big Wood River	13-1525	Gooding	6	1916-1977	45
Goose Creek	13-0825	Cassia	6	1911-1977	63
Snake River near Minidoka Dam	13-0815	Minidoka	6	1895-1977	51
Snake River near Milner Dam	13-0880	Cassia	6	1909-1977	51
Snake River near Twin Falls	13-0900	Twin Falls	6	1923-1977	54
Snake River near Buhl	13-0940	Gooding	6	1946-1977	30
Snake River near Lower Salmon Falls Dam	13-1350	Twin Falls	6	1937-1977	40
Box Canyon Springs Creek	13-0955	Gooding	6	1950-1977	27

Table 1 Critical streams with historical flow data. (continued)

Stream/location	Gage Station No.	County	Map	Period of record	Years of record
East Idaho					
Henrys Fork near Lake	13-0395	Fremont	7	1920-1977	48
Henrys Fork Snake River near Ashton	13-0460	Fremont	7	1890-1977	57
Henrys Fork Snake River near St. Anthony	13-0505	Fremont	7	1919-1977	16
Teton River near Driggs	13-522	Teton	7	1961-1977	16
South Fork Snake River near Irwin	13-0325	Bonneville	7	1935-1977	28
South Fork Snake River near Heise	13-0375	Bonneville	7	1910-1977	67
Southeast Idaho					
Snake River near Blackfoot	13-0695	Bingham	8	1910-1977	67
Snake River near American Falls Reservoir	13-0770	Power	8	1906-1977	51
Blackfoot River above reservoir	13-0630	Caribou	8	1914-1977	11
Portneuf River near Pebble	13-0720	Caribou	8	1910-1977	11
Portneuf River near Topaz	13-0730	Bannock	8	1913-1977	60
Cottonwood Creek near Cleveland	10-0845	Franklin	8	1938-1977	38
Cub River near Preston	10-0930	Franklin	8	1940-1977	34

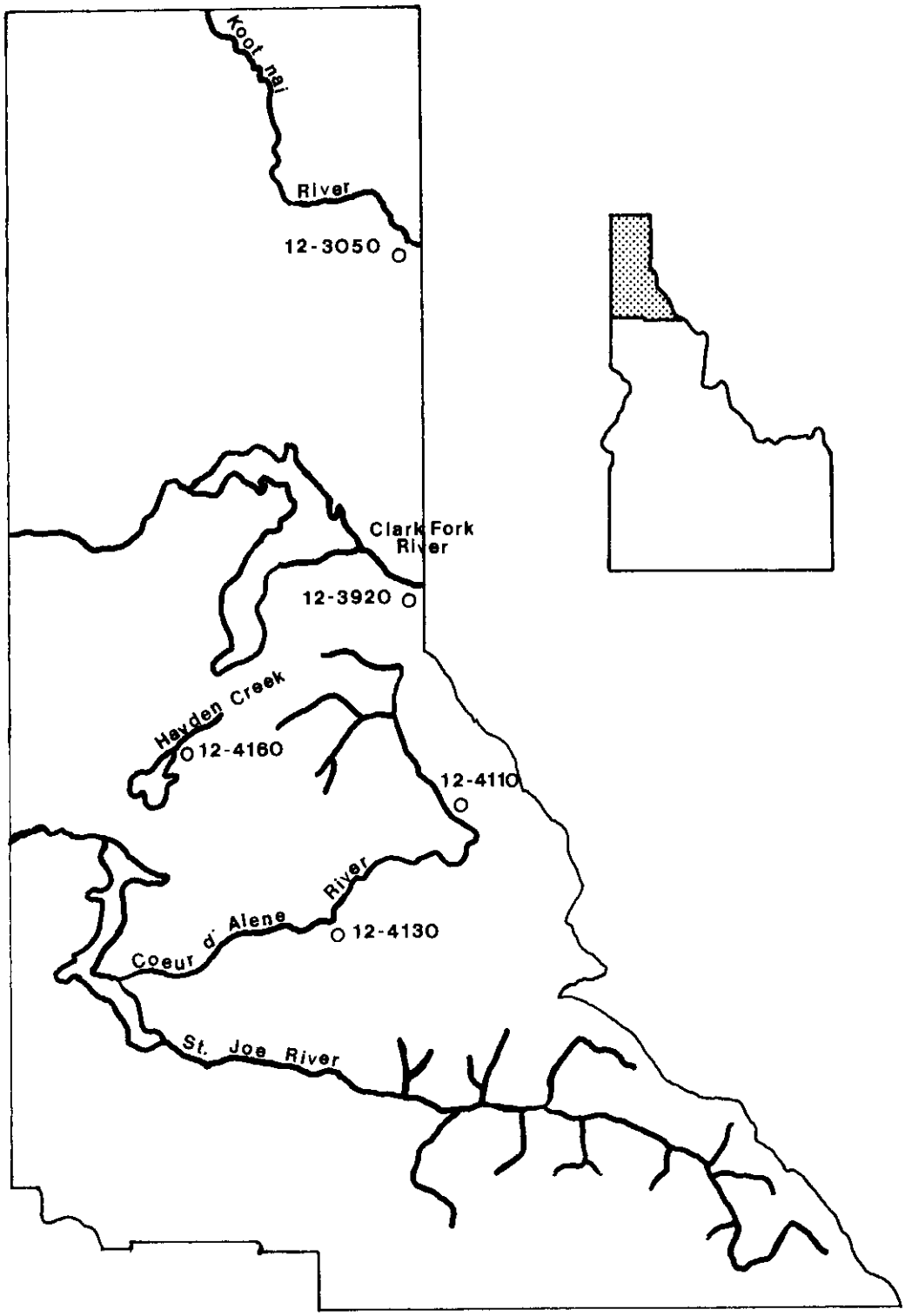

Figure 1. Location of gage stations on critical streams in north Idaho.

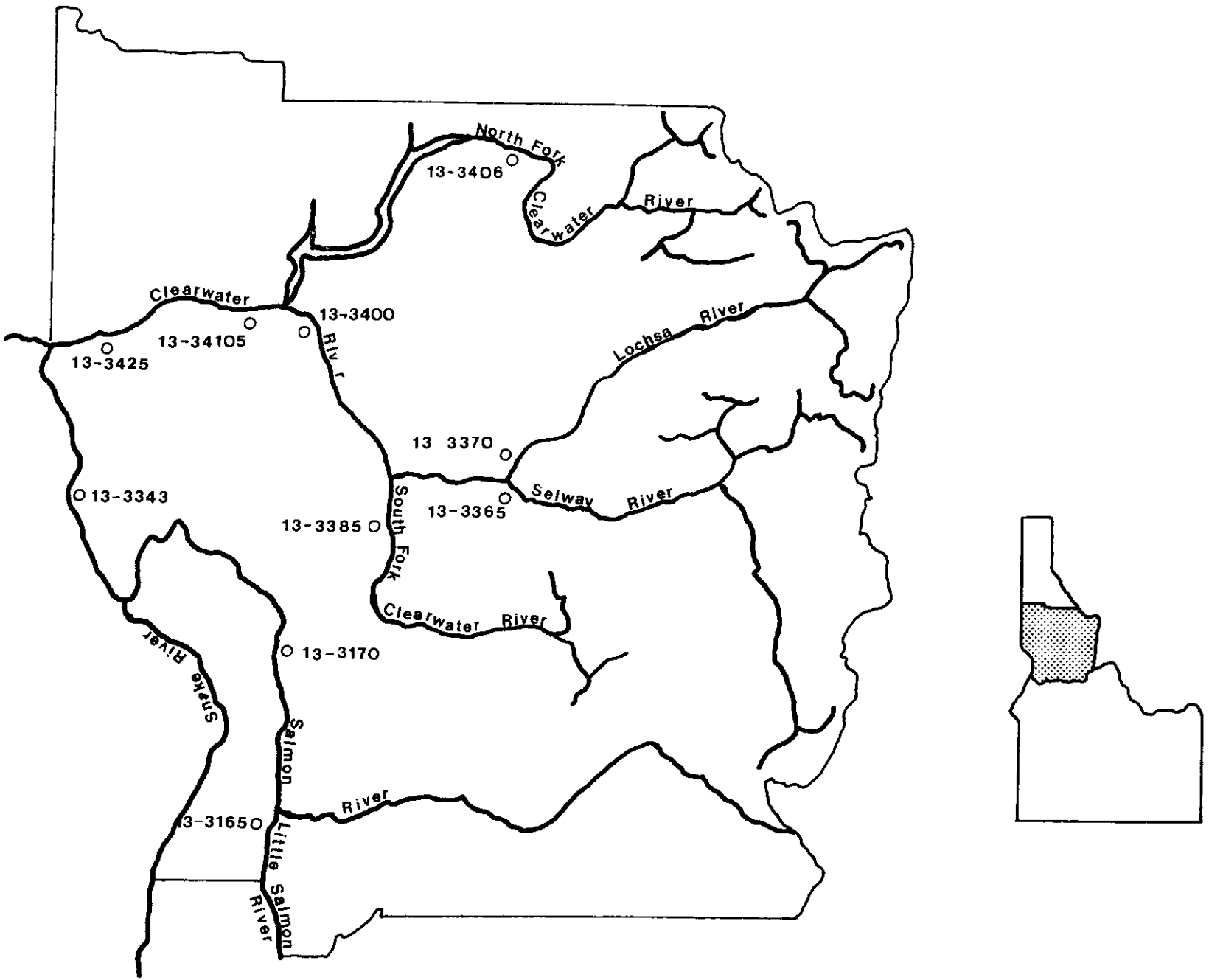

Figure 2. Location of gage stations on critical streams in north-central Idaho.

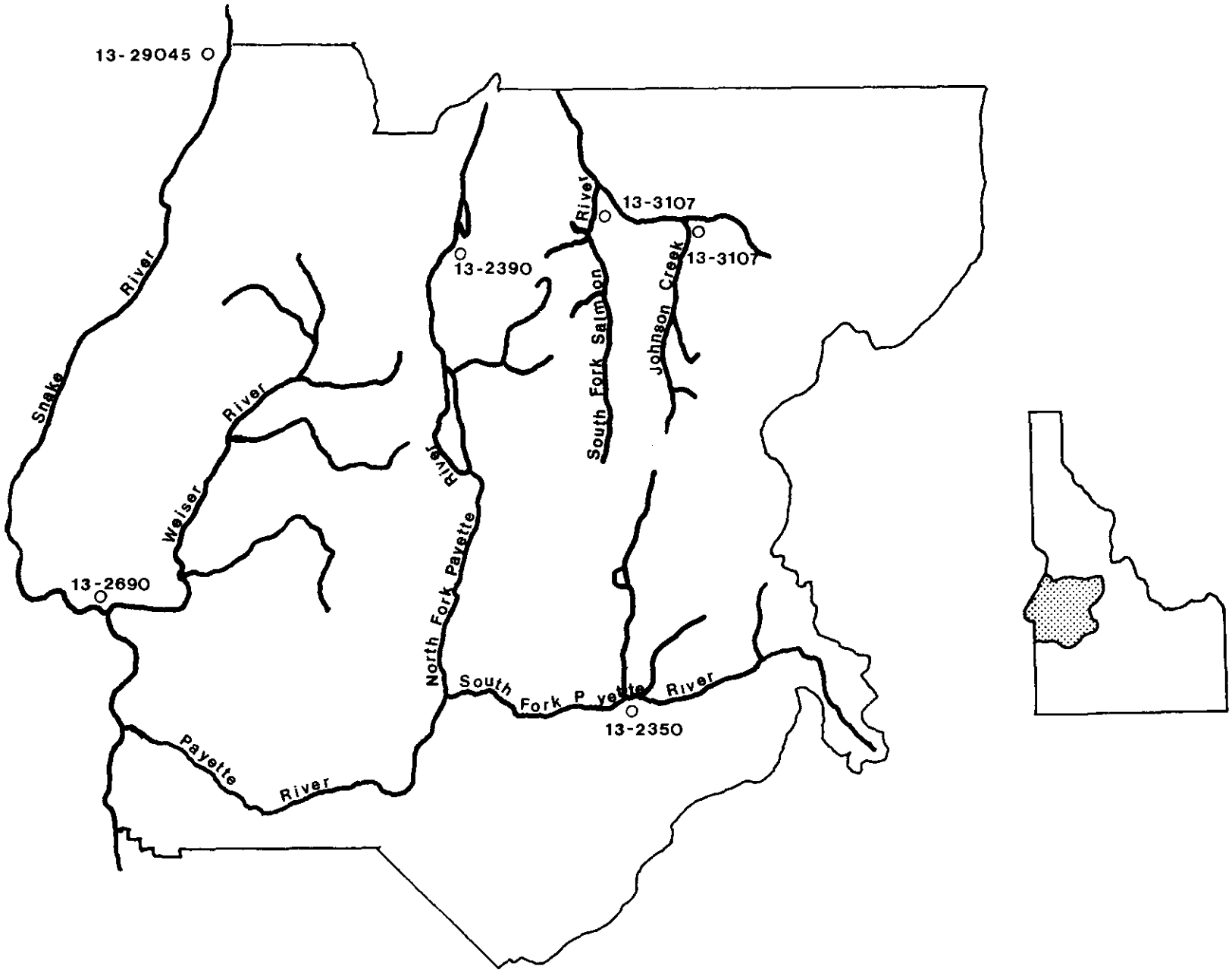

Figure 3. Location of gage stations on critical streams in west-central Idaho.

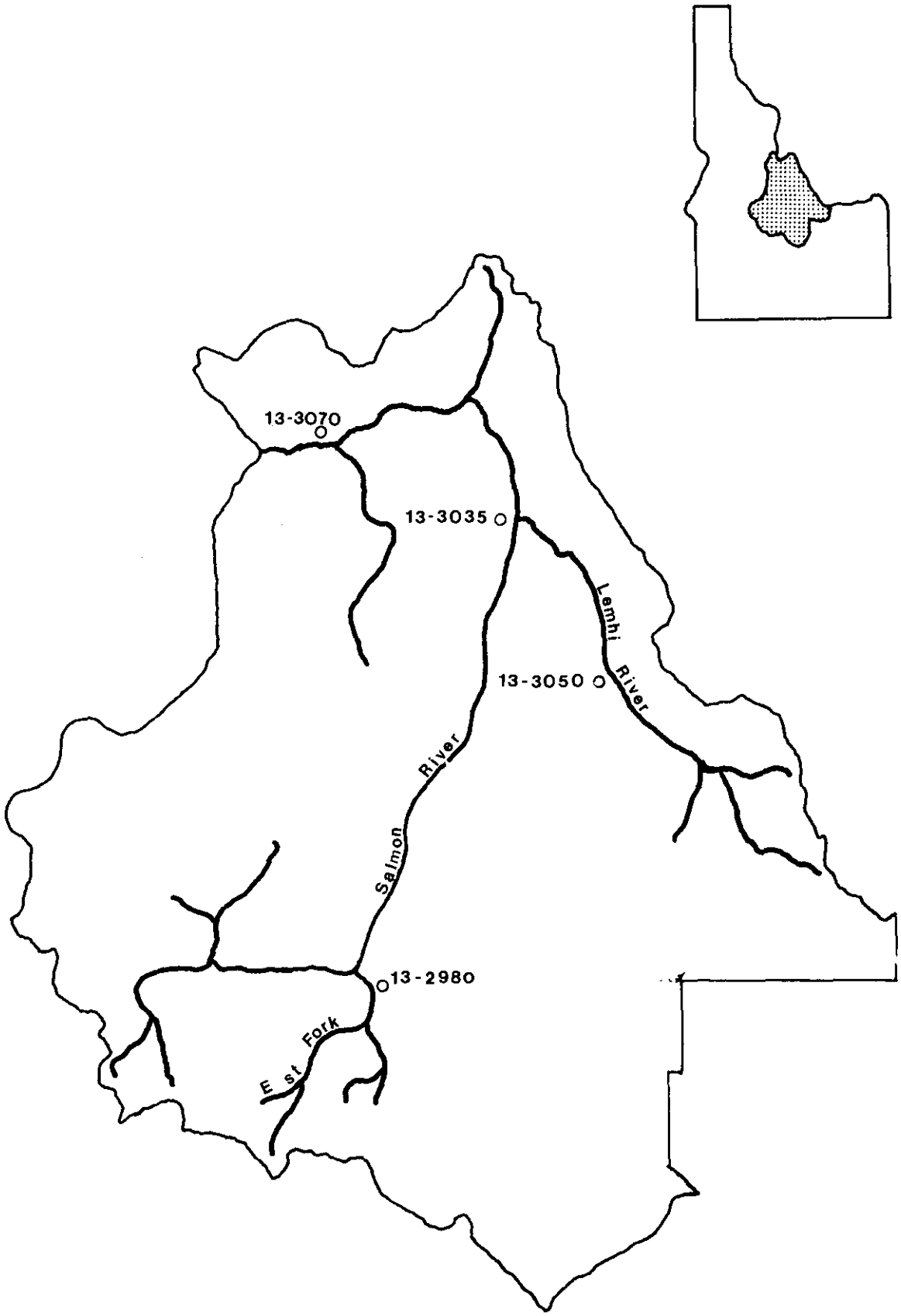

Figure 4. Location of gage stations on critical streams in east-central Idaho.

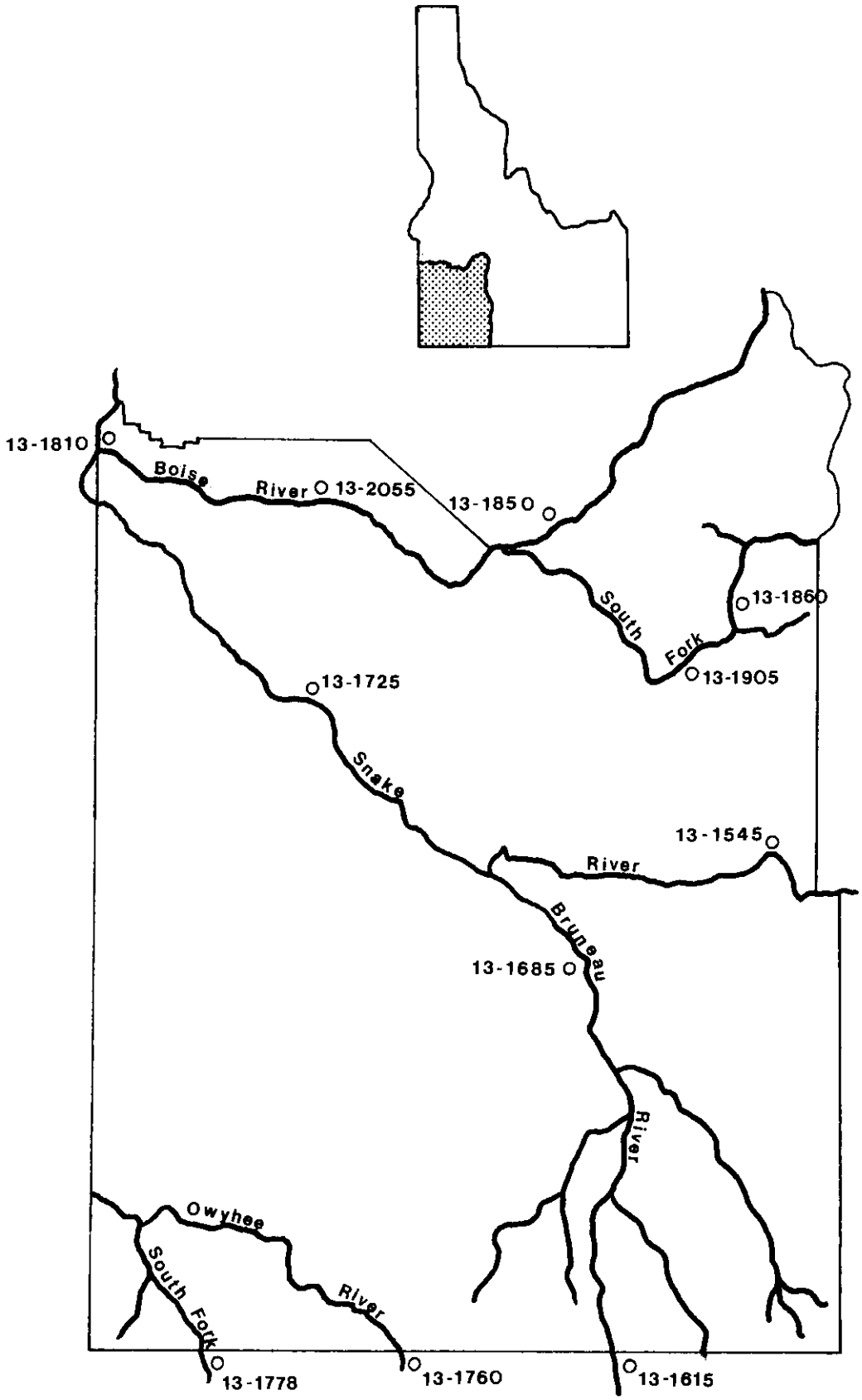

Figure 5. Location of gage stations on critical streams in southwest Idaho.

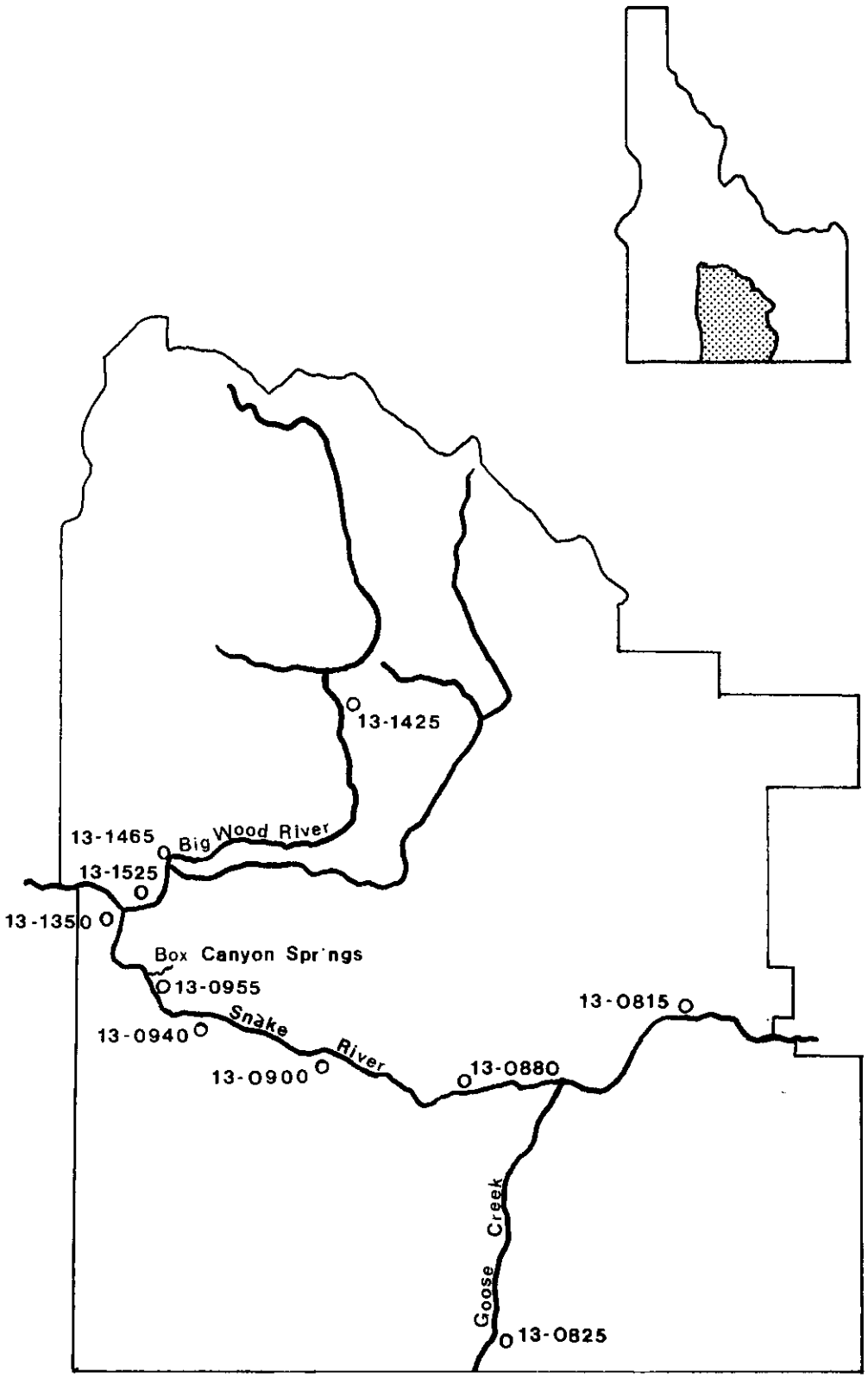

Figure 6. Location of gage stations on critical streams in south-central Idaho.

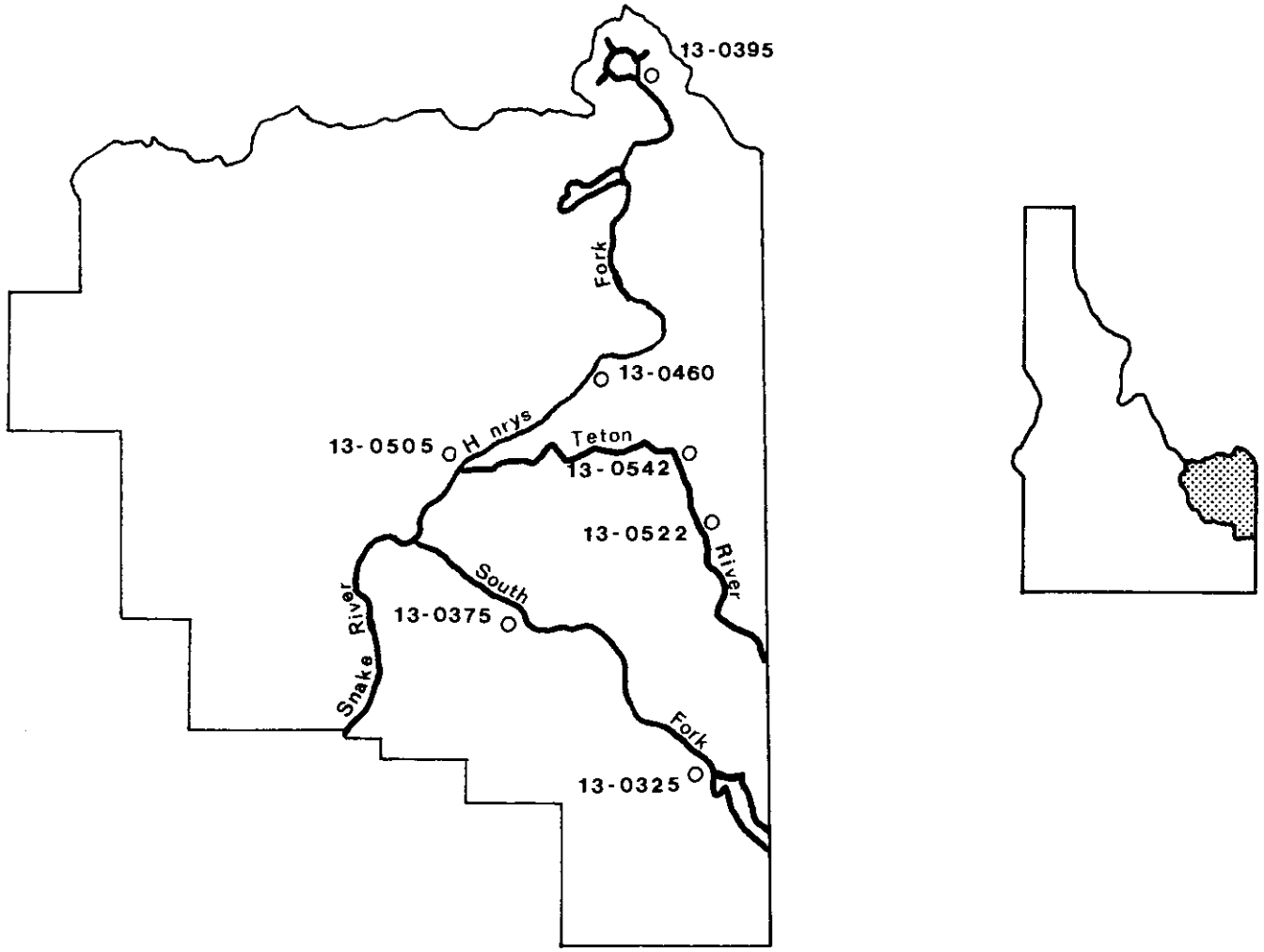

Figure 7. Location of gage stations on critical streams in east Idaho.

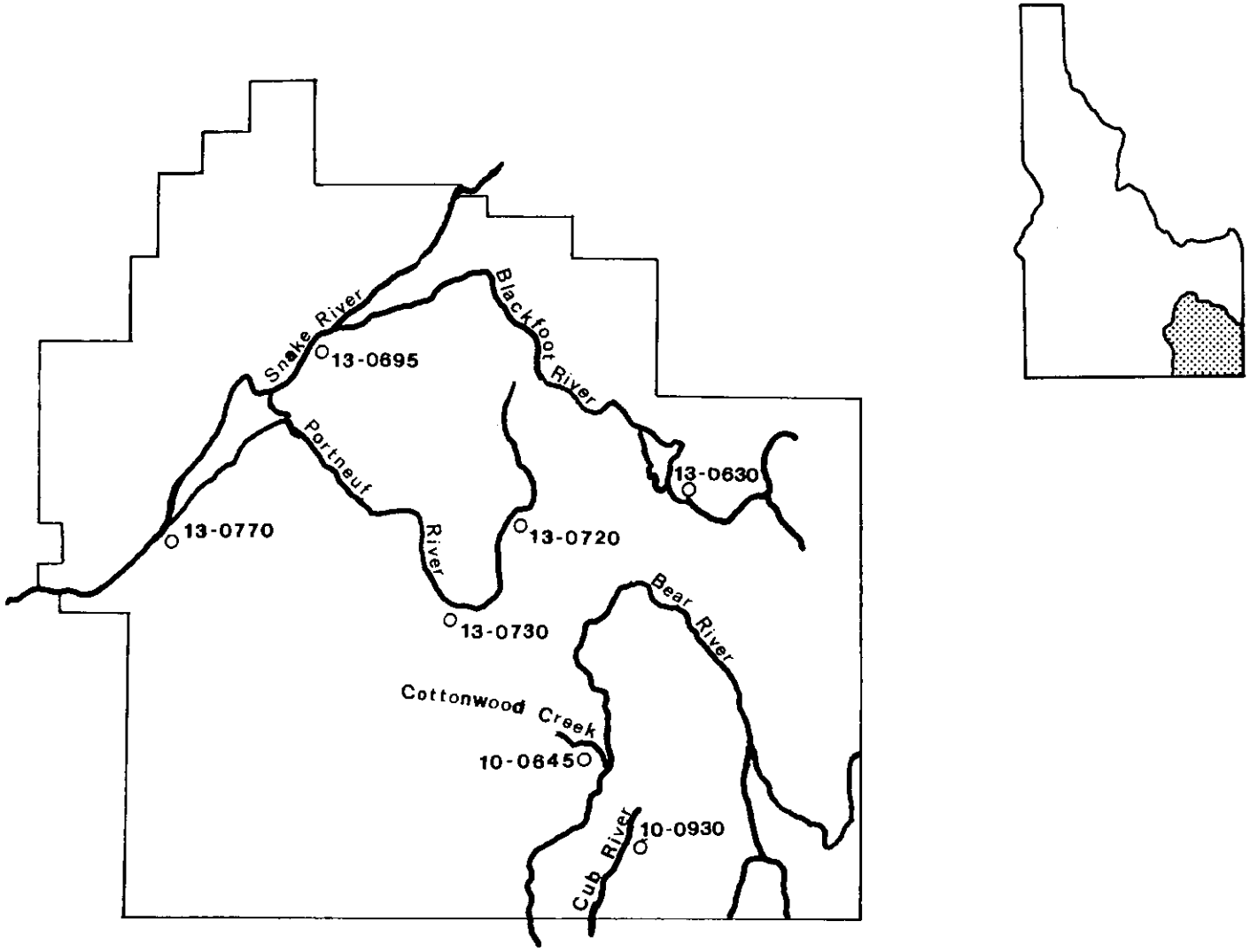

Figure 8. Location of gage stations on critical streams in southeast Idaho.

CHAPTER III

TASK II, SELECTION OF METHODOLOGIES

Chapter III

Task II

SELECTION OF METHODOLOGIES

Because of the large number of methodologies available today to quantify instream flow needs for any number of uses, the Instream Flow Group has contracted with many state agencies to determine the usefulness of methodologies for fish and wildlife needs. The Idaho Department of Fish and Game has selected five methodologies that cover a broad range of hydraulic simulation techniques, manpower requirements, field and office data gathering methods, and resolution strength. The reason for such variety is to define an approach that gives the best results for the least amount of effort or expense, or some adequate median between cost and effort that gives the needed results. More information concerning the methodologies will be covered in Chapter V.

The methodologies chosen are:

1. IFG1 - Preferred Habitat - the Single Cross Section computer program (SCSIFM) interfaced with biological criteria taken from species-life stage preferred habitat curves for indicator species in each study section.

2. The IFG incremental method (WSP) - the Water Surface Profile (WSP) computer program interfaced with the Incremental Habitat (HABTAT) computer program.

3. The IFG incremental method (IFG4) - the IFG4 computer program interfaced with the Incremental Habitat (HABTAT) computer program.

4. The Idaho method - the Water Surface Profile (WSP) computer program interfaced with the Wetted Perimeter (WETPER) computer program and biological criteria for rearing, spawning and passage of indicator species in each study section.

5. The Montana method - based on percentages of historic U.S. Geological Survey monthly flow records.

CHAPTER IV

TASK III, BIOLOGICAL CRITERIA

Chapter IV

Task III

BIOLOGICAL CRITERIA

The Cooperative Instream Flow Service Group, U.S. Fish and Wildlife Service, has developed and is continually updating an instream flow computer model to assess impacts of altered stream flows on stream habitat. An integral part of this model is the knowledge of preferred physical parameters (depth, velocity and substrate) of stream environments for life history phases of significant fish species. As part of the Stream Evaluation Project--Phase II, the Idaho Department of Fish and Game measured physical stream parameters for eight species of fish in 21 streams throughout Idaho (Fig. 9).

Preferred water depths, velocities and substrates were recorded for individual fish during 1977 and 1978. The species of primary concern were brown trout, brook trout, mountain whitefish, smallmouth bass and largemouth bass. Incidental species were rainbow trout, cutthroat trout and Dolly Varden. The species sampled in each stream are presented in Table 2.

TECHNIQUES USED

Fish locations were determined by two techniques. Electroshocking was performed in all streams except those where conductivity was too low to attract fish. On low conductivity streams, snorkeling was an effective means of obtaining information.

Depending on availability of equipment, size of stream and accessibility, electroshocking was accomplished with either a backpack shocker, or a variable voltage pulsator powered by a gas generator and transported in a car top boat or canoe. Stunned fish were removed from the stream and length measurements were taken. Species and size were recorded immediately, and a small buoy was placed at the site of first observation for later reference. The buoys were constructed by attaching duck decoy weights to styrofoam floats with braided cord. All fish were released into the stream far enough downstream so as not to reenter the sampling area.

After completion of a sampling run, depth, velocity, cover and substrate were recorded at each numbered buoy. A standard Price II current meter attached to a top setting wading rod was used for depth and velocity measurements. Velocity was measured at 0.6 depth from the water surface when depths were less than 2.5 ft (0.8 m) and 0.2 and 0.8 depth from the surface for depths greater than 2.5 ft (0.8 m). An attempt was made to sample all available habitat types (pools, riffles, near banks, middle stream, etc.) found in each stream.

Snorkeling was conducted in relatively small (100 cfs or less), clear streams. With few exceptions, sections of the streams were surveyed in the same manner as they had been with electroshocking. Fish were not removed from the stream for length measurement, but a measuring stick was placed close to the fish or between two points where the fish had been. The second crew member then recorded length, species and measured the required physical parameters as the snorkeler moved upstream.

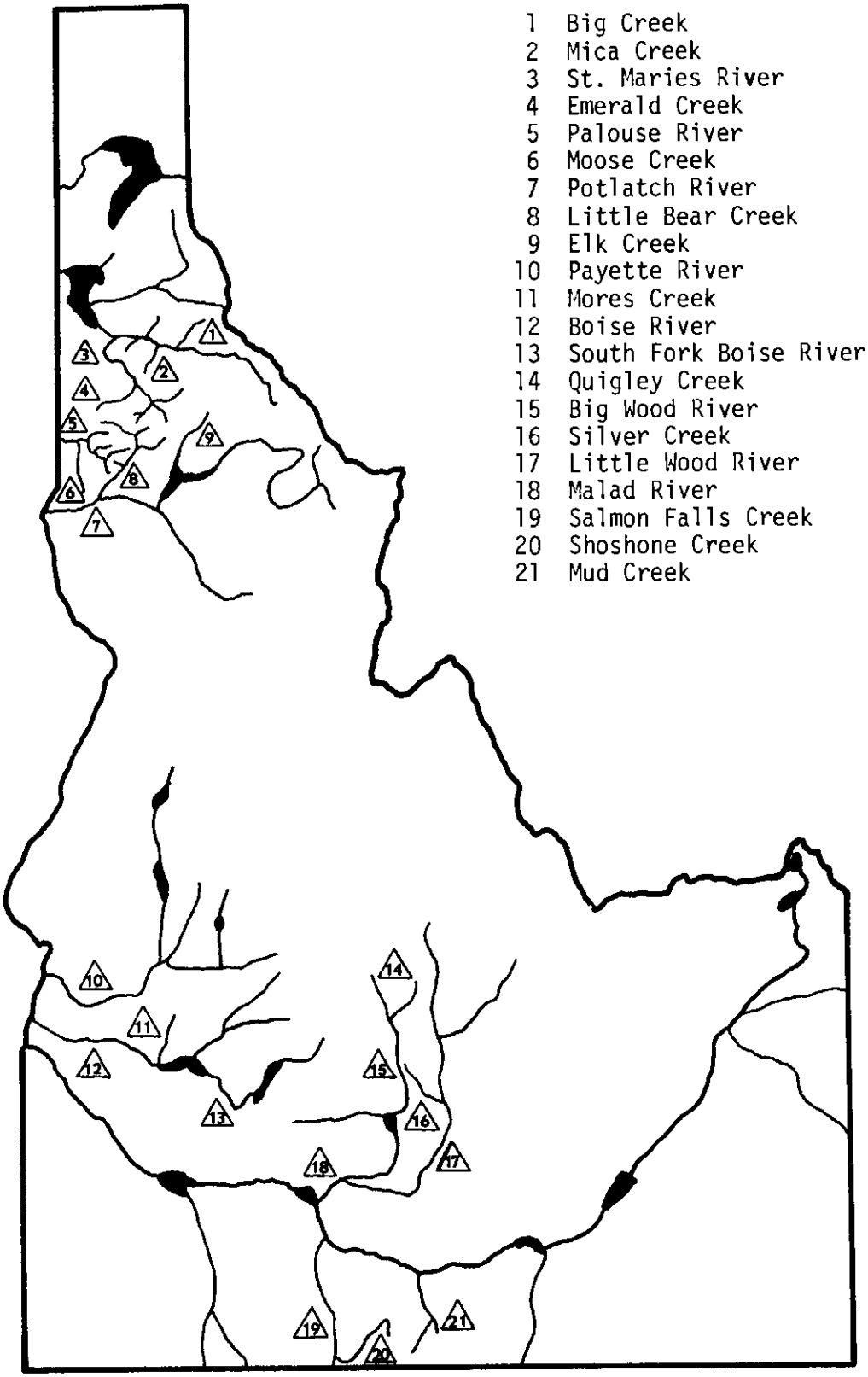

Figure 9. Streams on which preferred fish habitat data were collected.

DESCRIPTION OF STREAMS

Big Wood River flows southwesterly from the mountainous region of south-central Idaho near Sun Valley to the high arid plateau of the Snake River. The section upstream from Ketchum has a gravel/rubble substrate with little siltation due to the steep gradient. Most pools are less than 5 ft (1.5 m) deep, the riffles are shallow, and little or no aquatic vegetation exists. Cover is provided by logs and boulders, with some riparian vegetation (willows and cottonwoods) providing shade.

From Ketchum to Magic Reservoir, Big Wood River is predominantly rubble/gravel substrate with some boulders near altered stream sections. The gradient is moderate, allowing minor siltation. This section characteristically has pools greater than 5 ft (1.5 m) deep, and many 2 to 3 ft (0.6-0.9 m) deep runs and riffles. Instream cover is provided by logs and boulders, with no aquatic vegetation and only sparse riparian vegetation of grasses and sagebrush.

Big Wood River, downstream from its confluence with the Little Wood River, is named Malad River. Its substrate is primarily bedrock, with varying amounts of rubble, boulders, and gravel. Siltation is not heavy although commonplace. This section of the stream has deep pools over 5 ft (1.5 m) and more runs than riffles. The stream is lined with willows that provide shade and cover, and aquatic vegetation is present.

Little Wood River, where sampled, has a bedrock/rubble/gravel substrate with abundant instream vegetation. Pools are often long and greater than 5 ft (1.5 m) in depth. Few riffles exist, but many short runs divide pools. The riparian vegetation is grass and sagebrush, providing little shade or cover. Because the stream is slow-moving and meanders moderately, there is some undercutting present.

Silver Creek is a spring fed tributary of Little Wood River and originates on a high, flat, mountain plateau. It meanders severely resulting in many sloughs. Aquatic vegetation is abundant during the summer months and provides cover for fish. The unstable banks are often undercut and covered with willows, grasses and some sagebrush. The substrate is gravel/sand with an abundant silt and mud/detritus covering. Pools are often greater than 5 ft (1.5 m) deep, a few shallow riffles exist, and there are many runs between the long deep pools.

Boise River near Boise has a gravel/rubble substrate with silted pools of depths greater than 5 ft (1.5 m). It has shallow riffles and long pools with undercut banks, logs, and sparse vegetation providing the instream cover. Riparian vegetation consists of grasses, shrubs and trees. The flows in the study section of the Boise are controlled by Lucky Peak Dam.

South Fork Boise River, downstream from Anderson Ranch Reservoir, has a rubble/boulder substrate that often forms shallow wide riffles flowing into deep pools, greater than 10 ft (3 m). Cover is provided by large conspicious boulders and logs.

Mores Creek, a tributary to Boise River, drains moderately forested slopes before flowing into a broad, flat, valley floor where the fish observations were made. The substrate is gravel/sand with boulders present. The pools are small and rarely over 4 ft (1.2 m) deep, and the riffles are long and shallow.

The Palouse River drains the western slopes of the north Idaho mountains into the rich Palouse valley farmland before entering Snake River in eastern Washington. The river, upstream of Laird Park, has a rubble/gravel substrate with long riffles and numerous shallow pools less than 3 ft (0.9 m) in depth. Logs, undercut banks and boulders provide cover. The streamside vegetation is a dense tall shrub understory in a conifer dominant forest.

Moose Creek, a tributary to Palouse River, was also sampled and is similarly described. The last 20 mi (32 km) of stream meanders slowly, resulting in heavy siltation. Pools in this section are numerous and long with depth commonly over 5 ft (1.5 m). Long deep runs are common, but riffles are nonexistent. Little or no instream vegetation was noted.

Payette River originates in the west central Idaho mountains and drains the western slopes of the Sawtooth and Salmon River mountains. This streams flows into the Snake River at the town of Payette. The river, downstream of Horseshoe Bend, is characterized by meandering and off-channel sloughs. The substrate is primarily gravel with high silt/sand composition. Pools are commonly 10 ft (3 m) in depth and few riffles were noted. Instream cover is provided by large amounts of vegetation in the sloughs.

Potlatch River flows southerly into the Clearwater River near Lewiston. Upstream of Helmer, the stream drains a densely vegetated mountainous area. Instream cover is provided primarily by the rubble/boulder substrate. The riparian vegetation consists of dense shrubs and grasses with a conifer overstory. Pools are sparse and rarely over 4 ft (1.2 m) in depth, while shallow riffles and runs are common. The lower section flows through a deep canyon with bedrock/rubble substrate with sparse gravel pockets. Pools in this section are commonly silted and are often greater than 5 ft (1.5 m) in depth. There is little riparian vegetation along the stream.

St. Maries River is a tributary to the St. Joe River in mountainous northern Idaho. The stream has a rubble/gravel substrate forming long shallow riffles with numerous pools with depths less than 4 ft (1.2 m). Riparian vegetation consists of willows, grasses and conifers. Instream vegetation is sparse, and cover is provided by undercut banks and logs in the stream.

Emerald Creek is a tributary of St. Maries River and drains densely forested mountains. The upper 5 mi (8 km) of stream has dense streamside vegetation dominated by brush and grasses. Numerous dead trees provide instream fish cover. Substrate is coarse sand/gravel with occasional heavy silting in the pools. In the lower 10 mi (16 km) of the stream, pools are up to 5 ft (1.5 m) in depth. Instream cover is provided by logs and undercut banks. Riparian vegetation is dense brush growth with a conifer overstory.

Shoshone Creek is located in the Sawtooth National Forest in southern Idaho. The substrate is rubble/gravel with moderate amounts of silt deposits in pools. The pools are often greater than 5 ft (1.5 m) in depth and are separated by long slow runs. Few riffles were noted and instream vegetation is common. The riparian vegetation is predominantly grasses with some willows and sagebrush.

Salmon Falls Creek is located in southern Idaho. The substrate is primarily bedrock with varying amounts of boulders and rubble. There are few riffles, and pools are commonly greater than 5 ft (1.5 m) in depth. Silting is common in the pools. The riparian vegetation is limited to willows and sagebrush.

St. Joe River originates in the Bitterroot Mountains near the Idaho-Montana border and flows northwesterly into the southern tip of Coeur d'Alene Lake. The upper river flows through steep narrow canyons in a conifer dominated forest. This section is characterized by long shallow riffles and deep pools. The lower stretch of the river has wide channels and deep pools in a broad flat valley floor. Substrate ranges from bedrock and gravel/sand in the upper river to a clay bottom in the lower section. Riparian vegetation is abundant throughout the stream length, ranging from conifers with dense brush understory in the upper reaches to willow/sagebrush in the lower section. Sparse instream vegetation was present at the time of sampling.

Big Creek, a tributary to St. Joe River, drains a steep sided canyon with severe gradient characterized by many shallow rapids and deep pools. There was no instream vegetation and little riparian vegetation. Instream cover is provided by large boulders.

Elk Creek is a tributary to the Little North Fork Clearwater River. Where sampled, the stream meanders through a broad flat valley. The riparian vegetation was dense willow/brush mixed with grasses and conifers, and instream vegetation was not evident. Substrate was gravel/rubble with moderate silting. Pools were rarely over 4 ft (1.2 m) in depth and were divided by short riffle areas. Instream cover was provided by logs and undercut banks.

FINDINGS

Summaries of depth and velocity measurement for fish species are presented in Tables 3 through 16.

DISCUSSION

Each of the two methods used in this study has its advantages and disadvantages when applied to collecting data at specific fish locations. Electroshocking may displace fish from their location of activity due to a weak electrical field or by personnel working in the stream. Also the exact location from which the fish came may be uncertain in turbid water. Advantages of this method are that a lot of valuable information may be collected in a short period of time and that exact length measurement of fish can be taken.

Snorkeling has the advantage of being able to observe the fish undisturbed; however, exact length measurements are not available. This method is only suitable in water with low turbidity and on sunny days.

Both methods were evaluated on two streams, each in a different geographic location. One observer would snorkel a section of the stream, and note the location of fish and estimate lengths. Then the shocking crew would go through the same area, capturing all fish, marking locations and measuring lengths. Numbers of fish counted by each method were nearly the same; however, exact location (snorkeling) and capture location (shocking) were often different. An experienced snorkeler could estimate the length of fish closely to exact measurement. Electroshocking practices displaced fish from feeding locations to nearby cover. Measurements of depth and velocity at feeding locations and cover are each valid, but it should be recognized that electroshocking may displace fish to cover.

The efficiencies of electroshocking and snorkeling are both reduced with water depths over 6 ft (1.8 m).

Table 2. Fish species surveyed in study streams.

	Rainbow trout	Cutthroat trout	Brown trout	Mountain whitefish	Dolly Varden	Brook trout	Largemouth bass	Smallmouth bass
Big Creek	x							
Mica Creek		x				x		
St. Maries River		x						
Emerald Creek		x				x		
Palouse River	x				x	x	x	
Moose Creek	x							
Potlatch River					x	x		
Little Bear Creek	x						x	
Elk Creek						x		
Payette River							x	x
Mores Creek								x
Boise River			x	x		x		
South Fork Boise River				x				
Quigley Creek						x		
Big Wood River	x		x	x		x		x
Silver Creek	x		x	x				
Little Wood River	x		x					
Malad River								x
Salmon Falls Creek	x			x			x	x
Shoshone Creek	x		x					
Mud Creek	x							

Table 3. Summation of observations of rainbow trout at different depths (ft) in Big Wood River, Little Wood River, Shoshone Creek, Silver Creek, Mud Creek, Salmon Falls Creek, Spring Valley Reservoir outlet, North Fork Palouse River, and Moose Creek, Idaho.

	Total length (in)				
Depth (ft)	0.0 - 2.0	2.1 - 4.0	4.1 - 6.0	6.1 - 8.0	>8.0
0.0	-	-	-	-	-
0.1	-	-	-	-	-
0.2	-	-	-	-	-
0.3	-	-	-	-	-
0.4	-	-	-	-	-
0.5	-	-	-	-	-
0.6	-	1	1	-	3
0.7	-	2	-	-	-
0.8	-	-	1	-	2
0.9	-	-	1	-	2
1.0	-	1	5	2	2
1.1	-	-	2	1	2
1.2	-	-	2	1	1
1.3	-	-	3	2	3
1.4	-	-	1	4	2
1.5	-	-	5	1	5
1.6	-	-	3	2	6
1.7	-	-	1	1	6
1.8	-	-	-	1	4
1.9	-	-	-	-	2
2.0	-	3	2	4	12
2.1	-	-	-	-	5
2.2	-	2	3	2	4
2.3	-	-	1	4	9
2.4	1	-	3	2	7
2.5	-	-	-	-	5
2.6	-	-	2	1	6
2.7	-	-	-	-	1
2.8	-	-	-	-	2
2.9	-	-	-	1	2
3.0	-	-	-	-	-
3.1	-	-	-	-	1
3.2	-	-	-	-	-
3.3	-	-	-	-	1
3.4	-	-	-	-	1
3.5	-	-	-	-	2
3.6	-	-	-	1	-
3.7	-	-	-	-	-
3.8	-	-	-	-	-
3.9	-	-	-	-	1
4.0	-	-	-	-	-
$\bar{X}$	-	-	1.57	1.87	2.01
n	-	-	36	30	99

Table 4. Summation of observations of rainbow trout at different velocities (fps) in Little Wood River, Shoshone Creek, Big Wood River, Silver Creek, Mud Creek, Salmon Falls Creek, Spring Valley Reservoir outlet, Palouse River, and Moose Creek, Idaho.

	Total length (in)				
Velocity (fps)	0.0 - 2.0	2.1 - 4.0	4.1 - 6.0	6.1 - 8.0	>8.0
0.0	-	3	3	9	35
0.1	-	-	-	1	-
0.2	-	-	2	1	6
0.3	-	-	-	2	6
0.4	-	-	3	3	-
0.5	-	-	6	-	8
0.6	-	-	-	1	10
0.7	-	2	4	4	2
0.8	1	-	1	3	3
0.9	-	-	-	3	4
1.0	-	-	1	2	1
1.0	-	-	3	1	4
1.2	-	-	1	-	1
1.3	-	-	2	-	5
1.4	-	-	-	-	1
1.5	-	2	-	-	1
1.6	-	-	1	1	3
1.7	-	-	1	-	-
1.8	-	-	-	1	2
1.9	-	-	1	1	-
2.0	-	-	-	-	-
2.1	-	-	-	-	1
2.2	-	-	-	-	-
2.3	-	-	1	2	1
2.4	-	-	1	1	-
2.5	-	-	-	-	2
2.6	-	-	4	-	2
2.7					
2.8					
2.9					
3.0					
3.1					
3.2					
3.3					
3.4					
3.5					
3.6					
3.7					
3.8					
3.9					
4.0					
$\overline{X}$	-	-	1.05	0.73	0.61
n	-	-	35	35	98

Table 5. Summation of observations of cutthroat trout at different depths (ft) in Big Creek, Mica Creek, Middle and West Fork St. Maries River, and Emerald Creek, Idaho.

	Total length (in)				
Depth (ft)	0.0 - 2.0	2.1 - 4.0	4.1 - 6.0	6.1 - 8.0	>8.0
0.0	-	-	-	-	-
0.1	-	-	-	-	-
0.2	-	-	-	-	-
0.3	-	-	-	-	-
0.4	-	-	-	-	-
0.5	-	-	-	-	-
0.6	-	-	-	-	-
0.7	-	1	-	-	-
0.8	-	1	-	-	-
0.9	-	1	-	-	-
1.0	-	2	4	1	-
1.2	-	-	2	4	1
1.3	-	2	2	-	1
1.4	-	2	1	-	-
1.5	-	-	1	1	1
1.6	-	1	-	1	1
1.7	-	1	-	1	-
1.8	-	1	1	1	-
1.9	-	-	-	-	-
2.0	-	-	1	-	2
2.1	-	-	-	1	-
2.2	-	-	-	-	-
2.3	-	-	-	1	1
2.4	-	-	2	1	-
2.5	-	-	-	-	-
2.6	-	-	-	-	-
2.7	-	-	4	1	-
2.8	-	-	-	-	-
2.9	-	-	-	-	-
3.0	-	-	-	-	-
3.1	-	-	-	-	-
3.2	-	-	-	-	-
3.3	-	-	-	-	-
3.4	-	-	-	-	-
3.5	-	-	-	-	-
3.6	-	3	3	1	0
3.7	-	-	-	-	-
3.8	-	-	-	-	-
3.9	-	-	-	-	-
4.0	-	-	-	-	-
$\bar{X}$	-	1.68	2.00	1.83	-
n	-	16	21	14	

Table 6. Summation of observations of cutthroat trout at different velocities (fps) in Big Creek, Mica Creek, St. Maries River, and Emerald Creek, Idaho.

	Total length (in)				
Velocity (fps)	0.0 - 2.0	2.1 - 4.0	4.1 - 6.0	6.1 - 8.0	> 8.0
0.0	-	2	1	-	-
0.1	-	-	-	-	-
0.2	-	1	1	-	1
0.3	-	1	2	2	-
0.4	-	4	4	2	2
0.5	-	1	6	-	-
0.6	-	1	2	2	1
0.7	-	3	-	1	-
0.8	-	-	-	1	1
0.9	-	1	1	2	-
1.0	-	-	1	-	-
1.1	-	-	-	2	-
1.2	-	1	-	-	-
1.3	-	-	-	1	1
1.4	-	-	-	-	2
1.5	-	-	-	-	-
1.6	-	-	-	-	-
1.7	-	-	1	-	-
1.8	-	1	2	-	-
1.9	-	-	-	1	-
2.0					
2.1					
2.2					
2.3					
2.4					
2.5					
2.6					
2.7					
2.8					
2.9					
3.0					
3.1					
3.2					
3.3					
3.4					
3.5					
3.6					
3.7					
3.8					
3.9					
4.0					
$\overline{X}$	-	0.58	0.66	0.81	-
n	-	16	21	14	-

Table 7. Summation of observations of brown trout at different depths (ft) in Big Wood River, Little Wood River, Boise River, Shoshone Creek, and Silver Creek, Idaho.

	Total length (in)				
Depth (ft)	0.0 - 2.0	2.1 - 4.0	4.1 - 6.0	6.1 - 8.0	>8.0
0.0	-	-	-	-	-
0.1	-	-	-	-	-
0.2	-	-	-	-	-
0.3	-	-	-	-	-
0.4	-	-	-	-	-
0.5	-	-	-	-	-
0.6	-	-	-	-	-
0.7	-	2	-	1	-
0.8	-	2	-	-	1
0.9	-	-	1	-	1
1.0	-	1	1	-	-
1.1	-	2	2	4	4
1.2	-	3	2	-	1
1.3	-	1	2	2	3
1.4	-	3	3	3	1
1.5	-	2	6	1	6
1.6	1	1	4	6	2
1.7	-	4	4	3	2
1.8	1	8	3	5	1
1.9	-	-	1	4	6
2.0	-	6	3	6	7
2.1	-	5	1	1	6
2.2	-	1	2	2	5
2.3	-	2	1	4	2
2.4	-	1	7	5	4
2.5	-	7	2	1	-
2.6	-	1	1	3	6
2.7	-	-	-	-	-
2.8	-	-	-	2	-
2.9	-	-	3	1	1
3.0	-	1	-	-	1
3.1	-	-	-	-	-
3.2	-	1	-	-	1
3.3	-	-	-	1	5
3.4	-	-	2	-	1
3.5	-	-	-	1	1
3.6	-	-	-	-	-
3.7	-	2	-	-	-
3.8	-	-	-	1	2
4.1	-	-	-	-	2
4.3	-	-	-	-	1
4.6	-	1	-	-	-
6.6	-	-	-	-	1
$\bar{X}$	-	1.95	1.91	2.00	2.27
n	-	57	51	57	74

Table 8. Summation of observations of brown trout at different velocities (fps) in Big Wood River, Boise River, Little Wood River, Silver Creek and Shoshone Creek, Idaho.

	Total length (in)				
Velocity (fps)	0.0 - 2.0	2.1 - 4.0	4.1 - 6.0	6.1 - 8.0	> 8.0
0.0	1	11	4	7	22
0.1	1	-	1	-	-
0.2	-	2	1	3	2
0.3	-	2	1	1	7
0.4	-	5	2	1	3
0.5	1	4	4	7	7
0.6	-	9	5	10	2
0.7	-	6	4	2	4
0.8	-	1	5	6	5
0.9	1	1	2	2	1
1.0	-	4	5	3	3
1.1	-	4	3	2	3
1.2	-	3	2	2	2
1.3	-	-	1	-	1
1.4	-	-	2	4	5
1.5	-	3	4	3	-
1.6	-	3	1	-	1
1.7	-	-	2	-	1
1.8	-	-	1	2	1
1.9	-	-	-	2	1
2.0	-	-	-	-	-
2.2	-	-	-	-	-
2.3	-	-	-	-	-
2.4	-	-	-	-	-
2.5	-	-	-	-	-
2.6	-	1	-	-	-
2.7	-	-	1	-	-
2.8	-	-	-	-	-
2.9	-	-	-	-	-
3.0	-	-	-	-	-
3.1	-	-	-	-	-
3.2	-	-	-	-	-
3.3	-	-	-	-	-
3.4	-	-	-	-	-
3.5	-	-	-	-	-
3.6	-	-	-	-	-
3.7	-	-	-	-	-
3.8	-	-	-	-	-
3.9	-	-	-	-	-
4.0	-	-	-	-	-
$\overline{X}$	-	0.68	0.89	0.78	0.56
n	-	59	51	57	71

Table 9. Summation of observations of mountain whitefish at different depth (ft) in Big Wood River, Silver Creek, Boise River, South Fork Boise River, and Salmon Falls Creek, Idaho.

	Total length (in)				
Depth (ft)	0.0 - 2.0	2.1 - 4.0	4.1 - 6.0	6.1 - 8.0	> 8.0
0.0	-	-	-	-	-
0.1	-	-	-	-	-
0.2	-	-	-	-	-
0.3	-	-	-	-	-
0.4	-	-	-	-	-
0.5	-	-	-	-	-
0.6	-	-	-	-	-
0.7	-	-	-	3	-
0.8	-	1	1	5	4
0.9	-	-	2	1	1
1.0	-	-	5	11	4
1.1	-	-	-	4	9
1.2	-	-	1	4	11
1.3	-	1	4	9	6
1.4	-	-	9	5	36
1.5	-	-	1	-	20
1.6	-	6	1	-	20
1.7	-	1	2	7	44
1.8	-	-	-	-	19
1.9	-	2	3	2	27
2.0	-	2	-	4	9
2.1	-	-	-	1	5
2.2	-	-	1	3	29
2.3	-	-	1	2	16
2.4	-	-	1	9	68
2.5	-	1	-	1	15
2.6	-	-	1	5	37
2.7	-	1	2	3	7
2.8	-	5	3	-	17
2.9	-	-	-	-	13
3.0	-	1	-	-	15
3.1	-	-	1	-	7
3.2	-	-	-	1	13
3.3	-	-	-	-	14
3.4	-	-	-	-	9
3.5	-	-	-	-	5
3.6	-	-	-	-	2
3.7	-	-	-	-	22
3.8	-	-	-	-	5
3.9	-	-	-	-	5
4.0	-	-	-	-	-
$\bar{X}$	-	2.07	1.67	1.64	2.28
n	-	21	39	80	514

Table 10. Summation of observations of mountain whitefish at different velocities (fps) in Big Wood River, Silver Creek, Boise River, South Fork Boise River, and Salmon Falls Creek, Idaho.

	Total length (in)				
Velocity (fps)	0.0 - 2.0	2.1 - 4.0	4.1 - 6.0	6.1 - 8.0	> 8.0
0.0	-	-	1	-	8
0.1	-	-	-	-	-
0.2	-	-	-	-	1
0.3	-	-	1	-	1
0.4	-	-	1	1	1
0.5	-	1	-	1	3
0.6	-	-	-	-	5
0.7	-	-	-	6	24
0.8	-	1	-	-	9
0.9	-	1	-	-	9
1.0	-	5	5	1	10
1.1	-	-	3	2	38
1.2	-	4	3	2	3
1.3	-	2	8	14	31
1.4	-	-	1	6	28
1.5	-	1	8	18	72
1.6	-	-	-	2	24
1.7	-	-	1	5	15
1.8	-	-	1	1	31
1.9	-	-	-	-	12
2.0	-	-	3	8	39
2.1	-	-	1	3	34
2.2	-	-	-	-	24
2.3	-	2	-	4	15
2.4	-	-	-	-	2
2.5	-	-	-	-	-
2.6	-	-	1	3	32
2.7	-	1	-	2	25
2.8	-	-	-	-	4
2.9	-	1	3	9	2
3.0	-	-	-	-	1
3.1	-	-	-	-	4
3.2	-	-	-	-	4
3.3	-	-	-	1	-
3.4	-	-	-	-	-
3.5	-	-	-	-	-
3.6	-	-	-	-	6
3.7	-	-	-	-	1
3.8	-	-	-	-	1
3.9	-	-	-	1	1
4.0	-	-	-	-	2
$\bar{X}$	-	1.38	1.45	1.73	1.73
n	-	19	41	90	522

Table 11. Summation of observations of brook trout at different depths (ft) in Big Wood River, Little Wood River, Elk Creek, Emerald Creek, Mica Creek, Quigley Creek, Palouse River, and North Fork Potlatch River, Idaho.

	Total length (in)				
Depth (ft)	0.0 - 2.0	2.1 - 4.0	4.1 - 6.0	6.1 - 8.0	>8.0
0.0	-	-	-	-	-
0.1	-	-	-	-	-
0.2	-	-	-	-	-
0.3	1	-	-	-	-
0.4	7	-	1	-	1
0.5	7	1	-	1	-
0.6	3	1	4	2	2
0.7	-	2	13	-	-
0.8	2	2	6	2	1
0.9	-	6	10	3	1
1.0	2	3	20	3	4
1.1	-	5	12	5	-
1.2	-	3	5	3	2
1.3	-	12	8	7	-
1.4	-	5	13	6	1
1.5	-	4	14	6	-
1.6	-	-	8	1	-
1.7	-	4	3	2	1
1.8	-	5	8	4	2
1.9	-	3	5	3	1
2.0	-	2	5	3	3
2.1	-	-	4	-	1
2.2	-	-	4	4	1
2.3	-	4	4	1	1
2.4	-	1	6	-	-
2.5	-	4	2	-	-
2.6	-	8	-	1	-
2.7	-	-	-	-	-
2.8	-	-	-	-	-
2.9	-	-	-	-	-
3.0	-	-	-	-	-
3.1	-	1	-	-	-
3.2	-	-	1	-	-
3.3	-	-	-	-	1
3.4	-	-	-	-	-
3.5	-	-	-	-	-
3.6	-	-	-	-	-
3.7	-	-	-	-	-
3.8	-	-	-	-	-
5.6	-	1	-	-	-
$\bar{X}$	0.55	1.65	1.38	1.44	1.55
n	22	77	156	57	24

Table 12. Summation of observations of brook trout at different velocities (fps) in Big Wood River, Mica Creek, Boise River, Palouse River, Potlatch River, Quigley Creek, Elk Creek, and Emerald Creek, Idaho.

	Total length (in)				
Velocity (fps)	0.0 - 2.0	2.1 - 4.0	4.1 - 6.0	6.1 - 8.0	> 8.0
0.0	18	5	14	4	4
0.1	2	1	-	5	-
0.2	1	4	17	12	1
0.3	-	15	16	1	1
0.4	-	-	14	3	1
0.5	1	15	13	3	-
0.6	-	9	22	6	2
0.7	-	8	7	2	-
0.8	-	2	7	2	1
0.9	-	6	3	1	2
1.0	-	7	10	4	3
1.1	-	2	6	2	2
1.2	-	2	3	1	-
1.3	-	-	10	2	-
1.4	-	1	3	1	1
1.5	-	1	6	2	1
1.6	-	-	1	1	3
1.7	-	-	2	1	3
1.8	-	-	2	-	1
1.9	-	-	1	-	1
2.0	-	-	-	1	1
2.1	-	-	-	-	1
2.2	-	-	-	1	1
2.3	-	-	-	-	-
2.4	1	-	-	1	-
2.5	-	-	-	-	-
2.6	-	-	1	1	-
2.7	-	-	-	1	-
2.8	-	-	-	-	-
2.9	-	-	-	-	-
3.0	-	-	-	-	-
3.1	-	-	-	-	-
3.2	-	-	-	-	-
3.3	-	-	-	-	-
3.4	-	-	-	-	-
3.5	-	-	-	-	-
3.6	-	-	-	-	-
3.7	-	-	-	1	-
3.8	-	-	-	-	-
3.9	-	-	-	-	-
4.0	-	-	-	-	-
$\overline{X}$	0.13	0.58	0.67	0.74	1.09
n	22	78	158	58	30

Table 13. Summation of observations of largemouth bass at different depths (ft) in Payette River, Palouse River, Salmon Falls Creek, and Spring Valley Reservoir outlet, Idaho.

	Total length (in)				
Depth (ft)	0.0 - 2.0	2.1 - 4.0	4.1 - 6.0	6.1 - 8.0	≥8.0
0.0	-	-	-	-	-
0.1	-	-	-	-	-
0.2	-	-	-	-	-
0.3	-	-	-	-	-
0.4	-	-	-	-	-
0.5	-	3	10	2	-
0.6	-	-	-	-	-
0.7	-	-	-	-	-
0.8	-	-	-	-	-
0.9	-	10	8	4	-
1.0	1	2	5	-	-
1.1	-	-	3	-	-
1.2	-	2	1	-	-
1.3	-	1	2	2	-
1.4	-	4	4	2	-
1.5	-	1	-	-	-
1.6	-	17	23	-	-
1.7	-	-	-	-	-
1.8	-	-	-	-	-
1.9	-	-	-	1	-
2.0	-	-	1	-	-
2.1	-	-	1	-	-
2.2	-	2	1	1	-
2.3	-	-	-	-	-
2.4	-	-	-	1	-
2.5	-	-	-	-	-
2.6	-	-	-	-	-
2.7	-	-	-	-	-
2.8	-	-	-	-	-
2.9	-	-	-	-	-
3.0	-	-	-	-	-
3.1	-	-	-	-	-
3.2	-	-	-	-	-
3.3	-	-	-	-	-
3.4	-	-	-	-	-
3.5	-	-	-	-	-
3.6	-	-	-	-	-
3.7	-	-	-	-	-
3.8	-	-	-	-	-
3.9	-	-	-	-	-
4.0	-	-	-	-	-
$\overline{X}$	-	1.31	1.24	1.27	-
n	-	42	59	13	

Table 14. Summation of observations of largemouth bass at different velocities (fps) in Payette River, Palouse River, Salmon Falls Creek, and Spring Valley Reservoir outlet, Idaho.

	Total length (in)				
Velocity (fps)	0.0 - 2.0	2.1 - 4.0	4.1 - 6.0	6.1 - 8.0	>8.0
0.0	1	31	36	9	-
0.1	-	2	7	1	-
0.2	-	-	-	-	-
0.3	-	-	-	-	-
0.4	-	2	10	4	-
0.5	-	10	8	4	-
0.6	-	-	-	-	-
0.7	-	17	9	1	-
0.8	-	-	3	-	-
0.9	-	1	-	-	-
1.0	-	-	-	-	-
1.1	-	-	-	-	-
1.2	-	-	-	-	-
1.3	-	-	-	-	-
1.4	-	-	-	-	-
1.5	-	-	-	-	-
1.6	-	-	-	-	-
1.7	-	-	-	-	-
1.8	-	-	-	-	-
1.9	-	-	-	-	-
2.0	-	-	-	-	-
2.1	-	-	-	-	-
2.2	-	-	-	-	-
2.3	-	-	-	-	-
2.4	-	-	-	-	-
2.5	-	-	-	-	-
2.6	-	-	-	-	-
2.7	-	-	-	-	-
2.8	-	-	-	-	-
2.9	-	-	-	-	-
3.0	-	-	-	-	-
3.1	-	-	-	-	-
3.2	-	-	-	-	-
3.3	-	-	-	-	-
3.4	-	-	-	-	-
3.5	-	-	-	-	-
3.6	-	-	-	-	-
3.7	-	-	-	-	-
3.8	-	-	-	-	-
3.9	-	-	-	-	-
4.0	-	-	-	-	-
$\overline{X}$	-	0.30	0.24	0.23	-
n	-	63	73	19	-

Table 15. Summation of observations of smallmouth bass at different depths (ft) in Malad River, Big Wood River, Mores Creek, Payette River, and Salmon Falls Creek, Idaho.

	Total length (in)				
Depth (ft)	0.0 - 2.0	2.1 - 4.0	4.1 - 6.0	6.1 - 8.0	>8.0
0.0	-	-	-	-	-
0.1	-	-	-	-	-
0.2	-	-	-	-	-
0.3	-	-	-	-	-
0.4	-	-	-	-	-
0.5	-	-	-	-	-
0.6	-	-	-	-	-
0.7	-	-	1	-	-
0.8	-	-	3	1	-
0.9	-	-	2	1	-
1.0	-	1	5	1	-
1.1	-	3	11	-	-
1.2	-	5	15	4	3
1.3	-	3	17	5	-
1.4	-	1	16	1	1
1.5	-	7	20	5	2
1.6	-	-	11	3	5
1.7	-	-	1	6	-
1.8	-	-	1	-	2
1.9	-	1	3	-	2
2.0	-	4	3	-	2
2.1	-	-	-	-	-
2.2	-	4	3	-	-
2.3	-	-	1	1	-
2.4	-	-	-	2	-
2.5	-	-	-	-	-
2.6	-	-	-	-	-
2.7	-	-	-	1	-
2.8	-	-	-	-	-
2.9	-	-	1	-	1
3.0	-	-	2	-	-
3.1	-	-	-	-	-
3.2	-	-	-	-	-
3.3	-	-	-	-	1
3.4	-	-	-	-	-
3.5	-	-	-	-	-
3.6	-	-	-	-	-
3.7	-	-	-	-	1
3.8	-	-	-	-	-
3.9	-	-	-	-	-
4.0	-	-	-	-	-
$\bar{X}$	-	1.54	1.42	1.54	1.87
n	-	29	116	31	20

Table 16. Summation of observations of smallmouth bass at different velocities (fps) in Big Wood River, Mores Creek, Payette River, Malad River, and Salmon Falls Creek, Idaho.

	Total length (in)				
Velocity (fps)	0.0 - 2.0	2.1 - 4.0	4.1 - 6.0	6.1 - 8.0	>8.0
0.0	-	9	18	3	7
0.1	-	-	-	-	-
0.2	-	1	2	1	-
0.3	-	3	5	1	1
0.4	-	-	9	-	-
0.5	-	1	3	1	1
0.6	-	-	4	1	-
0.7	-	1	1	2	-
0.8	-	4	4	5	1
0.9	-	6	11	1	1
1.0	-	1	6	-	-
1.1	-	-	10	-	1
1.2	-	-	7	2	-
1.3	-	-	10	2	1
1.4	-	-	1	1	1
1.5	-	-	5	4	-
1.6	-	1	7	2	3
1.7	-	1	2	-	1
1.8	-	-	5	-	2
1.9	-	-	-	2	-
2.0	-	-	4	-	1
2.1	-	-	2	-	1
2.2	-	-	-	1	-
2.3	-	-	1	-	-
2.4	-	-	-	-	-
2.5	-	-	-	-	2
2.6	-	-	-	-	-
2.7	-	-	-	-	-
2.8	-	-	-	-	-
2.9	-	-	-	-	-
3.0	-	-	-	-	-
3.1	-	-	-	-	-
3.2	-	-	-	-	-
3.3	-	-	-	-	-
3.4	-	-	-	-	-
3.5	-	-	-	-	-
3.6	-	-	-	-	-
3.7	-	-	-	-	-
3.8	-	-	-	-	-
3.9	-	-	-	-	-
4.0	-	-	-	-	-
$\bar{X}$	-	0.54	0.93	1.02	0.94
n	-	28	117	29	21

CHAPTER V

TASK IV, DATA COLLECTION

Chapter V

Task IV

DATA COLLECTION

Two important tasks in this project are to collect data in a standard procedure so other investigators can duplicate efforts and keep variability to a minimum, and to process data efficiently so errors do not cause undue time loss and increased costs. So, it is important for investigators to describe their techniques accurately, and in sufficient detail to make the job easier for others who wish to use a given methodology. Over the past several years each of the methodologies evaluated has been described in detail, or in part by the many investigators pioneering their use or using them after their initial development.

To avoid repetition, the reader unfamiliar with these methodologies is referred to the literature citings in this report. If descriptions from the literature appear inadequate or incomplete, additional information on techniques is offered here.

DESCRIPTION OF METHODOLOGIES

1. Single cross section computer program (acronyms=IFG1, SCSIFM) was developed by Robert Milhous (1978) from the U. S. Forest Service R2 Cross computer program. Hydraulic information is predicted with either the stage-discharge approach or the Manning equation. Output from this program is interfaced with biological criteria taken from the probability of use curves of indicator species and life stages for each study section (Bovee and Cochnauer 1977).

An average velocity and width of the stream at specified depths is needed from IFG1 to process the biological criteria. A weighting factor for velocity and each of the specified depths is obtained from the probability of use curves. Substrate, temperature, and cover were all weighted with a value of 1, or essentially ignored since selection of the cross section by a biologist is expected to be in a favorable location for the species of concern. The weighting factors are then multiplied by the width of stream (in feet) available for a given depth. This value is multiplied by 1,000 feet of stream length to give a square foot value of available habitat for that reach. This is what occurs using the IFG incremental habitat (WSP) method, only without the use of the computer.

The only documentation available to the authors is the manual for the Single Cross Section program (Milhous 1978) and IFG Information Paper #5 (Bovee and Milhous 1978). Of the methodologies evaluated in this paper, this is the least documented and tested.

2. The IFG Incremental Method (WSP). The Water Surface Profile computer program was developed by the U.S. Bureau of Reclamation (anon 1967) to study tailraces of dams constructed by the Bureau. It is referred to as PSUEDO or WSP in its original form, and a modified version of IFG2. This is an energy balance model, using the Manning equation and one set of calibration measurements to predict the hydraulic information. It is interfaced with the Incremental Habitat Analysis computer program (HABTAT or IFG3) developed by Robert Main (1978A) for the IFG. Both programs are well documented from a variety of sources (Anon 1978; Bovee 1977; Bovee and Cochnauer 1977; Bovee and Milhous 1978; Cochnauer 1976A; Dooley 1976; Graham and

and Penkal 1978; Prewitt and Carlson 1977; Spence 1976; White and Cochnauer 1975; White 1976.

3. The IFG Incremental Method (IFG4). Robert Main (1978B) developed the IFG4 computer program to supply the hydraulic information to the HABTAT computer program. IFG4 develops the hydraulic simulation through two (preferably three) or more stage and velocity measurements from which a stage discharge relationship is formed. This methodology has been tested with several sets of data and is moderately documented (Anon. 1978; Bovee 1977; Bovee and Cochnauer 1977; Bovee and Milhous 1978; Main 1978A; Prewitt and Carlson 1977).

4. The Idaho Method. Based on hydraulic information supplied by WSP, the Idaho method links WSP with the Wetted Perimeter computer program (WETPER) developed by the U.S. Bureau of Reclamation and biological criteria for rearing, spawning and passage of indicator species (Collins 1974). White (White and Cochnauer 1975; White 1976) proposed the methodology and Cochnauer (1976A, 1976B, 1977, 1978, 1979; White and Cochnauer 1975) used it extensively. Although it was designed for large unwadeable rivers, the Idaho method is easily adapted to small streams. Wyoming Water Resources Institute personnel (Anon. 1978) also summarized the field techniques.

5. The Montana Method. Donald Tennant (1976) used 10 years of data on several streams to devise a non-field methodology using historic flow records from U.S. Geological Survey gaging stations. The average annual discharge or flow is the basis for all recommendations. Ten percent of the average flow is the minimum instantaneous flow recommended to sustain short term survival habitat for most aquatic life forms. Thirty percent is recommended to sustain good survival conditions for most aquatic life forms. Other investigators reported on it (Anon. 1978; Prewitt and Carlson 1977; Stalnaker and Arnette 1976).

CHAPTER VI

TASK V, COST AND MANPOWER REQUIREMENTS

AND

DETERMINATION OF WATER NEEDS

Chapter VI

Task V

COST AND MANPOWER REQUIREMENTS

AND

DETERMINATION OF WATER NEEDS

Tables 17-22 are condensed forms showing costs and manpower requirements, and recommended flows for each stream and methodology. An explanation on how some of the values were derived is presented here to clarify comparisons with other investigators assessing costs and manpower needs. When determining manpower requirements it is assumed that any crew will have some experience at each method. Sufficient expertise can be learned with one field trip to qualify an individual as experienced. Only novice crew members should be expected to take more time to perform field duties. This same analogy should be true for data processing and computer work.

No initial costs were incurred by the Idaho Department of Fish and Game since all equipment has been in use for several years in Idaho's instream flow program. Manpower costs are computed at $5.00 per hour per person. This gives an easy figure to work with, and is close to the average wage of temporary and permanent employees combined.

Each table has recommended instream flows (median condition) and a low flow contingency plan. The Montana Method uses 30% of the average annual discharge for its median condition flow recommendation. This regimen differs from that recommended by Tennant (1976) since mean monthly discharges through the summer months are consistently below the 50% average annual flow recommended for the April-September period. For the Idaho Method the flow recommendations were determined by correlating wetted perimeter with the discharge (Cochnauer 1976A). The recommended quantity of water was selected at the inflection point where wetted perimeter increases slowly while the discharge increases rapidly (Appendix, Fig. A7-A12).

The other methods correlated biological criteria and hydraulic information with discharge. Four indicator fish species were chosen for each stream and the amount of habitat available to each species predicted by the programs was plotted against the respective discharge. Starting at zero discharge, the weighted value of habitat increases rapidly for small increases in discharge up to a point where the habitat value increases slowly while discharge increases rapidly. At this inflection point, the greatest amount of weighted habitat is available for the least amount of flow, and is selected at the flow recommendation for a particular life history phase.

To assimilate flow recommendation for the selected biological activities of all indicator species, a periodicity chart was completed for each study stream (Tables 23-28). The flow determination for each life history phase is arrayed according to the applicable period. The recommended flow regime for each stream is determined by selecting the highest flow required to accommodate all biological activities each month.

The contingency low flow for the Montana method is 10% of the average annual discharge, but the low flows for the other methods are taken from U.S. Geological Survey data as the mean daily flow that is exceeded 90% of the time (Kjelstrom, personal communication and unpublished data).

Table 17. Cost-manpower requirements and instream flow recommendations for selected methodologies on Hayden Creek.

Stream Name: Hayden Creek State: Idaho
Stream Segment: From North Fork Hayden Creek at R.M. 2.5 downstream to Hayden Lake at R.M. 0.0
Coldwater or Warmwater Coldwater Wadable: Yes x No __
Gage Station at R.M. 2.0

	UNITS	Montana Method	Single X-Section Method IFG1	IFG Incremental Method (WSP)	IFG Incremental Method (IFG4)	Idaho Method
Total Manpower Req	Person-hours	2	16	22	27	23
Pre-Field Work	%	-	6.25	4.5	3.7	4.3
Planning						
Field Effort	%	-	37.5	54.6	44.4	52.2
Data Processing	%	50	6.25	18.2	22.2	17.4
Analysis and Interpretation	%	50	50.0	22.7	29.6	26.1
Crew Size	#	1	3	3	3	3
Costs	$	10	81.30	125.00	141.00	126.60
Initial Costs	%	-	-	-	-	-
Manpower Costs	%	100	98.4	88.0	95.7	90.8
Machine Time Costs	%	-	1.6	12.0	4.3	9.2
Applications Required to Become Proficient	#	1	1	1	1	2
Recommended Instream Flows (median condition)						
October	cfs	8.82	21.5	30.0	25	10
November	cfs				25	
December	cfs				25	
January	cfs				25	
February	cfs				25	
March	cfs				25	
April	cfs				30	
May	cfs				30	
June	cfs				30	
July	cfs				30	
August	cfs				25	
September	cfs	8.82	21.5	30.0	25	10
Ave. Annual	cfs	8.82	21.5	30.0	26.7	10
Contingency Plan (1-in-10 year low flow condition)						
October	cfs	2.94	4.10	4.10	4.10	4.10
November	cfs					
December	cfs					
January	cfs					
February	cfs					
March	cfs					
April	cfs					
May	cfs					
June	cfs					
July	cfs					
August	cfs					
September	cfs	2.94	4.10	4.10	4.10	4.10
Ave. Annual	cfs	2.94	4.10	4.10	4.10	4.10

Table 18. Cost-manpower requirements and instream flow recommendations for selected methodologies on South Fork Clearwater River.

Stream Name: South Fork Clearwater River State: Idaho
Stream Segment: From Highway 13 Bridge at R.M. 11.4 downstream to Clearwater River at R.M. 0.0
Coldwater or Warmwater Coldwater Wadable Yes ___ No x
Gage Station at R.M. 4.0

	UNITS	Montana Method	Single X-Section Method IFG1	IFG Incremental Method (WSP)	IFG Incremental Method (IFG4)	Idaho Method
Total Manpower Req.	Person-hours	2	16	22	27	23
Pre-Field Work Planning	%	-	6.25	4.5	3.7	4.3
Field Effort	%	-	37.5	54.6	44.4	52.2
Data Processing	%	50	6.25	18.2	22.2	17.4
Analysis and Interpretation	%	50	50.0	22.7	29.6	26.1
Crew Size	#	1	3	3	3	3
Costs	$	10	81.30	125.00	141.00	126.60
Initial Costs	%	-	-	-	-	-
Manpower Costs	%	100	98.4	88.0	95.7	90.8
Machine Time Costs	%	-	1.6	12.0	4.3	9.2
Applications Required to Become Proficient	#	1	1	1	1	2
Recommended Instream Flows (median condition)						
October	cfs	328	162	206	300	180
November	cfs		162		300	
December	cfs		162		300	
January	cfs		162		300	
February	cfs		162		300	
March	cfs		162		300	
April	cfs		162		300	
May	cfs		162		300	
June	cfs		162	206	300	
July	cfs		134	100	100	
August	cfs		134	100	100	
September	cfs	328	134	100	100	180
Ave. Annual	cfs	328	155	179.5	250	180
Contingency Plan (1-in-10 year low flow condition)						
October	cfs	109	200	200	200	200
November	cfs					
December	cfs					
January	cfs					
February	cfs					
March	cfs					
April	cfs					
May	cfs					
June	cfs					
July	cfs					
August	cfs					
September	cfs	109	200	200	200	200
Ave. Annual	cfs	109	200	200	200	200

Table 19. Cost-manpower requirements and instream flow recommendations for selected methodologies on Clearwater River.

Stream Name: Clearwater River State: Idaho
Stream Segment: From North Fork Clearwater at R.M. 40.4 downstream to Potlatch River at R.M. 15.1
Coldwater or Warmwater Coolwater Wadable Yes___ No x
Gage Station at R.M. 28.5

	UNITS	Montana Method	Single X-Section Method IFG1	IFG Incremental Method (WSP)	IFG Incremental Method (IFG4)	Idaho Method
Total Manpower Req.	Person-hours	2	16	22	27	23
Pre-Field Work	%	-	6.25	4.5	3.7	4.3
Planning						
Field Effort	%	-	37.5	54.6	44.4	52.2
Data Processing	%	50	6.25	18.2	22.2	17.4
Analysis and Interpretation	%	50	50.0	22.7	29.6	26.1
Crew Size	#	1	3	3	3	3
Costs	$	10	81.30	125.00	141.00	126.60
Initial Costs	%	-	-	-	-	-
Manpower Costs	%	100	98.4	88.0	95.7	90.8
Machine Time Costs	%	-	1.6	12.0	4.3	9.2
Applications Required to Become Proficient	#	1	1	1	1	2
Recommended Instream Flows (median condition)						
October	cfs	4716	2000	4830	2500	3100
November	cfs			4830		
December	cfs			4830		
January	cfs			4830		
February	cfs			4830		
March	cfs			4830		
April	cfs			4830		
May	cfs			4830		
June	cfs			4830		
July	cfs			2500		
August	cfs			2500		
September	cfs	4716	2000	4830	2500	3100
Ave. Annual	cfs	4716	2000	4442	2500	3100
Contingency Plan (1-in-10 year low flow condition)						
October	cfs	1572	3100	3100	3100	3100
November	cfs					
December	cfs					
January	cfs					
February	cfs					
March	cfs					
April	cfs					
May	cfs					
June	cfs					
July	cfs					
August	cfs					
September	cfs	1572	3100	3100	3100	3100
Ave. Annual	cfs	1572	3100	3100	3100	3100

Table 20. Cost-manpower requirements and instream flow recommendations for selected methodologies on Snake River.

Stream Name: Snake River State: Idaho
Stream Segment: From Grande Rhonde River at R.M. 168.5 downstream to Clearwater River at R.M. 139.3
Coldwater or Warmwater Warmwater Wadable Yes___ No x
Gage Station at R.M. 167.4

	UNITS	Montana Method	Single X-Section Method IFG1	IFG Incremental Method (WSP)	IFG Incremental Method (IFG4)	Idaho Method
Total Manpower Req	Person-hours	2	16	22	27	23
Pre-Field Work	%	-	6.25	4.5	3.7	4.3
Planning						
Field Effort	%	-	37.5	54.6	44.4	52.2
Data Processing	%	50	6.25	18.2	22.2	17.4
Analysis and Interpretation	%	50	50.0	22.7	29.6	26.1
Crew Size	#	1	3	3	3	3
Costs	$	10	81.30	125.00	141.00	126.60
Initial Costs	%	-	-	-	-	-
Manpower Costs	%	100	98.4	88.0	95.7	90.8
Machine Time Costs	%	-	1.6	12.0	4.3	9.2
Applications Required to Become Proficient	#	1	1	1	1	2
Recommended Instream Flows (median condition)						
October	cfs	10890	18000	10000	5000	15000
November	cfs					
December	cfs					
January	cfs					
February	cfs					
March	cfs					
April	cfs					
May	cfs					
June	cfs					
July	cfs					
August	cfs					
September	cfs	10890	18000	10000	5000	15000
Ave. Annual	cfs	10890	18000	10000	5000	15000
Contingency Plan (1-in-10 year low flow condition)						
October	cfs	3630	18000	18000	18000	18000
November	cfs					
December	cfs					
January	cfs					
February	cfs					
March	cfs					
April	cfs					
May	cfs					
June	cfs					
July	cfs					
August	cfs					
September	cfs	3630	18000	18000	18000	18000
Ave. Annual	cfs	3630	18000	18000	18000	18000

Table 21. Cost-manpower requirements and instream flow recommendations for selected methodologies on Boise River.

Stream Name: Boise River State: Idaho
Stream Segment: From Middleton Canal at R.M. 40.4 downstream to Caldwell Highline Canal at R.M. 32.4
Coldwater or Warmwater Coolwater Wadable Yes x No
Gage Station at R.M. 39.1

	UNITS	Montana Method	Single X-Section Method IFG1	IFG Incremental Method (WSP)	IFG Incremental Method (IFG4)	Idaho Method
Total Manpower Req.	Person-hours	2	16	22	27	23
Pre-Field Work	%	-	6.25	4.5	3.7	4.3
Planning						
Field Effort	%	-	37.5	54.6	44.4	52.2
Data Processing	%	50	6.25	18.2	22.2	17.4
Analysis and Interpretation	%	50	50.0	22.7	29.6	26.1
Crew Size	#	1	3	3	3	3
Costs	$	10	81.30	125.00	141.00	126.60
Initial Costs	%	-	-	-	-	-
Manpower Costs	%	100	98.4	88.0	95.7	90.8
Machine Time Costs	%	-	1.6	12.0	4.3	9.2
Applications Required to Become Proficient	#	1	1	1	1	2
Recommended Instream Flows (median condition)						
October	cfs	No Flow Records Available	332	400	400	87
November	cfs					
December	cfs					
January	cfs					
February	cfs					
March	cfs					
April	cfs					
May	cfs					
June	cfs					
July	cfs					
August	cfs					
September	cfs		332	400	400	87
Ave. Annual	cfs		332	400	400	87
Contingency Plan (1-in-10 year low flow condition)						
October	cfs	No Flow Records Available	No Flow Records Available	No Flow Records Available	No Flow Records Available	No Flow Records Available
November	cfs					
December	cfs					
January	cfs					
February	cfs					
March	cfs					
April	cfs					
May	cfs					
June	cfs					
July	cfs					
August	cfs					
September	cfs					
Ave. Annual	cfs					

Table 22. Cost-manpower requirements and instream flow recommendations for selected methodologies on Big Wood River.

Stream Name: Big Wood River State: Idaho
Stream Segment: From R.M. 27.0 downstream to Little Wood River at R.M. 11.9
Coldwater or Warmwater Warmwater Wadable Yes x No
Gage Station at R.M. 22.1

	UNITS	Montana Method	Single X-Section Method IFG1	IFG Incremental Method (WSP)	IFG Incremental Method (IFG4)	Idaho Method
Total Manpower Req.	Person-hours	2	16	22	27	23
Pre-Field Work Planning	%	-	6.25	4.5	3.7	4.3
Field Effort	%	-	37.5	54.6	44.4	52.2
Data Processing	%	50	6.25	18.2	22.2	17.4
Analysis and Interpretation	%	50	50.0	22.7	29.6	26.1
Crew Size	#	1	3	3	3	3
Costs	$	10	81.30	125.00	141.00	126.60
Initial Costs	%	-	-	-	-	-
Manpower Costs	%	100	98.4	88.0	95.7	90.8
Machine Time Costs	%	-	1.6	12.0	4.3	9.2
Applications Required to Become Proficient	#	1	1	1	1	2
Recommended Instream Flows (median condition)						
October	cfs	71	95	150	100	34
November	cfs					
December	cfs					
January	cfs					
February	cfs					
March	cfs					
April	cfs					
May	cfs					
June	cfs					
July	cfs					
August	cfs					
September	cfs	71	95	150	100	34
Ave. Annual	cfs	71	95	150	100	34
Contingency Plan (1-in-10 year low flow condition)						
October	cfs	23.6	No Flow Records Available	No Flow Records Available	No Flow Records Available	No Flow Records Available
November	cfs					
December	cfs					
January	cfs					
February	cfs					
March	cfs					
April	cfs					
May	cfs					
June	cfs					
July	cfs					
August	cfs					
September	cfs	23.6				
Ave. Annual	cfs	23.6				

It is important to realize that contingency low flows are derived from another source and with a concept different than the recommended instream flows for all but the Montana method. This information is reiterated to explain why a contingency low flow may be higher than a recommended instream flow for several of the streams.

Some water districts operate existing U.S.G.S. gaging stations as was discovered for our Big Wood River site. Therefore, data for this stream are available only for the irrigation season, April through September. Records (53 years) for this gage station were retrieved from archives of the U.S. Geological Survey, Boise Office. Flow determinations cannot be applied as the methodologies are intended; however, mean period and monthly discharges were tabulated for the irrigation season and given in Table 22.

It is understood that the 6-month irrigation period mean flow may not be representative of the mean annual flow, but it was used to calculate the Montana method values on the Big Wood River.

A similar problem occurred on the Boise River transect site. Because of heavy irrigation demand and location of the various gage stations with adequate historic flow, we were unable to locate a suitable transect near a gage station without loss of water occurring between the two. Therefore, recommendations for the Montana method and contingency low flows for all methods are not included for the Boise River.

Table 23. Instream flow recommendations (cfs) for different life history phases and methodologies in Hayden Creek.

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Montana Method 30%	8.82	8.82	8.82	8.82	8.82	8.82	8.82	8.82	8.82	8.82	8.82	8.82
IFG1												
Cutthroat												
Spawning	---	---	---	21.5	21.5	21.5	---	---	---	---	---	---
Incubation	---	---	---	26	26	26	26	---	---	---	---	---
Fry rearing	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8
Juvenile Rearing	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5
IFG Incremental(WSP)												
Cutthroat												
Spawning	---	---	---	7.4	7.4	7.4	---	---	---	---	---	---
Incubation	---	---	---	9.3	9.3	9.3	9.3	---	---	---	---	---
Fry Rearing	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Juvenile Rearing	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
IFG Incremental (IFG4)												
Cutthroat												
Spawning	---	---	---	15	15	15	---	---	---	---	---	---
Incubation	---	---	---	30	30	30	30	---	---	---	---	---
Fry Rearing	15	15	15	15	15	15	15	15	15	15	15	15
Juvenile Rearing	25	25	25	25	25	25	25	25	25	25	25	25
Idaho Method	10	10	10	10	10	10	10	10	10	10	10	10

Table 24. Instream flow recommendations (cfs) for different life history phases and methodologies in South Fork Clearwater River.

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Montana Method												
30%	328	328	328	328	328	328	328	328	328	328	328	328
IFG1												
Steelhead Trout												
Juvenile												
Rearing	134	134	134	134	134	134	134	134	134	134	134	134
Adult												
Rearing	162	162	162	162	162	162	---	---	---	162	162	162
Chinook Salmon												
Juvenile												
Rearing	98	98	98	98	98	98	98	98	98	98	98	98
IFG Incremental (WSP)												
Steelhead Trout												
Juvenile												
Rearing	100	100	100	100	100	100	100	100	100	100	100	100
Adult												
Rearing	206	206	206	206	206	206	---	---	---	206	206	206
Chinook Salmon												
Juvenile												
Rearing	100	100	100	100	100	100	100	100	100	100	100	100
IFG Incremental (IFG4)												
Steelhead Trout												
Juvenile												
Rearing	100	100	100	100	100	100	100	100	100	100	100	100
Adult												
Rearing	300	300	300	300	300	300	---	---	---	300	300	300
Chinook Salmon												
Juvenile												
Rearing	50	50	50	50	50	50	50	50	50	50	50	50
Idaho Method	180	180	180	180	180	180	180	180	180	180	180	180

Table 25. Instream flow recommendations (cfs) for different life history phases and methodologies in Clearwater River.

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Montana Method												
30%	4716	4716	4716	4716	4716	4716	4716	4716	4716	4716	4716	4716
IFG1												
Steelhead Trout												
Adult-rearing	1300	1300	1300	1300	1300	1300	---	---	1300	1300	1300	1300
Juv-rearing	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300
Rainbow Trout												
Adult-rearing	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Smallmouth Bass												
Adult-rearing	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
IFG Incremental (WSP)												
Steelhead Trout												
Adult-rearing	4830	4830	4830	4830	4830	4830	---	---	4830	4830	4830	4830
Juv-rearing	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Rainbow Trout												
Adult-rearing	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500
Smallmouth Bass												
Adult-rearing	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500
IFG Incremental (IFG4)												
Steelhead Trout												
Adult-rearing	2500	2500	2500	2500	2500	2500	---	---	2500	2500	2500	2500
Juv-rearing	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Rainbow Trout												
Adult-rearing	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500
Smallmouth Bass												
Adult-rearing	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500
Idaho Method	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100

Table 26. Instream flow recommendations (cfs) for different life history phases and methodologies in Snake River.

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Montana Method 30%	10890	10890	10890	10890	10890	10890	10890	10890	10890	10890	10890	10890
IFG1												
Smallmouth Bass												
Adult-rearing	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000
Juv-rearing	---	---	---	---	---	---	---	---	---	---	---	---
Channel Catfish												
Adult-rearing	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000
Juv-rearing	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000
IFG Incremental (WSP)												
Smallmouth Bass												
Adult-rearing	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
Juv-rearing	---	---	---	---	---	---	---	---	---	---	---	---
Channel catfish												
Adult-rearing	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
Juv-rearing	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
IFG Incremental (IFG4)												
Smallmouth Bass												
Adult-rearing	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
Juv-rearing	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500
Channel catfish												
Adult-rearing	---	---	---	---	---	---	---	---	---	---	---	---
Juv-rearing	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
Idaho Method	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000

Table 27. Instream flow recommendations (cfs) for different life history phases and methodologies in Boise River.

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Montana Method												
30%	---	---	---	NO FLOW RECORDS AVAILABLE				---	---	---	---	---
IFG1												
Rainbow Trout												
Adult-rearing	332	332	332	332	332	332	332	332	332	332	332	332
Juv-rearing	199	199	199	199	199	199	199	199	199	199	199	199
Smallmouth Bass												
Adult-rearing	332	332	332	332	332	332	332	332	332	332	332	332
Mountain Whitefish												
Adult-rearing	332	332	332	332	332	332	332	332	332	332	332	332
IFG Incremental (WSP)												
Rainbow Trout												
Adult-rearing	250	250	250	250	250	250	250	250	250	250	250	250
Juv-rearing	100	100	100	100	100	100	100	100	100	100	100	100
Smallmouth Bass												
Adult-rearing	400	400	400	400	400	400	400	400	400	400	400	400
Mountain Whitefish												
Adult-rearing	400	400	400	400	400	400	400	400	400	400	400	400
IFG Incremental (IFG4)												
Rainbow Trout												
Adult-rearing	300	300	300	300	300	300	300	0300	300	300	300	300
Juv-rearing	100	100	100	100	100	100	100	100	100	100	100	100
Smallmouth Bass												
Adult-rearing	400	400	400	400	400	400	400	400	400	400	400	400
Mountain Whitefish												
Adult-rearing	100	100	100	100	100	100	100	100	100	100	100	100
Idaho Method												
	87	87	87	87	87	87	87	87	87	87	87	87

Table 28. Instream flow recommendations (cfs) for different life history phases and methodologies in Big Wood River.

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Montana Method												
30%	71	71	71	71	71	71	71	71	71	71	71	71
IFG1												
Brown Trout												
Adult-rearing	95	95	95	95	95	95	95	95	95	95	95	95
Juv-rearing	95	95	95	95	95	95	95	95	95	95	95	95
Smallmouth Bass												
Adult-rearing	25	25	25	25	25	25	25	25	25	25	25	25
Juv-rearing	40	40	40	40	40	40	40	40	40	40	40	40
IFG Incremental (WSP)												
Brown Trout												
Adult-rearing	150	150	150	150	150	150	150	150	150	150	150	150
Juv-rearing	100	100	100	100	100	100	100	100	100	100	100	100
Smallmouth Bass												
Adult-rearing	---	---	---	---	NO RECOMMENDATIONS				---	---	---	---
Juv-rearing	130	130	130	130	130	130	130	130	130	130	130	130
IFG4 Incremental (IFG4)												
Brown Trout												
Adult-rearing	76	76	76	76	76	76	76	76	76	76	76	76
Juv-rearing	50	50	50	50	50	50	50	50	50	50	50	50
Smallmouth Bass												
Adult-rearing	---	---	---	---	NO RECOMMENDATIONS				---	---	---	---
Juv-rearing	100	100	100	100	100	100	100	100	100	100	100	100
Idaho Method	34	34	34	34	34	34	34	34	34	34	34	34

CHAPTER VII

TASK VI, EVALUATION OF EFFECTIVENESS OF SELECTED METHODOLOGIES

Chapter VII

Task VI

EVALUATION OF SELECTED METHODOLOGIES

Task VI showed the variability of the results in the determination of instream flow requirements using the different methodologies. The flow determinations are graphed with mean monthly flows (except Boise River) in Figures 10-14. Though flow recommendations varied, the values were less than the graphed mean monthly flow in all but two streams. The two exceptions were the two smallest study streams, Hayden Creek and Big Wood River.

All methodologies were assessed independently in an attempt to explain variability of flow determinations and effectiveness of each.

1. IFG1-preferred habitat. Before an investigator steps into the water, a critical judgment decision has to be made for IFG1. Placement of the cross section must either approximate the typical reach or be placed at a hydraulic control associated with a fish activity, i.e., rearing, spawning or passage. The multiple transects, covering complete pool-riffle cycles, were measured for other methodologies and the cross section assessed as most critical was chosen for IFG1.

Data collection is relatively easy, and straight forward. Use of the stage-discharge relationship as opposed to using the Manning equation, was preferred for predicting alternate flows. This necessitates at least three trips to the study site, but appears well worth the added time. Input into the computer program was easy because of brevity, especially when compared to the multiple cross section methods. However, it is hard to understand some terms presented in the IFG1 manual (Milhous 1978). For instance, datum of stage, zero stage, zero of stage, and stage of zero flow are used in describing stage discharge calculations on the same page. Once the terminology is understood then the computer work goes easy.

When processing hydraulic data through the program the outstanding shortcoming is inadequate velocity information. An average velocity for the entire cross section is all that is supplied, and when trying to relate this to habitat requirements for fry, juvenile, and adult fish, important information is lost in the process. If the program could be written with at least ten segments (preferably 25) detailing velocity and depth, the reliability of the data would be greatly improved.

The speed and precision of the computer can be greatly appreciated when the opportunity is presented to do habitat computations by hand calculator, as was done for this methodology. If the output from IFG1 can be interfaced with the HABTAT computer program this methodology will be more attractive to investigators.

2. IFG Incremental Method (WSP). The WSP program develops its predictive capability through use of Manning's equation and one set of calibration measurements. It is calibrated by adjusting roughness coefficients (Mannings's n) until the water surface elevations predicted by the computer approximate those measured in the field. The predicted velocities should also approximate those measured.

Examples showing problems with this type of hydraulic simulation are offered in Tables 29 and 30. Predicted and measured elevations on the South Fork Clearwater River (Table 29) varied less than 0.05 foot because each was calibrated to that degree of accuracy. But when hydraulic data from all flows are processed together

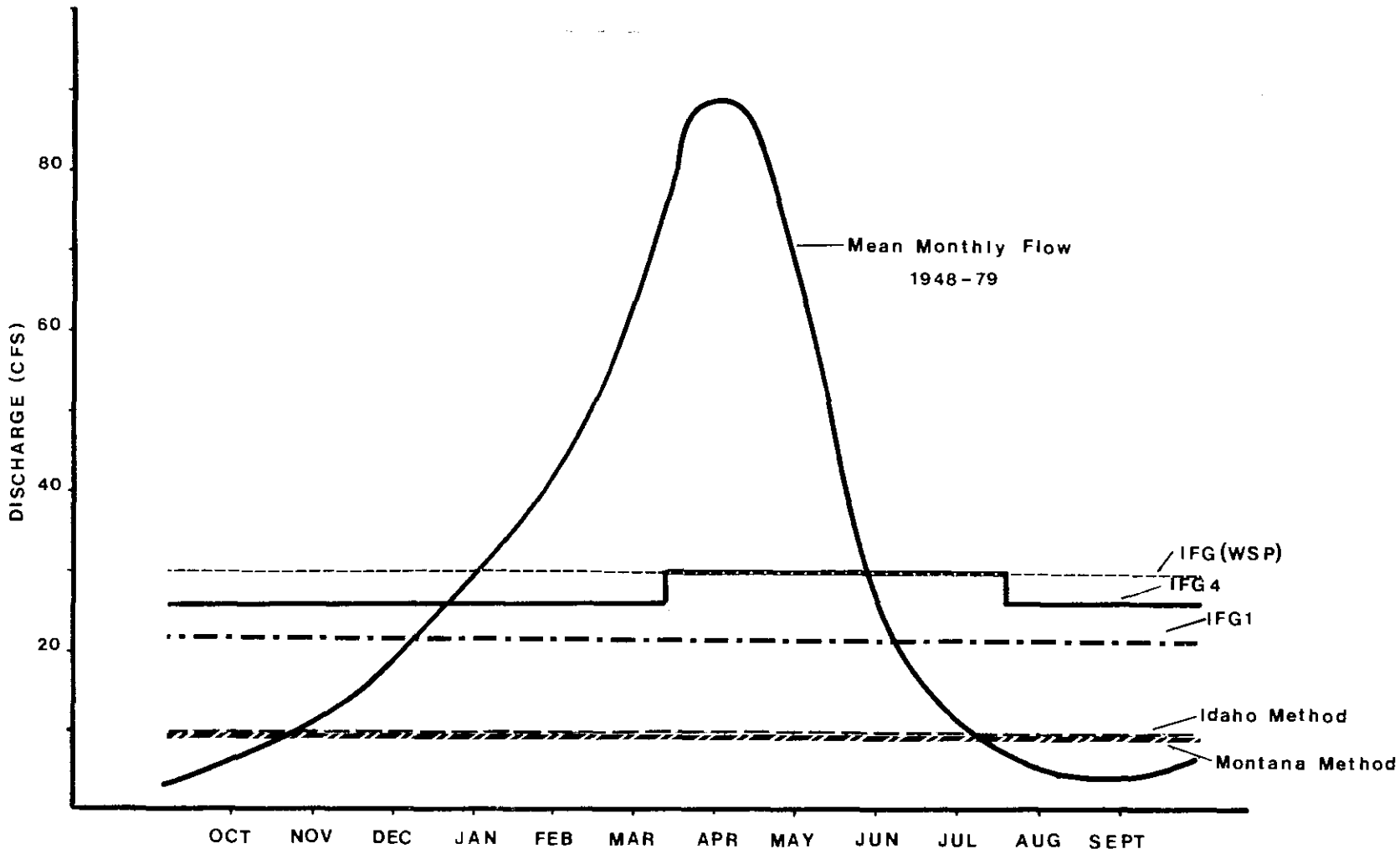

Figure 10. Instream flow recommendations graphed with mean monthly flows (1948-79) on Hayden Creek.

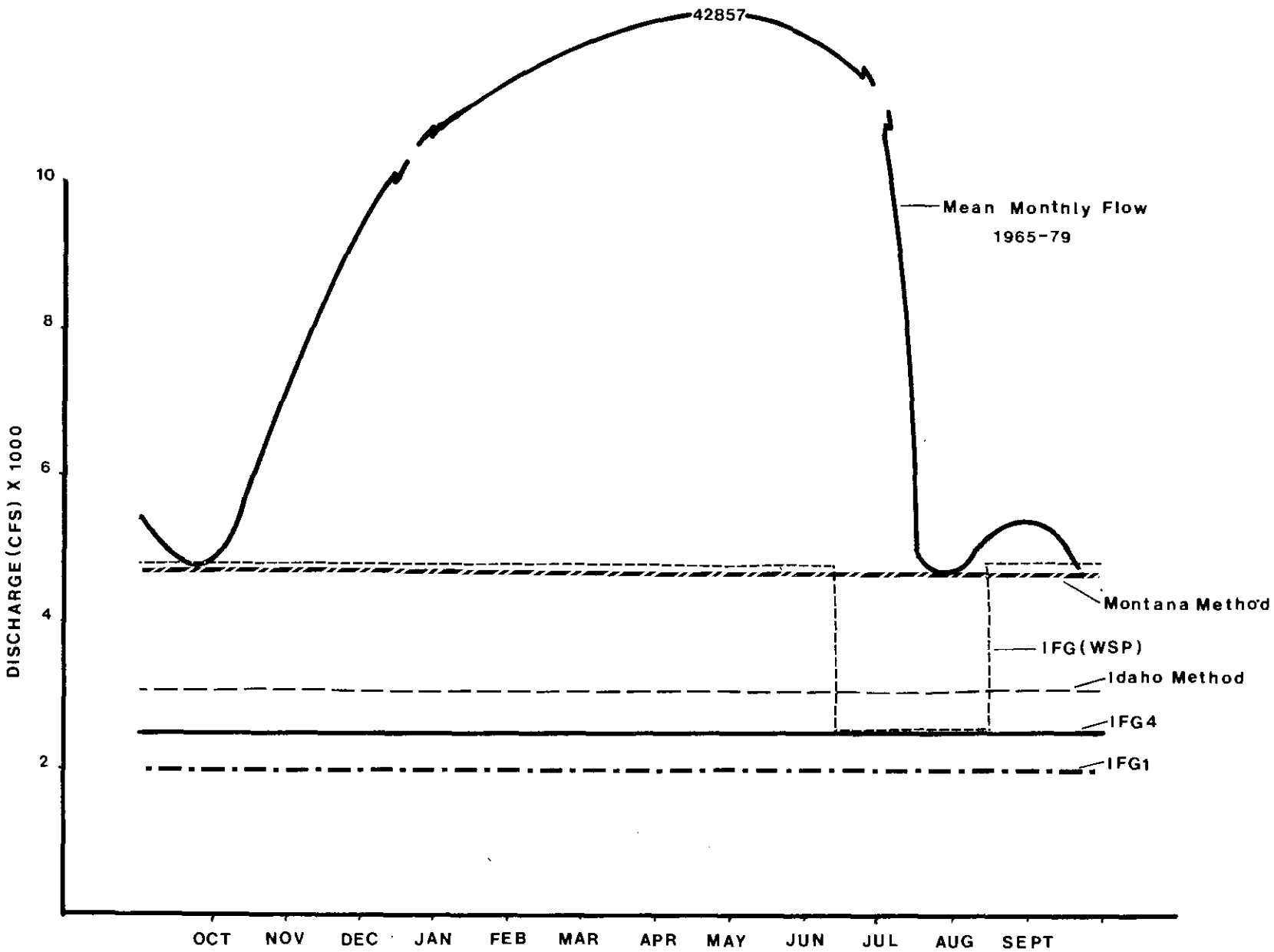

Figure 11. Instream flow recommendations graphed with mean monthly flows (1911-79) on South Fork Clearwater River.

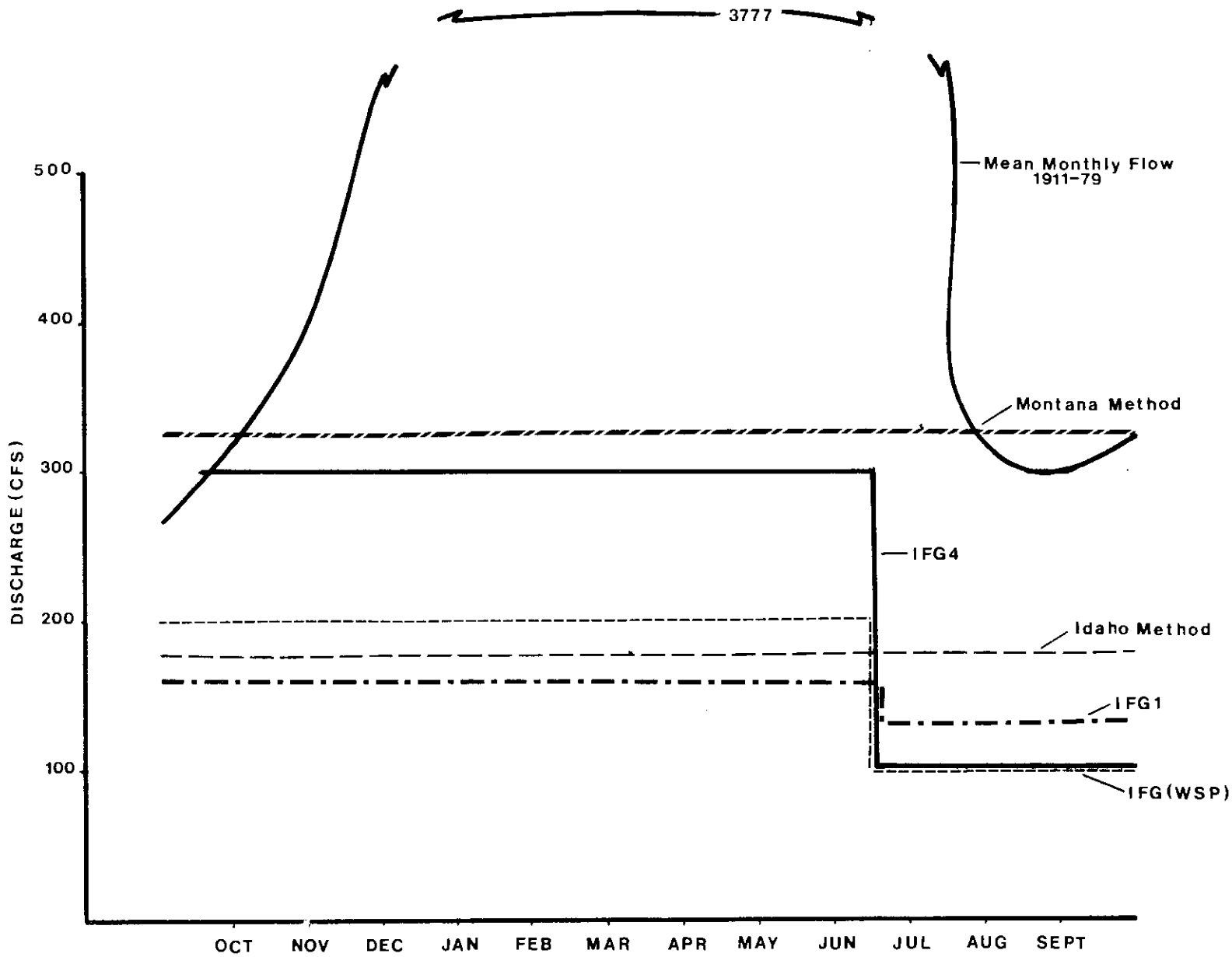

Figure 12. Instream flow recommendations graphed with mean monthly flows (1965-79) on Clearwater River.

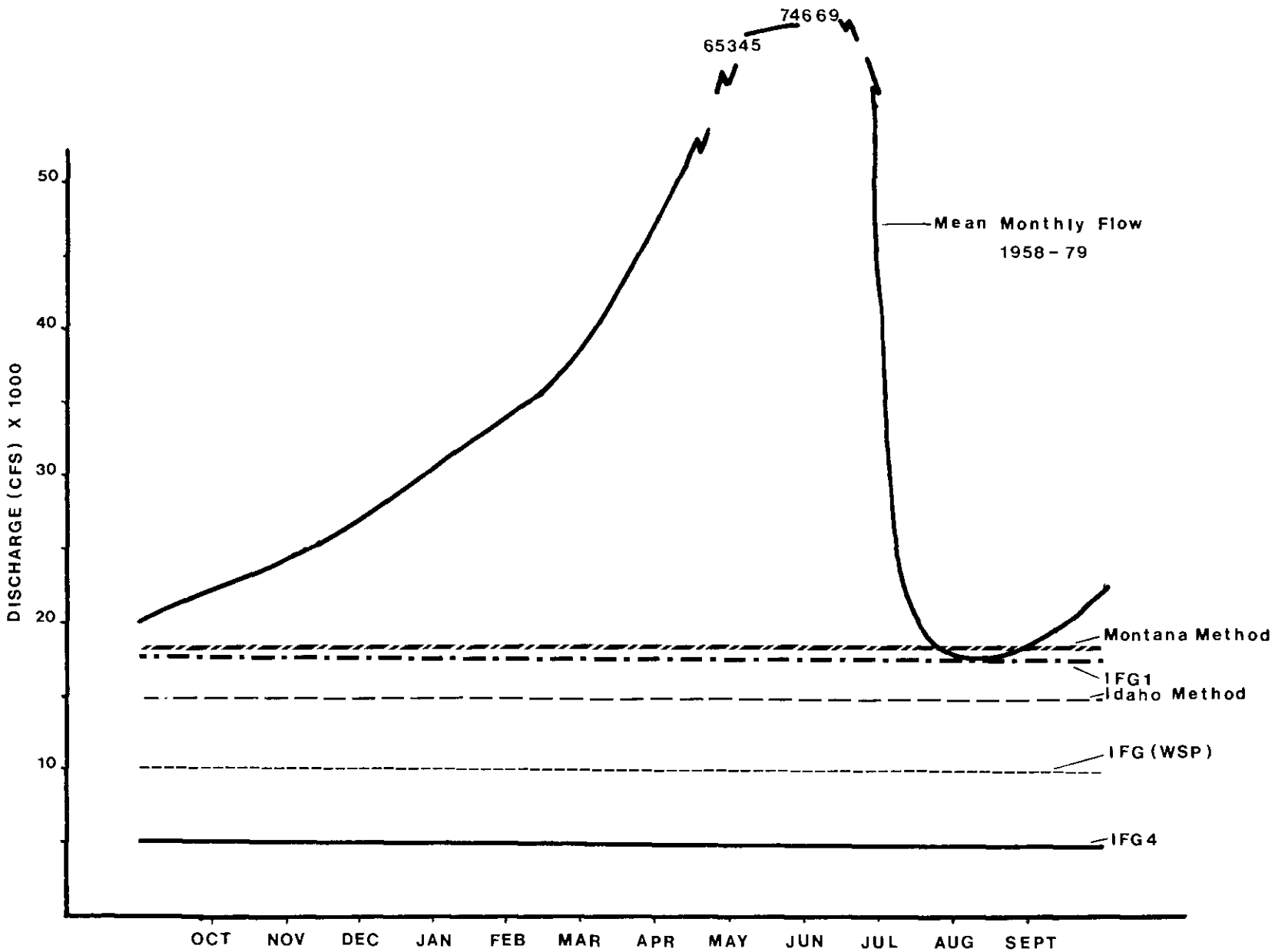

Figure 13. Instream flow recommenations graphed with mean monthly flows (1958-79) Snake River.

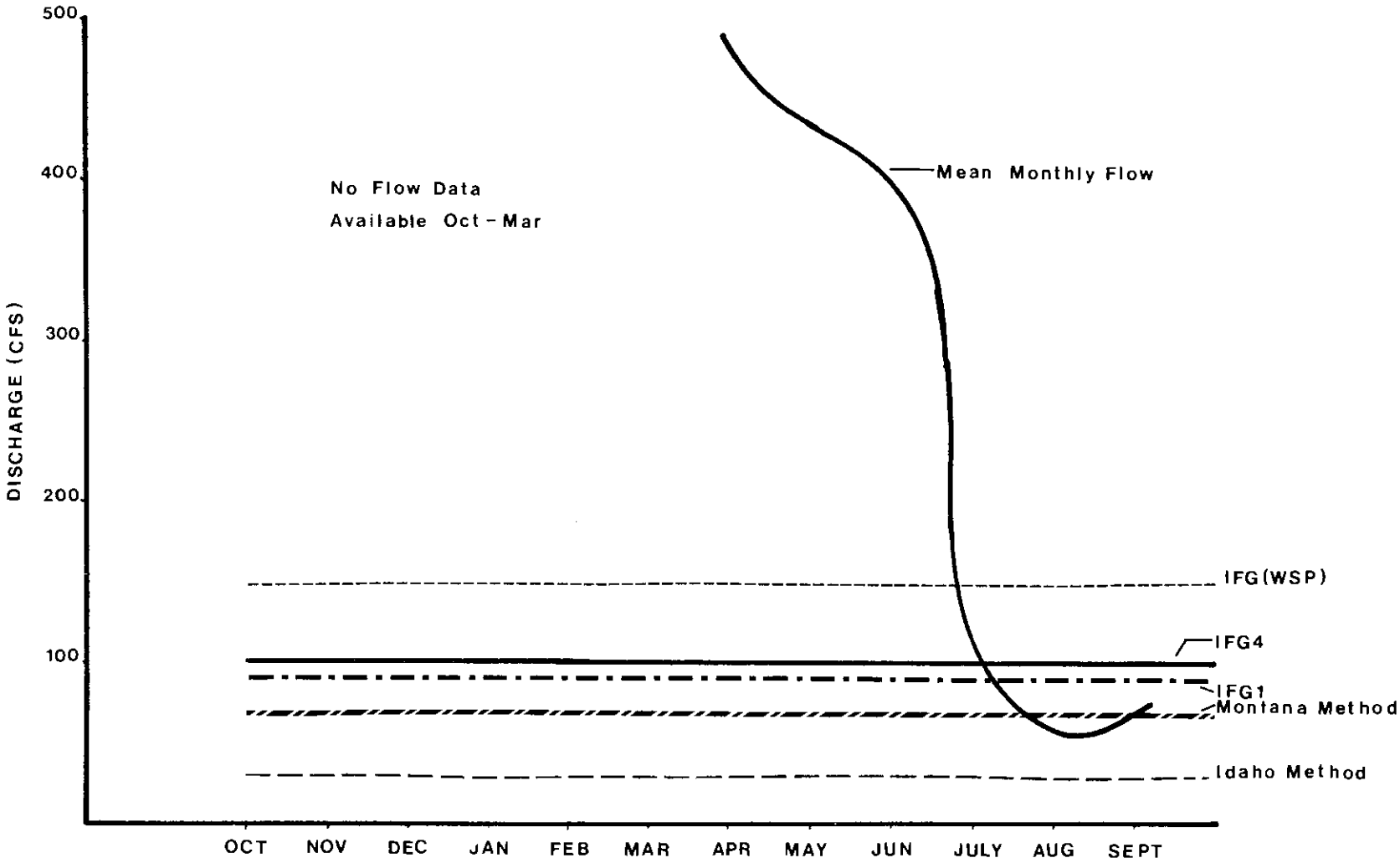

Figure 14. Instream flow recommenations graphed with mean monthly flows (1896-1977) on Big Wood River.

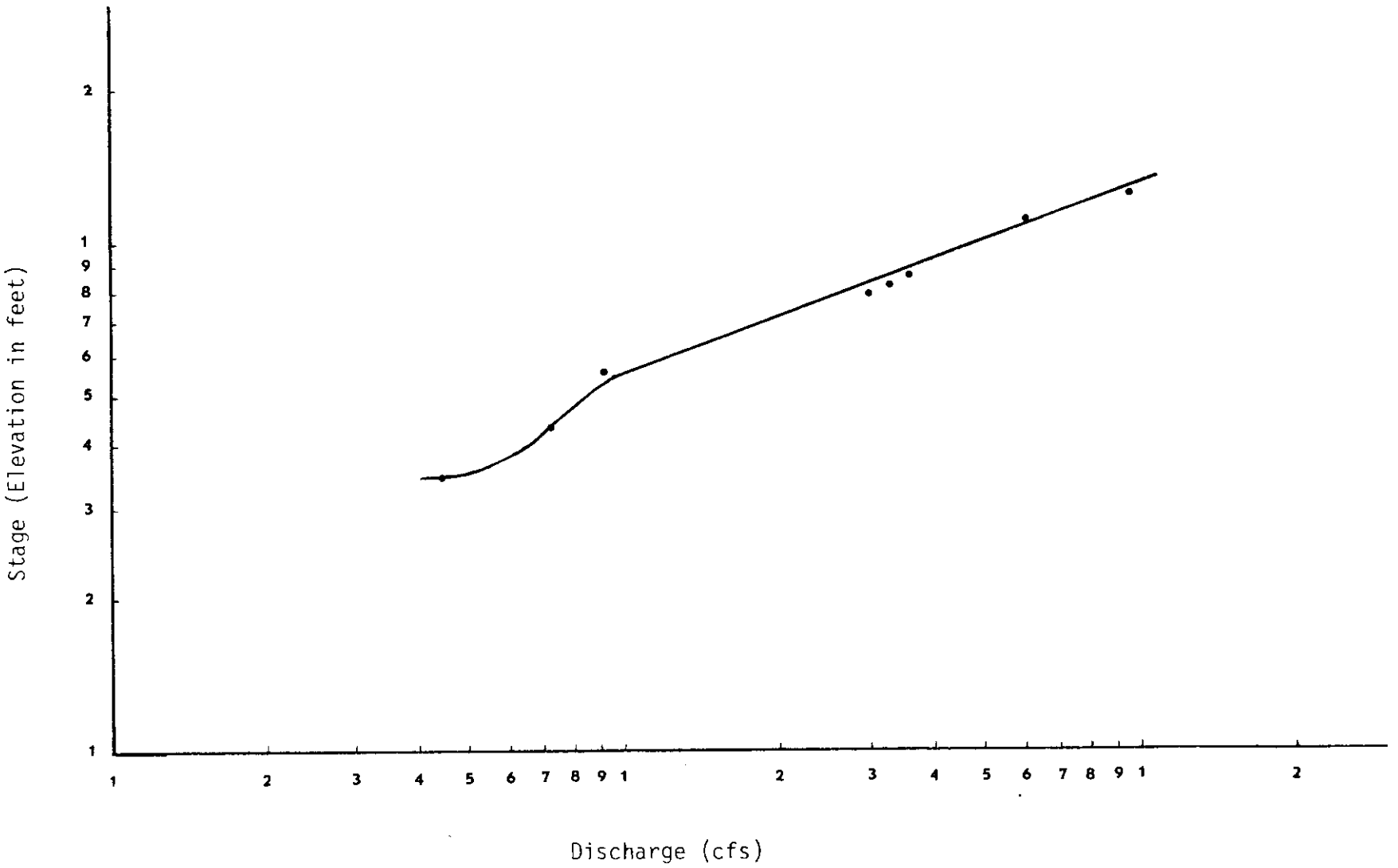

Figure 15. S-shaped rating curve resulting from plotting stage versus discharge for eight flows. Data from Hayden Creek - 1978.

Table 29. Variation in water surface elevations when using the WSP model for individual flow measurements or collectively for a series of flow measurements. Data from South Fork Clearwater River - 1978.

Discharge (CFS)			3850	2196	1590	640	214
		cx1	18.56	17.50	16.88	15.81	14.89
	Measured	cx2	18.96	17.76	17.15	16.01	15.02
A	Elevation	cx3	19.38	18.02	17.59	16.51	15.48
	(Ft)	cx4	20.62	19.14	19.01	18.17	17.12
	Predicted	cx1	18.56	17.50	16.88	15.81	14.89
B	Elevation	cx2	18.95	17.75	17.14	15.96	14.97
	run	cx3	19.34	18.00	17.58	16.46	15.44
	Separately*	cx4	20.64	19.12	19.01	18.20	17.07
	Difference	cx1	-	-	-	-	-
C	in	cx2	- .01	- .01	- .01	- .05	- .05
	Elevation	cx3	- .04	- .02	- .01	- .05	- .04
	Between A&B	cx4	+ .02	- .02	-	+ .03	- .05
	Predicted	cx1	18.56	17.50	16.88	15.81	14.89
	Elevation	cx2	19.02	17.85	17.22	15.99	14.99
D	run	cx3	19.57	18.30	17.66	16.36	15.35
	Collec-	cx4	21.19	19.75	19.10	17.83	16.95
	tively**						
	Difference	cx1	-	-	-	-	-
E	in	cx2	+ .06	+ .09	+ .07	- .02	- .03
	Elevation	cx3	+ .19	+ .28	+ .07	- .15	- .13
	Between A&D	cx4	+ .57	+ .61	+ .09	- .34	= .17

* This is the elevation predicted by WSP for each discharge when each was run as a separate program. Elevations for cross sections vary according to the Mannings 'n' selected. A cross section was considered calibrated when elevations were ±0.05 feet from measured elevation.

** This is the elevation predicted by WSP for each discharge when all five were run in one program. Mannings 'n' values were set as those used for the median flow (1590 cfs). A change in these values causes a change in all cross sections.

Table 30. Variation in predicted velocities when using the WSP model for individual flow measurements or collectively for a series of flow measurements. Data from Hayden Creek - 1978

Right Most Coordinate (FT)	VELOCITIES (FPS)																							
	Measured	Separate	Collective	Measured	Separate	Collective	Measured	Separate	Collective	Measured	Separate	Collective	Measured	Separate	Collective	Measured	Separate	Collective	Measured	Separate	Collective	Measured	Separate	Collective
4	0	0	.10	0	0	0	0	.65	.34	.40	.65	.65	.50	.47	.66	.57	.70	.68	0	.23	.85	1.3	1.4	1.1
8	.15	.11	.19	.34	.26	.27	.31	.66	.69	1.1	1.3	1.3	1.3	1.5	1.4	1.1	1.3	1.4	1.5	2.2	1.9	1.8	2.8	2.4
12	.49	.40	.21	.71	.61	.54	.84	.85	.72	1.5	1.4	1.4	1.8	1.9	1.5	1.8	1.7	1.5	2.3	2.3	2.0	3.1	3.5	2.6
15	.65	.44	.30	.84	.70	.57	.98	.90	1.2	2.0	2.0	2.0	2.1	2.3	2.1	2.1	2.1	2.2	2.2	2.4	2.8	4.0	3.1	3.5
19	.55	.52	.29	.79	.78	.94	.95	.90	1.1	2.0	2.0	2.0	1.9	2.3	2.0	2.0	2.0	2.1	3.1	2.5	2.7	3.9	3.5	3.4
23	.53	.47	.25	.79	.74	.90	.82	.85	.98	1.9	1.7	1.7	1.9	1.7	1.8	2.1	2.0	1.9	2.6	2.5	2.4	2.9	3.4	3.0
26	.31	.26	.24	.53	.41	.77	.51	.56	.88	1.6	1.6	1.6	1.8	1.5	1.7	1.8	1.9	1.8	2.6	2.4	2.3	3.4	2.9	2.9
29	.10	0	.15	0	0	.69	0	.19	.46	.50	1.1	1.1	1.1	1.2	1.1	.96	1.2	1.2	1.7	2.3	1.7	2.2	1.9	2.1
36	0	0	.06	0	0	.36	0	0	0	0	.45	.45	0	.49	.50	0	.42	.54	.10	.47	.81	.10	1.2	1.1
Avg. Velocity (FPS)	.42	.43	.26	.62	.73	.80	.74	.83	1.0	1.5	1.7	1.7	1.5	1.9	1.8	1.7	1.9	1.9	2.3	2.4	2.4	3.0	3.2	3.0
Discharge (CFS)	4			7			9			30			33			36			60			96		

(as in WSP-HABTAT) to obtain habitat information, only one set of Manning's "n" values can be used. This increases the variability in predicted water surface elevations from less than 0.05 foot to as much as 0.61 foot. A difference of 7 inches of water can have considerable effect on habitat predictions.

The effect on velocities is expressed in the Hayden Creek data (Table 30). Characteristically WSP predicts higher velocities than measured. Five years of previous data collected in Idaho bears this out strongly (Cochnauer, unpublished data). As in water surface elevations, the variability among velocities increases when using a constant "n" value for all flows.

A hydrologist is likely concerned with the hydraulic simulation from this model, but the real concern to the biologist or hydrologist making flow recommendations from WSP is the available habitat predicted by the HABTAT model.

As in IFG1, increasing the number of segments for velocity measurements for WSP should increase its sensitivity and allow more accurate hydraulic simulation. Emphasis should be made to increase that capability for the next version of WSP.

3. IFG Incremental method (IFG4). The authors are more comfortable with the use of a stage-discharge model of hydraulic simulation. If accurate discharge measurements are taken over a series of field trips, we feel an adequate definition of the velocity-depth profiles will be made. Hayden Creek was the primary test stream used to show the stage-discharge relation. The study site was visited eight times at various flows from near the all-time low to average high flows. Bovee and Milhous (1978) reported an S-shaped curve when plotting stage versus discharge over a very wide range of flows, but Hayden Creek only displayed half of this typical curve because no very high flows were encountered during the study.

A straight line relationship is characteristic for most of the curve but the low flows do not follow this pattern. Figure 15 shows a flattening of the curve at low flows because much of the discharge is accommodated by an increase in wetted channel width rather than an increase in stage.

The IFG4 program assumes a straight line relations and, therefore, does not handle the low flow hydraulics very well. This must be considered heavily when investigators are determining flows from a stage-discharge approach. Interpolation of flows may be quite accurate, but when extrapolating below (or above) measured flows caution must be taken.

HABTAT is the state-of-the-art in habitat modeling. This does not suggest blanket approval, for many questions are yet unanswered, but the HABTAT model can only be as good as the hydraulic information input and the biological criteria designed into it. Gathering velocity and depth information on a species over vast geographic areas, greatly differed instream environments, and under many different collection techniques has led to generalizations that may not be applicable to every study reach.

For many species data is insufficient to properly define probability-of-use curves. Bovee (1978) rated much of the information collected as only fair to good quality, and although data has been added, more is needed. Likewise, most information gathered has been taken from collections in small wadeable streams and may not be applicable to large streams. Preferred depths of a species may actually be greater than recorded.

The ability of the IFG4 model to simulate the actual stream measurements is shown in Table 31. As in WSP, there is some variability between measured and predicted elevations. This is anticipated since we are dealing with models, but closeness of fit is important. Maximum difference between measured and predicted elevations was 0.36 feet; it compares to 0.61 feet for WSP. Elevations, velocities and depths for both methods are the same, so the variability observed is the result of the simulation procedures the models use.

Predictions of available habitat may be in error if the hydraulic data are not simulated accurately. A case in point is the habitat units predicted for the Big Wood River juvenile brown trout with WSP, IFG4, and IFG1 supplying the hydraulic input (Table 32). The variations among programs is apparent even though discharges are different due to program character. The variation is only attributable to the hydraulic input.

Table 31. Variation in water surface elevations when using the IFG4 model. Data from South Fork Clearwater River - 1978.

		Discharge (cfs)				
		3850	2196	1590	640	214
1	cx1	18.56	17.50	16.88	15.81	14.89
Measured	cx2	18.96	17.76	17.15	16.01	15.02
Elevation	cx3	19.38	18.02	17.59	15.51	15.48
(ft.)	cx4	20.62	19.14	19.01	18.17	17.12
2	cx1	18.5	17.5	17.0	15.8	14.9
Predicted	cx2	18.8	17.8	17.3	16.0	15.0
Elevation	cx3	19.2	18.2	17.6	16.5	15.5
(ft.)	cx4	20.4	19.5	19.0	18.0	17.2
3	cx1	.06	.0	.12	.01	.01
Difference	cx2	.04	.04	.15	.01	.02
Between	cx3	.18	.18	.01	.01	.02
1 and 2 (ft.)	cx4	.22	.36	.01	.03	.08

The same parallel can be drawn for the two modes of WSP. If the water surface elevation can vary as much as 0.61 feet between flow processed separately and together, then great differences may exist in habitat units predicted by HABTAT.

Table 32. Comparison of brown trout habitat predictions by WSP, IFG4, and IFG1 on Big Wood River.

WSP		IFG4		IFG1	
Discharge	Habitat	Discharge	Habitat	Discharge	Habitat
28	454	10	1523	24.8	44949
35	857	20	2024		
44	1699	30	2578	39.3	45902
54	4014	40	2888		
64	6824	50	3032		
76	9831	75	3309	76.5	48888
89	11841	100	3817	95.3	50123
103	12935	125	4344		
118	13937	150	4313		
135	14539	175	4210		
152	15185	200	4069	187.4	34782
189	15486	250	3783		

The major shortcoming of IFG4-HABTAT is time consumption. In gathering data and processing it for the computer, more time is needed than in other methods evaluated. But some of this time is spent gathering information specifically for the HABTAT model.

4. Idaho Method. Until a better means of measuring large unwadeable streams is developed, this methodology is ideal for rivers such as the Snake River in Idaho. Stage-discharge type models require measurements in the same location for at least three visits to the study site. Without the undue expense of constructing cable crossings at each cross section, or some other permanent means of setting up the transect, only an energy slope program as WSP, using the Manning equation, can be used. The predictive capability of this program has been tested, but as mentioned previously, Cochnauer has found velocities are characteristically predicted high (Cochnauer 1977).

The Idaho method does not relate flow to aquatic habitat directly, as does the previous methodologies. The WSP program is interfaced with the WETPER program (U.S. Bureau of Reclamation) to relate water surface elevation to wetted perimeter and inherently providing habitat requirements for target species. This indirect route has been avoided by many, but investigators in Oregon (Thompson 1972) and Idaho (Cochnauer 1976-1978) have had satisfactory results for many years. Continued development and improvement have kept this methodology a viable alternative.

Since the Idaho method formed the basis for this state's introduction into stream flow work, it was studied more closely than the other methodologies. The relationship between the wetted perimeter and discharge, from which the flow recommendations are derived, was especially scrutinized because of the indirect method of relating to fishery habitat. A total of 30 visits was made to the six streams studied for this report. Each stream had four transects on which depth-velocity profiles were taken each visit. The wetted perimeter-discharge relationship was compared among transects per discharge and among discharges at one transect. As

many as eight and as few as three discharges were measured per stream. The bulk of the appendix (Figures A7-AZ1) is composed of these relationships graphically displayed.

The difficulties in calibrating WSP, using Manning's "n", make it less desirable to use. Until a worker has become proficient at the calibration process, it can be very frustrating and time consuming. However, this should not dissuade investigators from using WSP, for calibrating becomes second nature in due time.

If the investigating agency has not measured unwadeable rivers previously, the expense of a boat and motor (preferably jet) direct readout current meter, and a sounding reel can be prohibitive. The price has to be weighed against the urgency for the information, and the amount and type of information desired. One of the non-field methods may suffice for a subcritical situation. It should be pointed out that the additional expense does not apply to wadeable streams.

The Idaho method was the tool used to obtain velocities on the Snake and Clearwater Rivers on subsequent visits for the stage-discharge programs. Making three visits to these streams to get measurements in the same positions on a cross section was impossible because they are not wadeable. But using the predictive ability of WSP, discharge from the USGS gage stations, and accurate stream level measurements, velocities were calculated for IFG1 and IFG4 and used to determine hydraulics for those computer programs.

This modification was necessary to utilize IFG1 and IFG4. Some might argue that this will make the capabilities of these predictive models invalid, but all information collected is relative. Modeling, by definition, is no exact science and answers we seek from such endeavors are only as good as the background information input into the models. Any information is better than ignoring the situation and until further economically feasible steps can be taken to procure the information needed, the use of WSP to support IFG1 and IFG4 can be substantiated.

5. Montana Method. Tennant (1976) did extensive study over a 10-year period before reporting on this methodology. His field tests on several streams showed that a non-field method can supply valuable information. If the stream being studied has a stable fish population then recommendations from the Montana method can define the limits at which the population may be adversely affected by low flows. If, however, the population is for some reason unstable, then biological information is needed before an assessment can be made. That information can only be obtained in the field, and applied to instream flow requirements through some method that interfaces hydraulic and biological data. However, for the agency that is strapped with fiscal or manpower shortages, but has to come up with flow recommendations, the Montana method is a proven alternative.

On streams that have USGS gage stations with at least 10 years of data (preferably 20 years) this method should be automatically applied before investigators enter the field because it is so easy and fast to work. It can give ballpark figures with little effort that may decide future direction for study.

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PERSONNEL

The following individuals collected data for biological criteria determinations and stream flow measurements.

Cochnauer, Tim. Fishery Research Biologist. Education: B. S. Zoology, M. S. Zoology, University of Oklahoma. Previous stream flow experience: Directed Idaho's investigation in stream flow work since 1974. Six month IPA appointment to Instream Flow Group, 1977.

Horton, William D. Fish and Wildlife Technician. B. S. Fishery Management, University of Idaho. M. S. in progress. Previous stream flow experience: Six months as temporary employee with the Idaho Department of Fish and Game, 1975.

Hoyt, Neil R. Biological Aide. B. S. Fishery Management, University of Idaho. No previous stream flow experience.

Kendra, William. Biological Aide. Pursuing B. S. Fishery Management, University of Idaho. No previous stream flow experience.

Nelson, Lance. Biological Aide. Pursuing B. S. Fishery Management, University of Idaho. Previous stream flow experience: Three months as temporary employee with the Idaho Department of Fish and Game, 1977.

APPENDIX

Table A1. Fish species, abbreviations and control numbers used in this study.

Species	Life history phase	Abbreviation	Control number
Chinook Salmon	Juvenile	JV Chinook	10101
Winter Steelhead	Juvenile	JV Steelhd	11001
Winter Steelhead	Adult	AD Steelhd	11002
Rainbow Trout	Juvenile	JV Rainbow	11101
Rainbow Trout	Adult	AD Rainbow	11102
Cutthroat Trout	Fry	Cutt Fry	11200
Cutthroat Trout	Juvenile	Cutt Juv	11201
Cutthroat Trout	Spawning	Cutt Spawn	11210
Cutthroat Trout	Incubation	Cutt Incub	11221
Brown Trout	Juvenile	JV Brown	11301
Brown Trout	Adult	AD Brown	11302
Mountain Whitefish	Adult	AD White F	12002
Smallmouth Bass	Juvenile	JV SM Bass	20101
Smallmouth Bass	Adult	AD SM Bass	20102
Smallmouth Bass	Juvenile	JV SM Bass	20113
Smallmouth Bass	Adult	AD SM Bass	20114
Channel Catfish	Juvenile	JV Catfish	30101
Channel Catfish	Adult	AD Catfish	30102

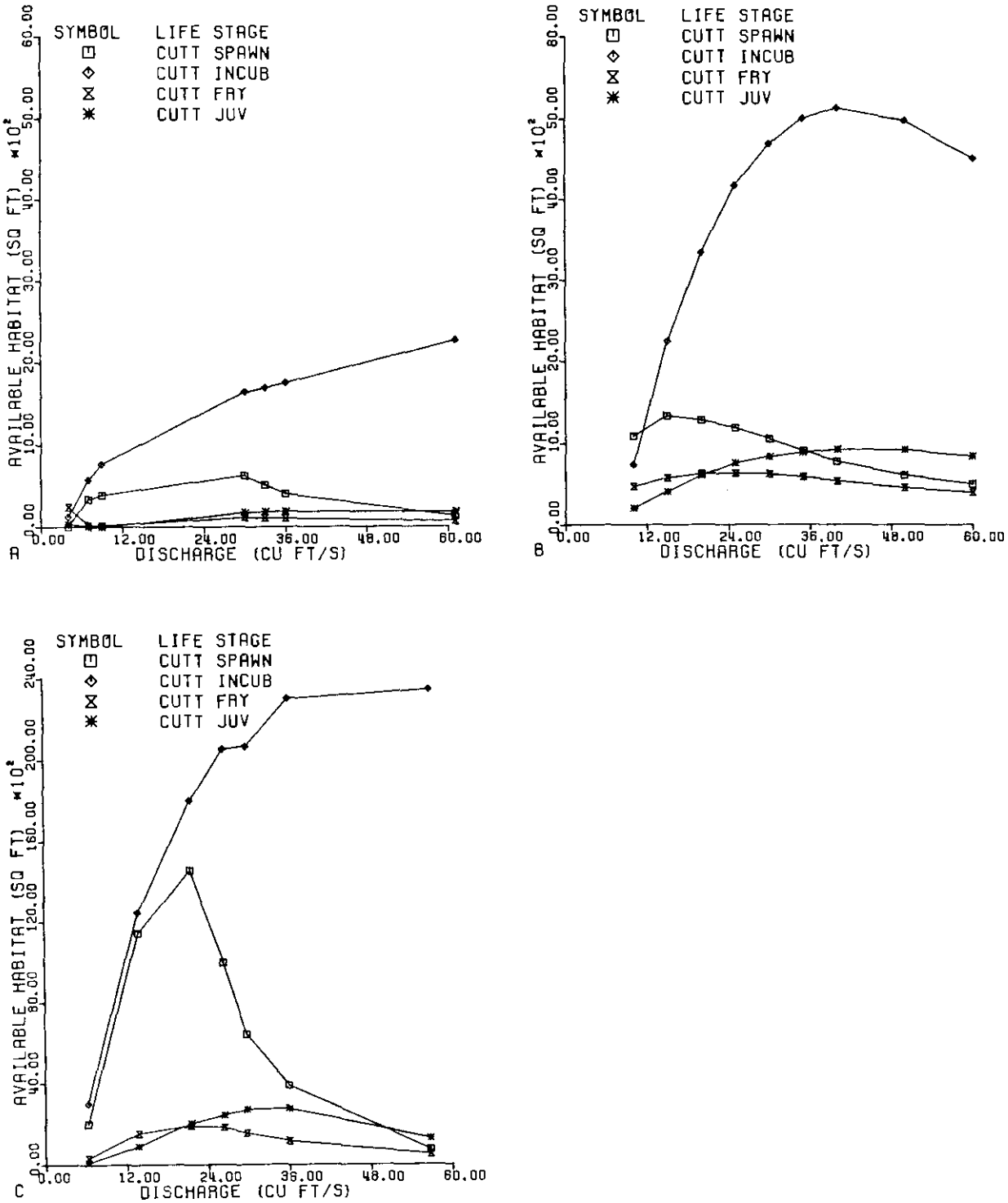


Figure A 1. Habitat curves for Hayden Creek as predicted by (A) WSP-HABTAT, (B) IFG4-HABTAT, (C) IFG1-preferred habitat.

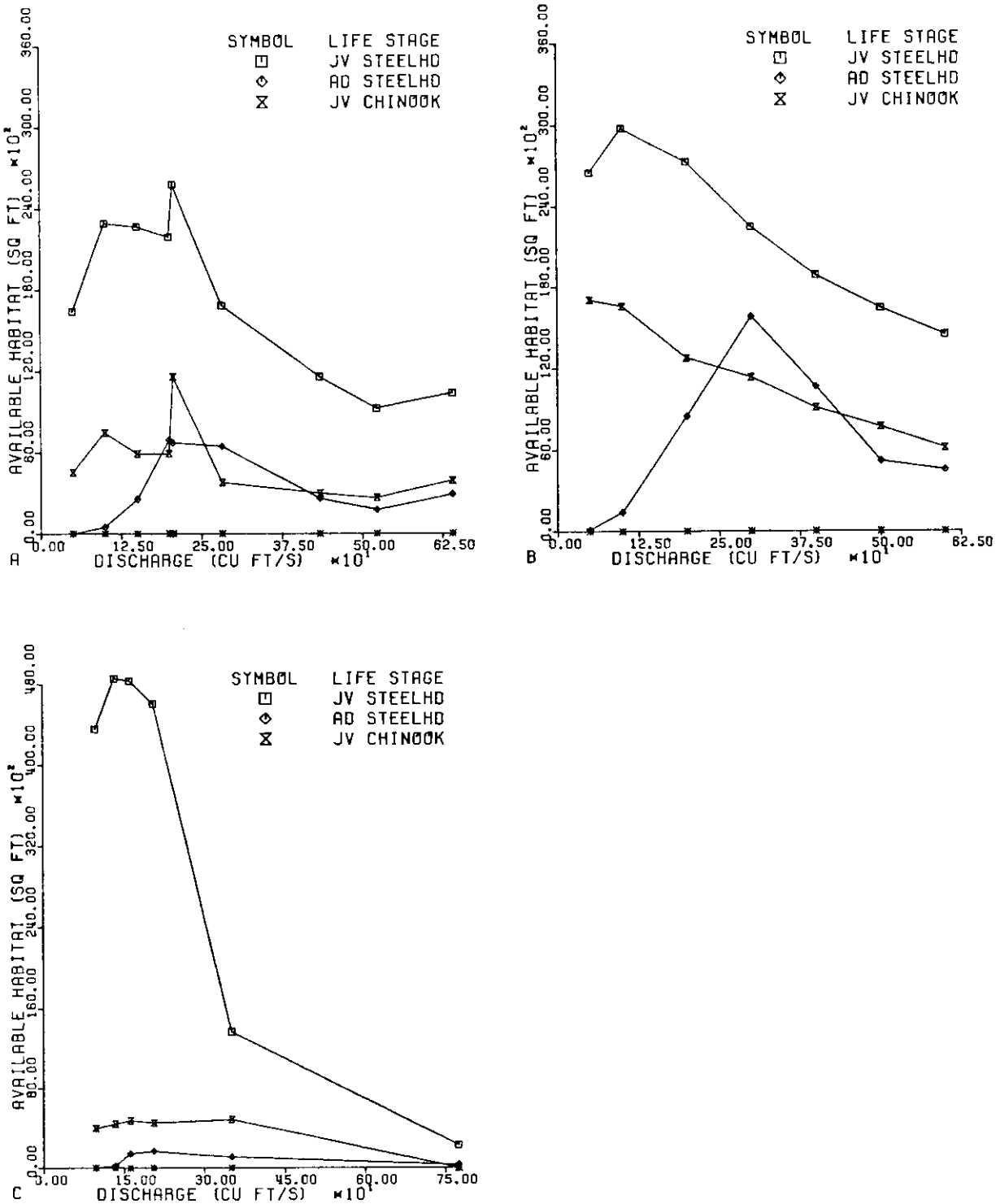


Figure A 2. Habitat curves for South Fork Clearwater River as predicted by (A) WSP-HABTAT, (B) IFG4-HABTAT, (C) IFG1-preferred habitat.

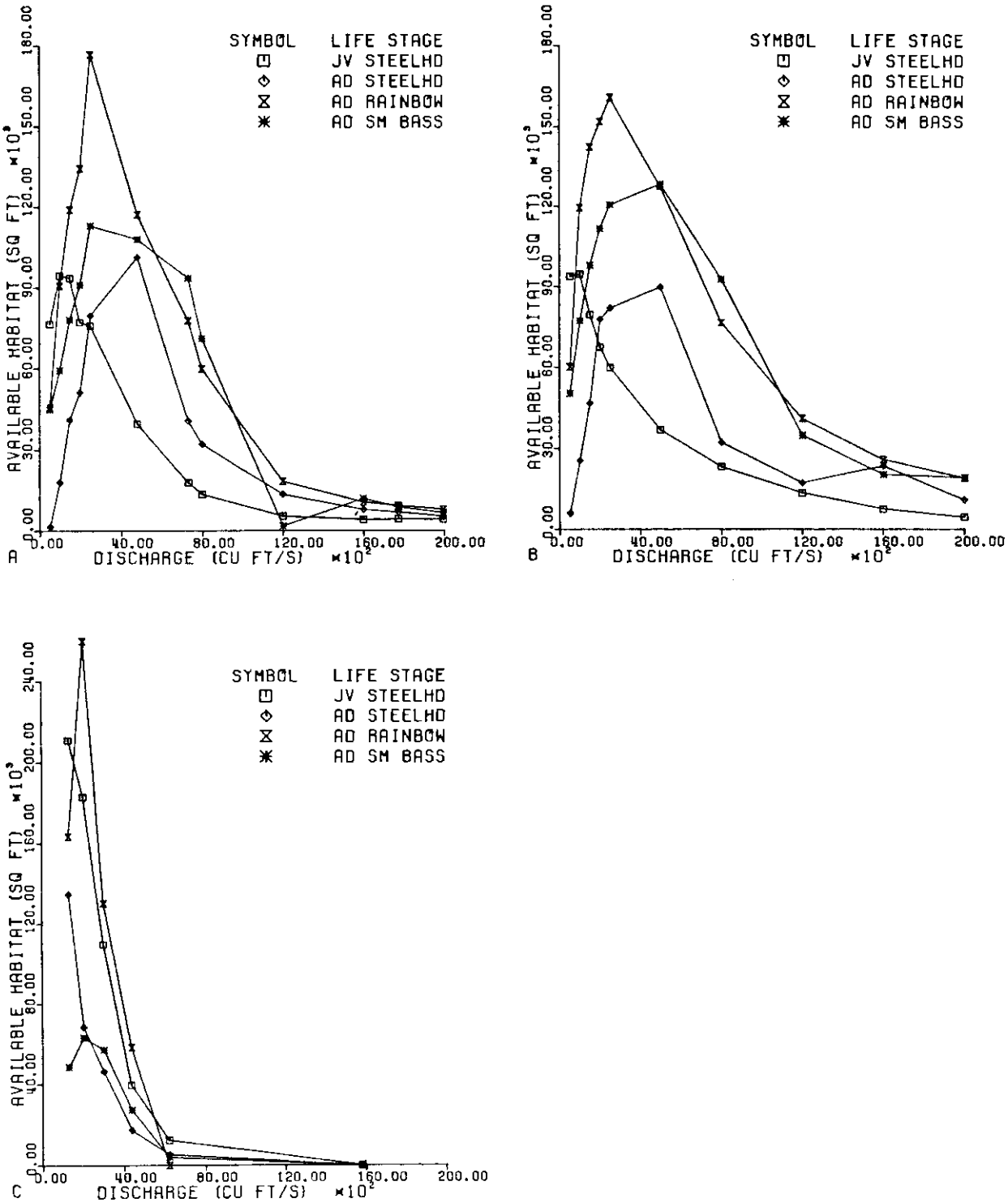
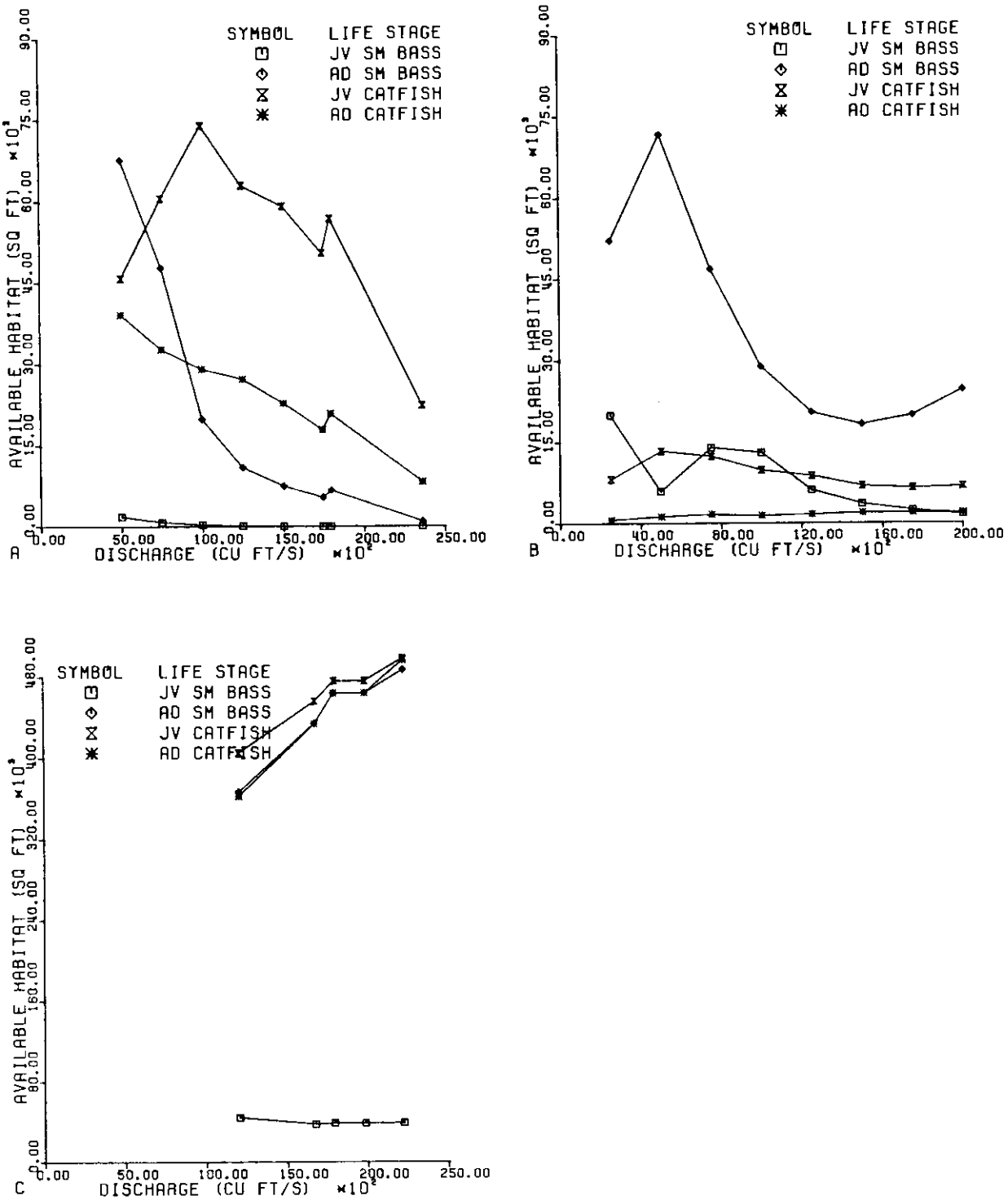


Figure A 3. Habitat curves for Clearwater River as predicted by (A) WSP-HABTAT, (B) IFG4-HABTAT, (C) IFG1-preferred habitat.



igure A 4. Habitat curves for Snake River as predicted by (A) WSP-HABTAT, (B) IFG4-HABTAT, (C) IFG1-preferred habitat.

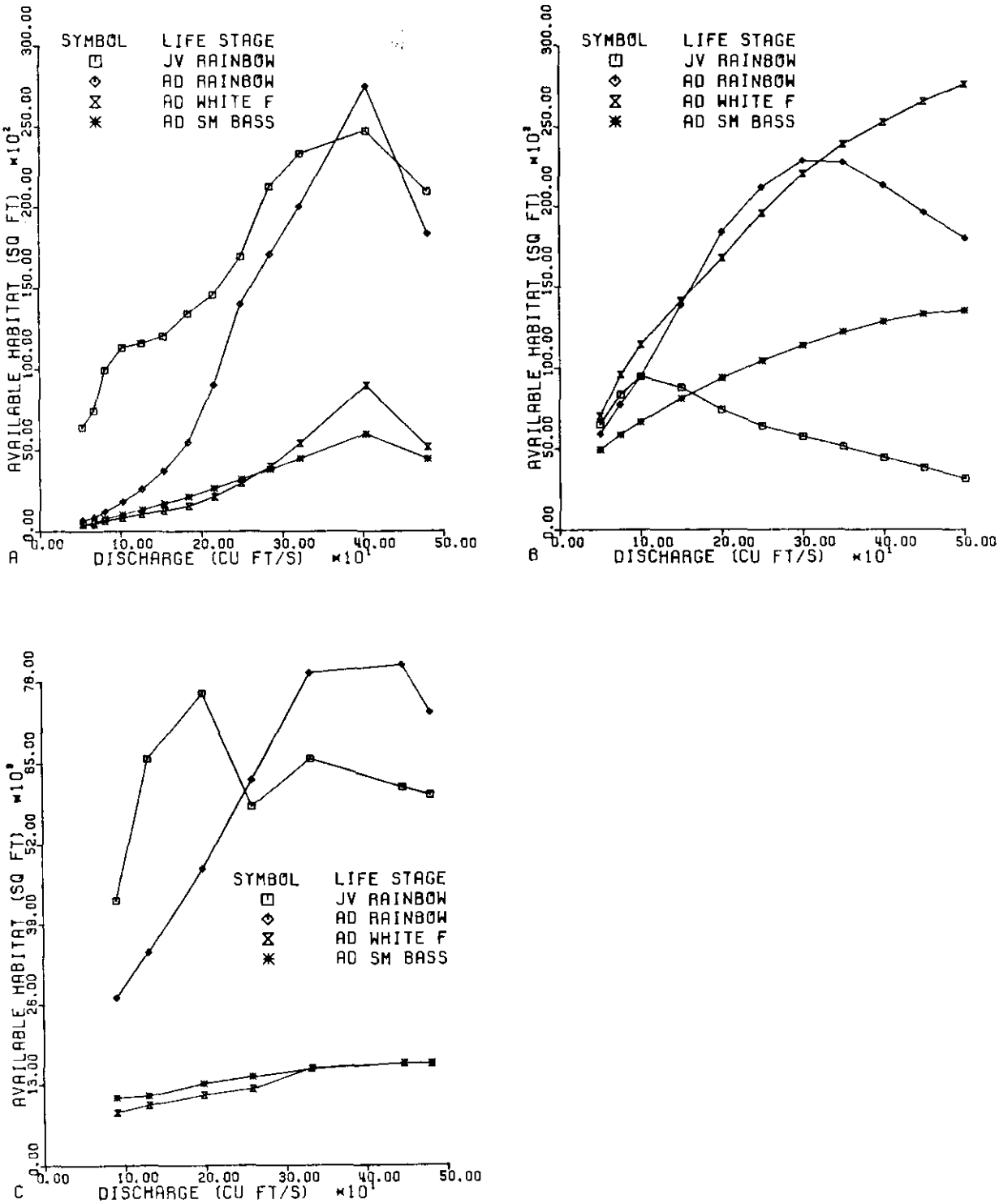
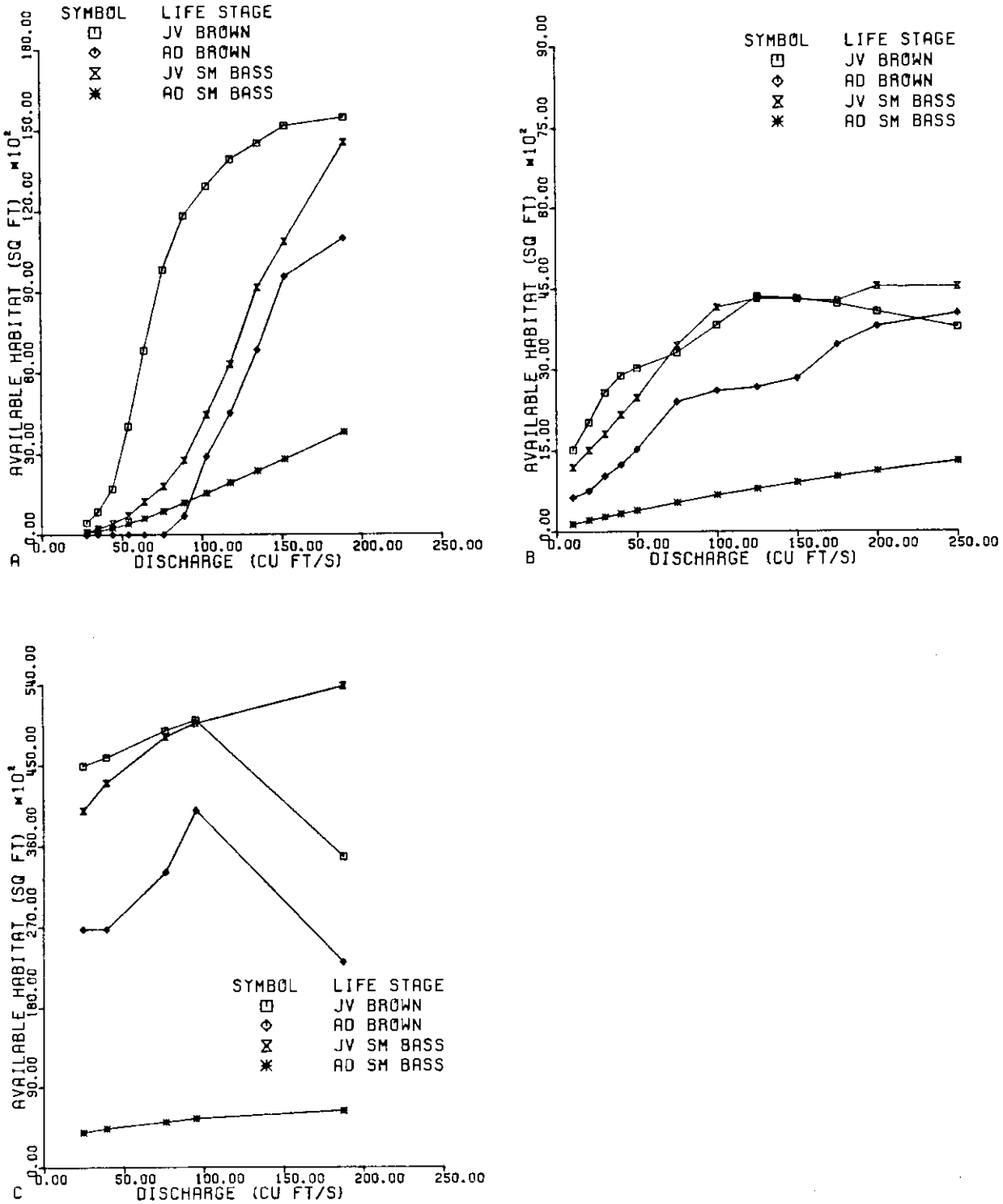


Figure A 5. Habitat curves for Boise River as predicted by (A) WSP-HABTAT, (B) IFG4-HABTAT, (C) IFG1-preferred habitat.



gure A 6. Habitat curves for Big Wood River as predicted by (A) WSP-HABTAT, (B) IFG4-HABTAT, (C) IFG1-preferred habitat.

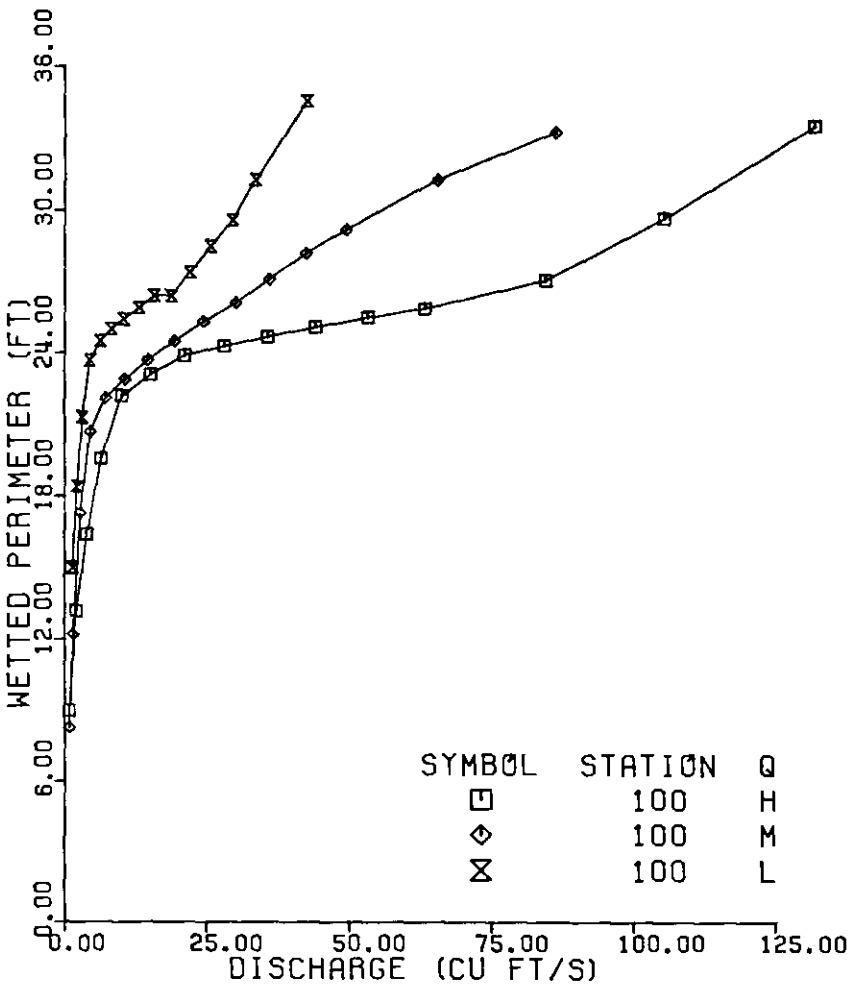


Figure A 7. Habitat curve for Hayden Creek as predicted by the Idaho Method.

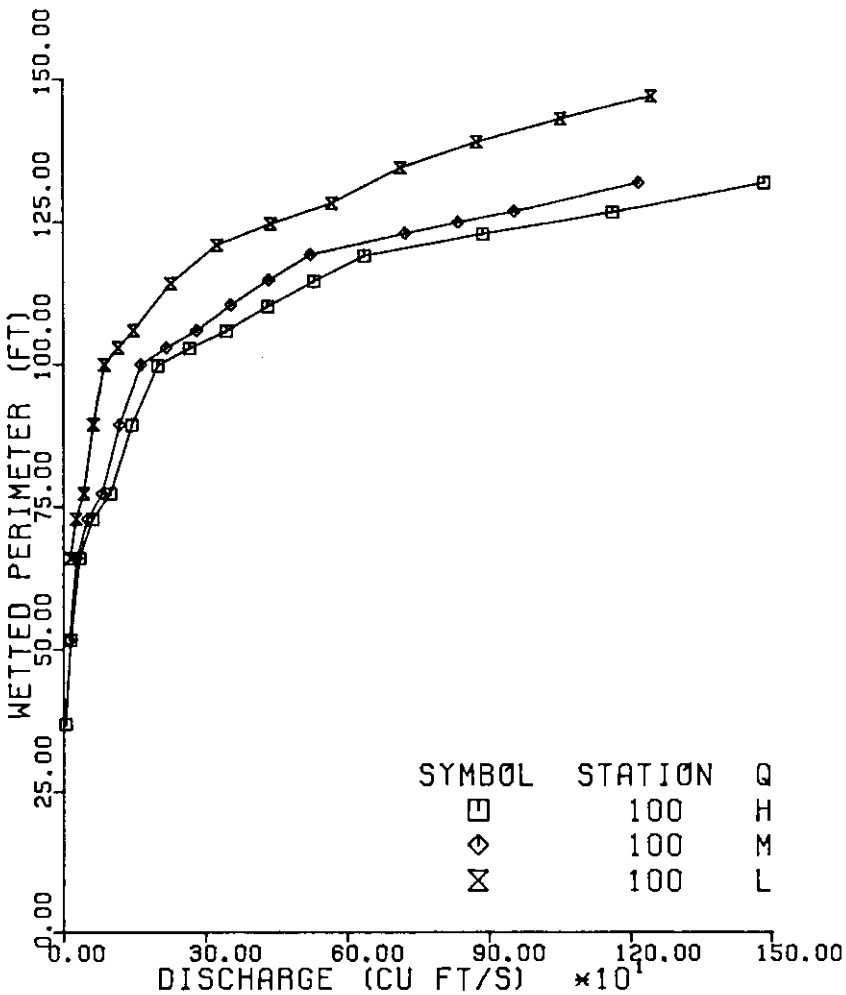


Figure A 8. Habitat curve for South Fork Clearwater as predicted by the Idaho Method.

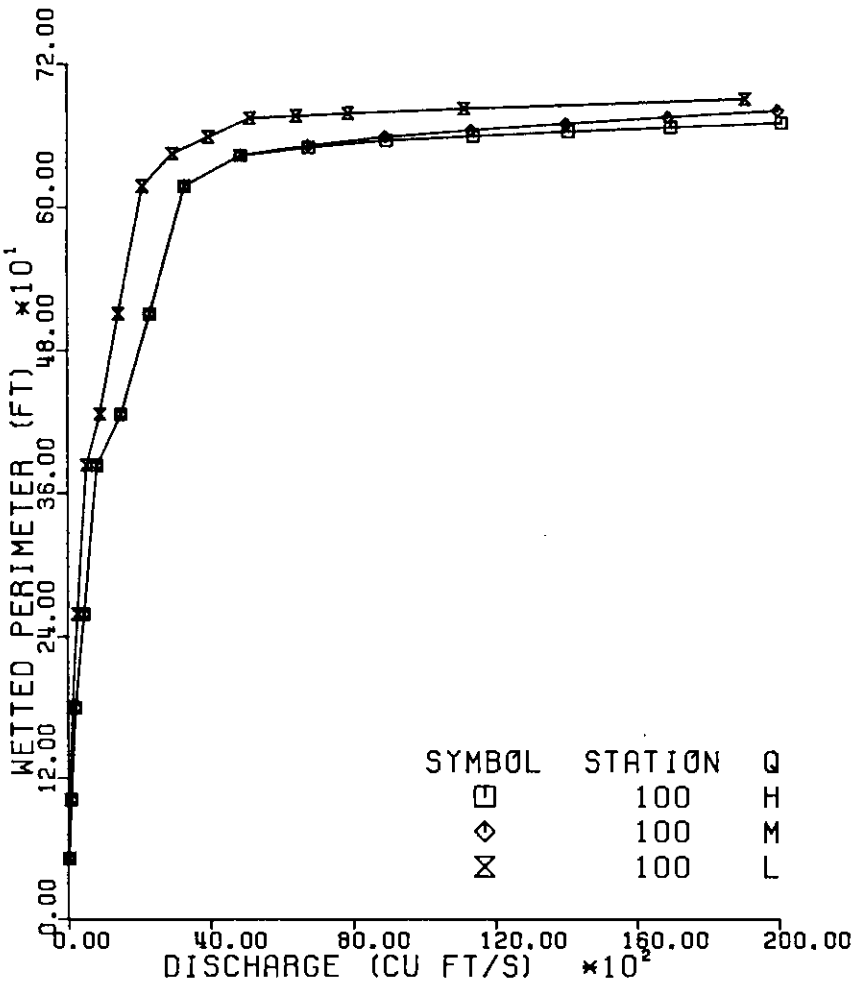


Figure A 9. Habitat curve for Clearwater River as predicted by the Idaho Method.

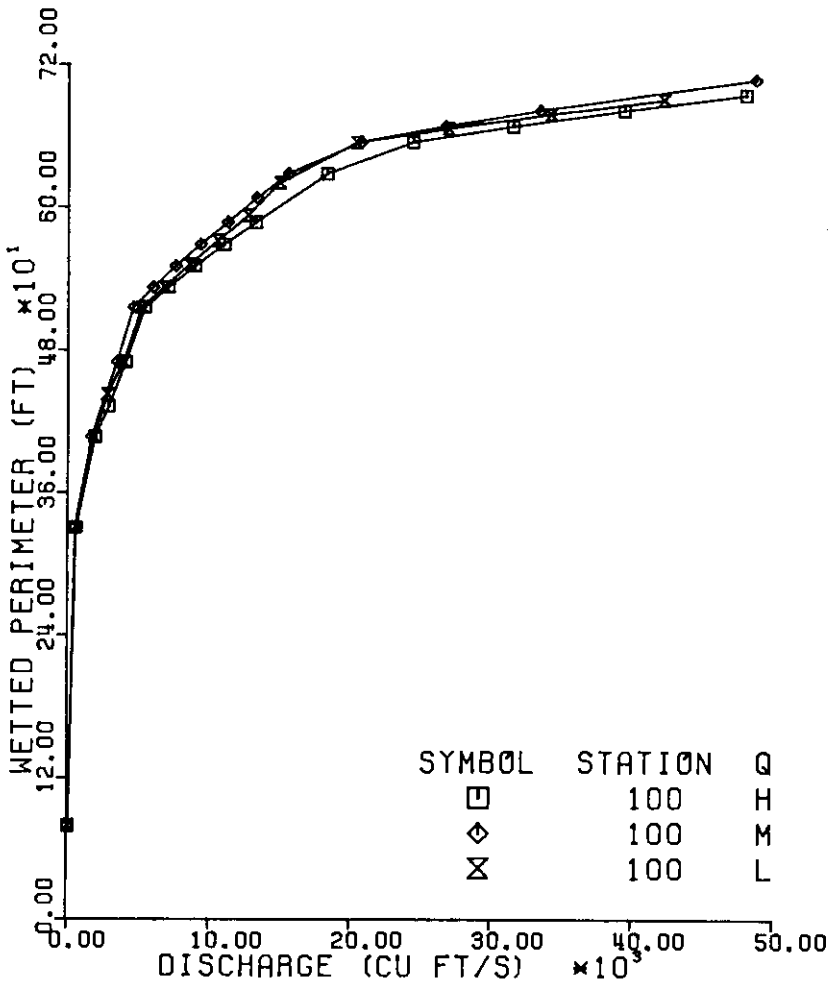


Figure A 10. Habitat curve for Snake River as predicted by the Idaho Method.

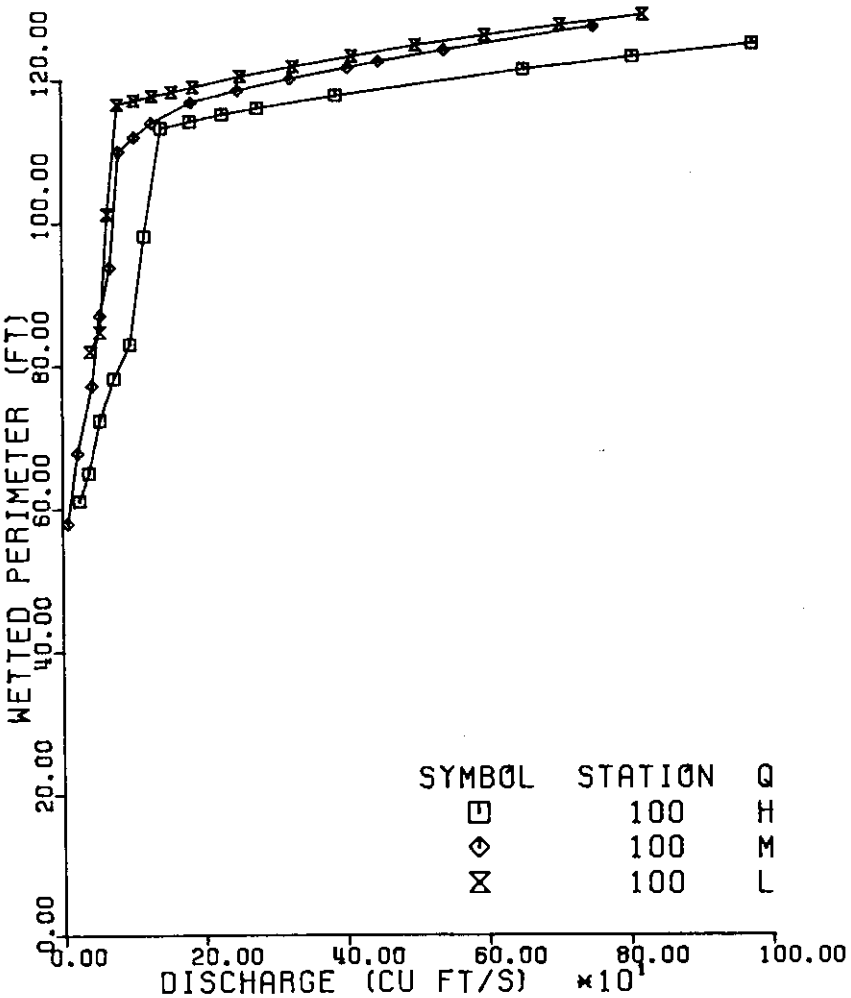


Figure A 11. Habitat curve for Boise River as predicted by the Idaho Method.

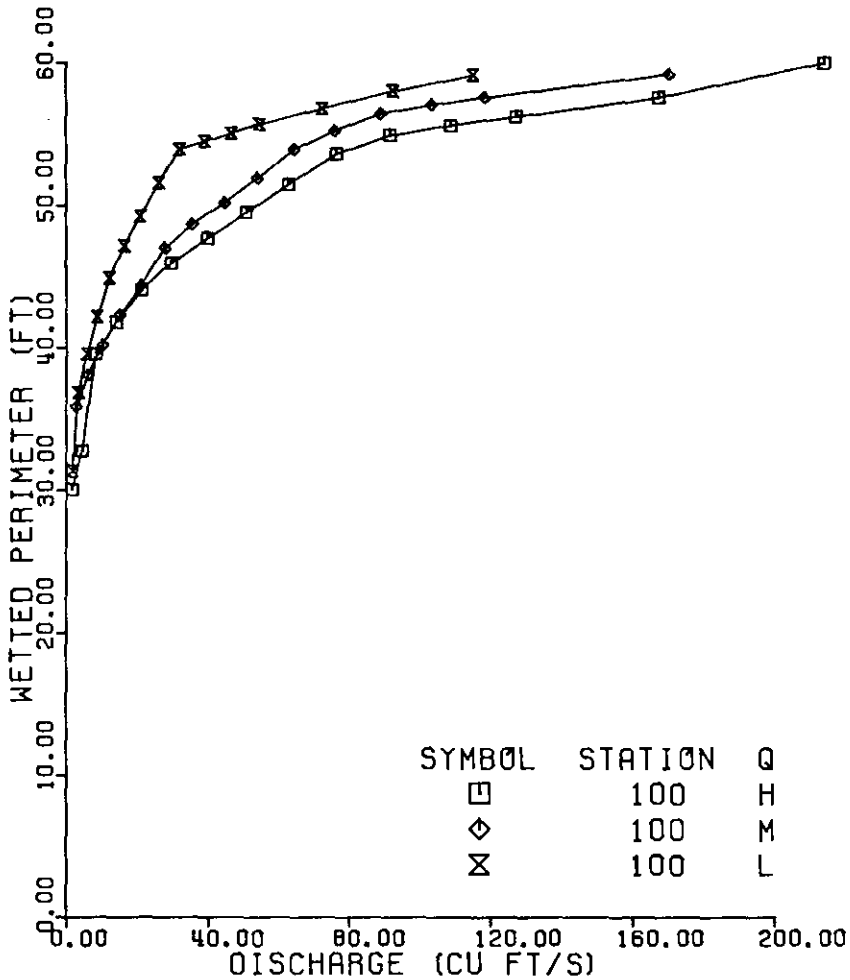


Figure A 12. Habitat curve for Big Wood River as predicted by the Idaho Method.

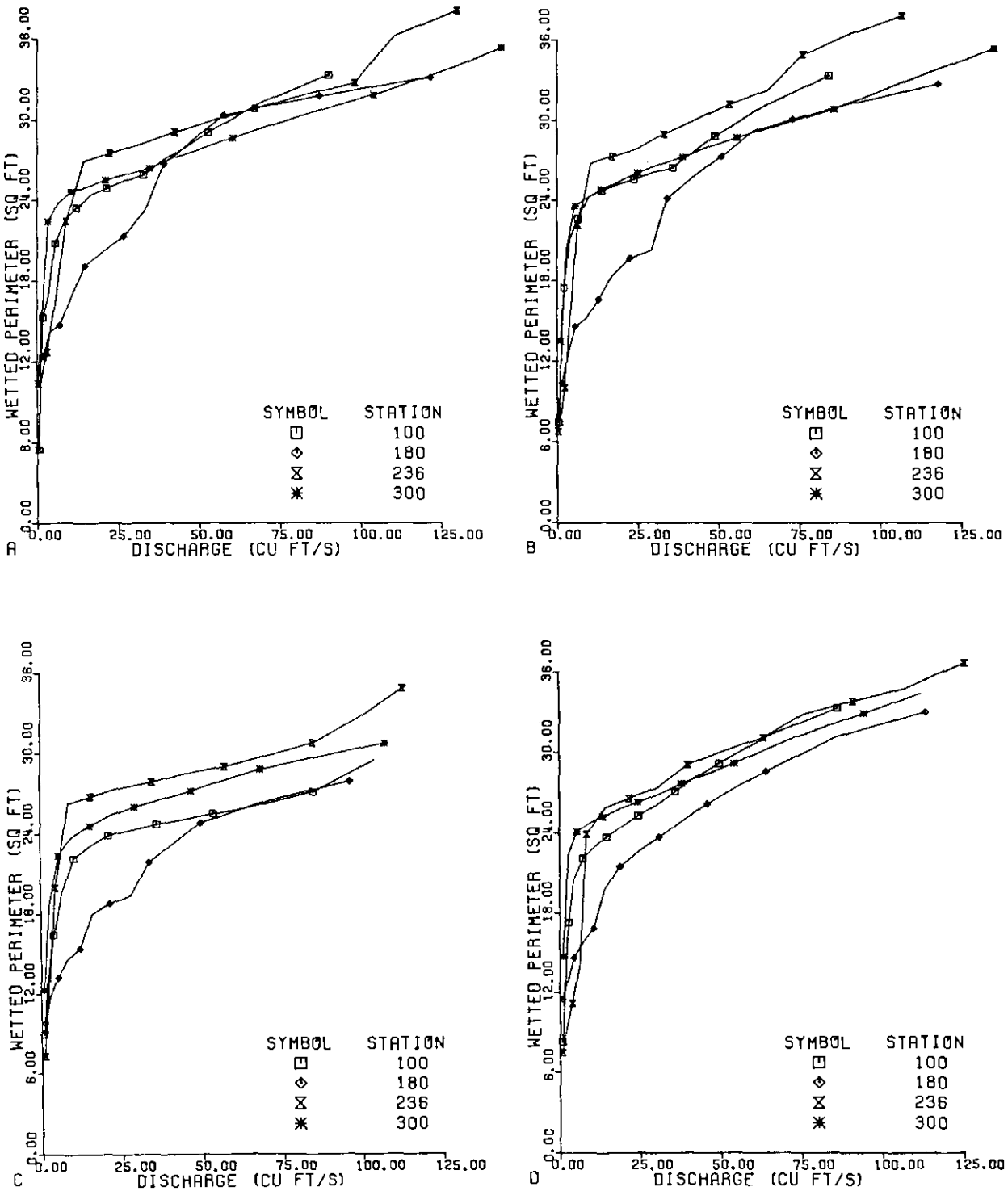


Figure A 13. Hayden Creek discharge-wetted perimeter relationship predicted from data collected at (A) 36 cfs, (B) 33 cfs, (C) 96 cfs and (D) 30 cfs.

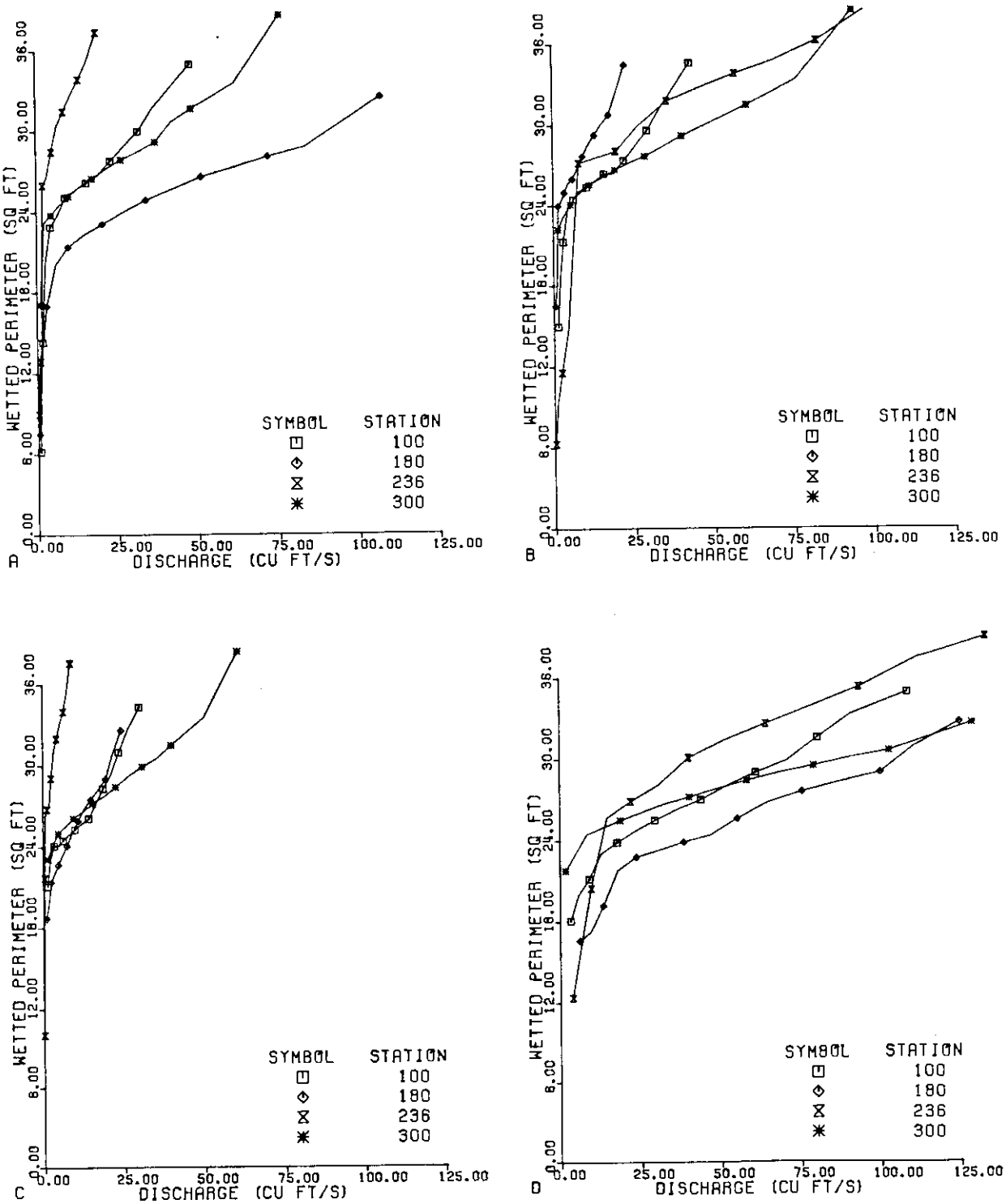


Figure A 14. Hayden Creek discharge-wetted perimeter relationship predicted from data collected at (A) 9.3 cfs, (B) 7.4 cfs, and (C) 4.3 cfs.

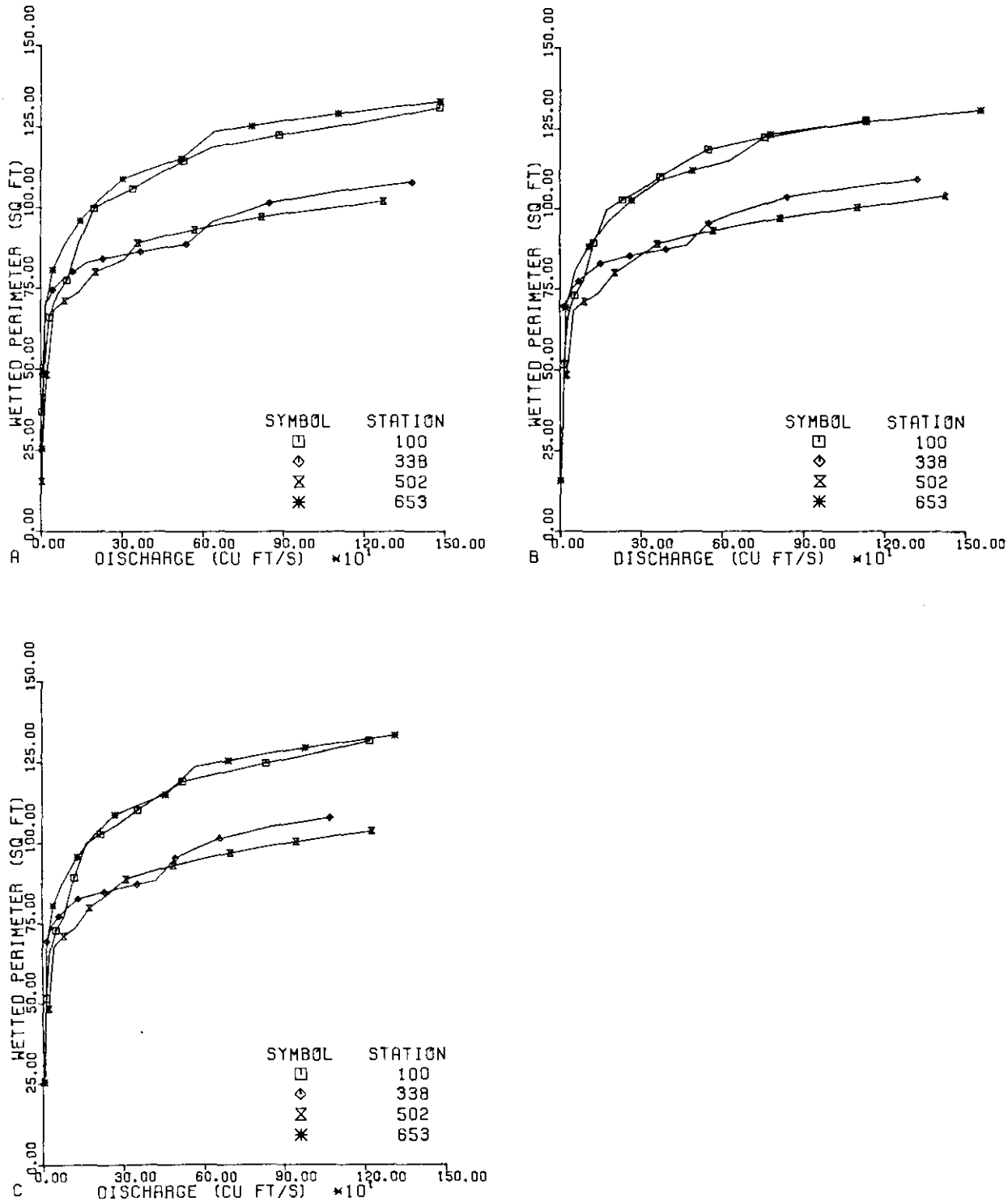


Figure A 15. South Fork Clearwater River discharge-wetted perimeter relationship predicted from data collected at (A) 3850 cfs, (B) 2196 cfs, and (C) 1590 cfs.

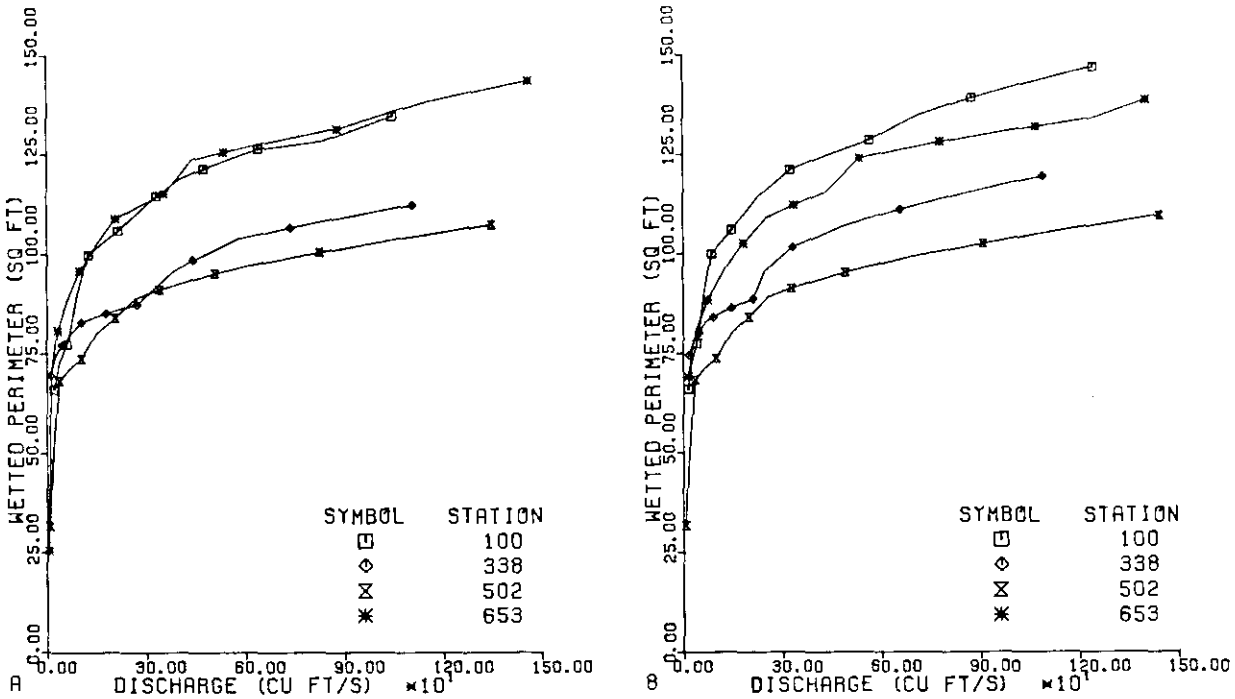
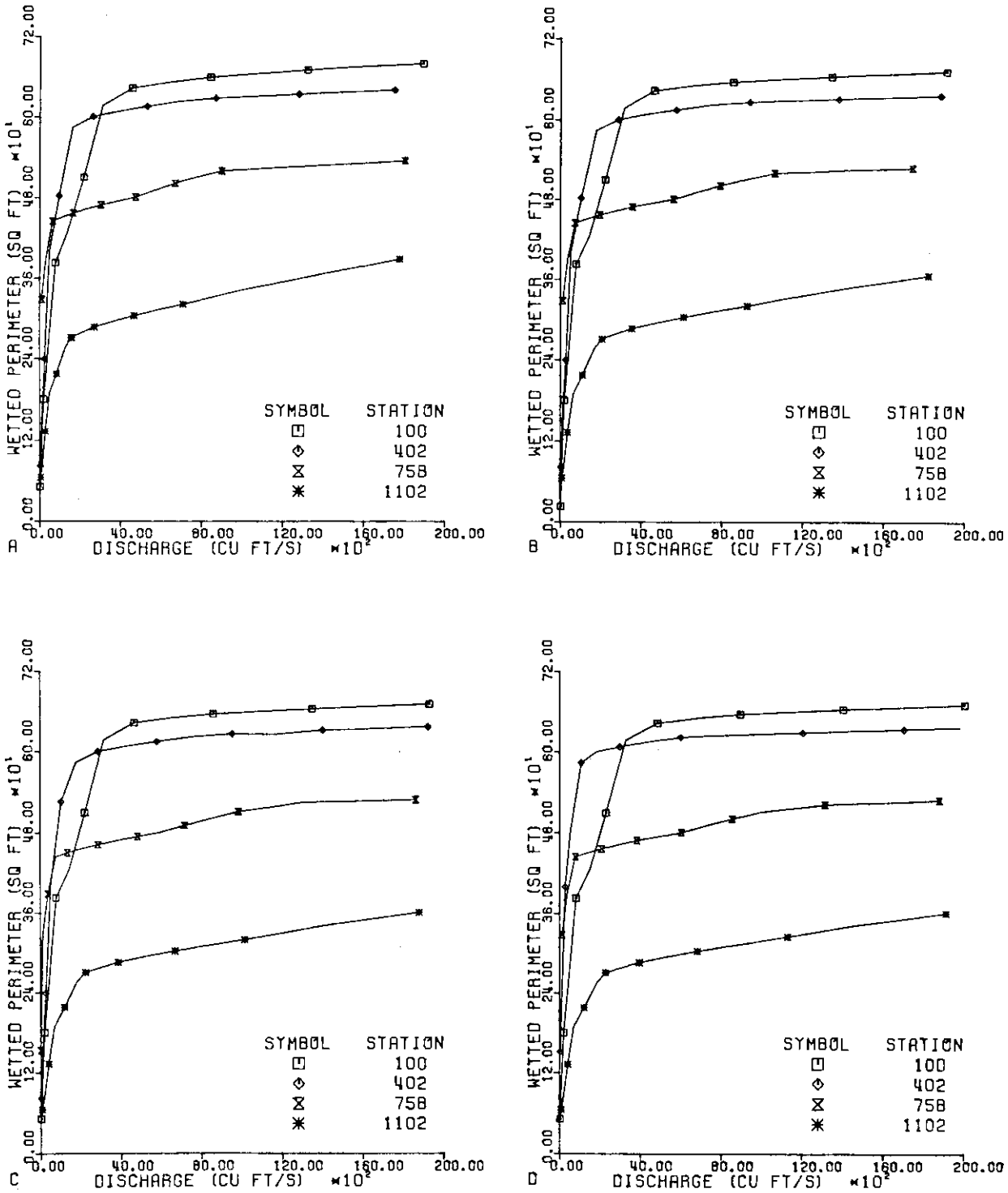
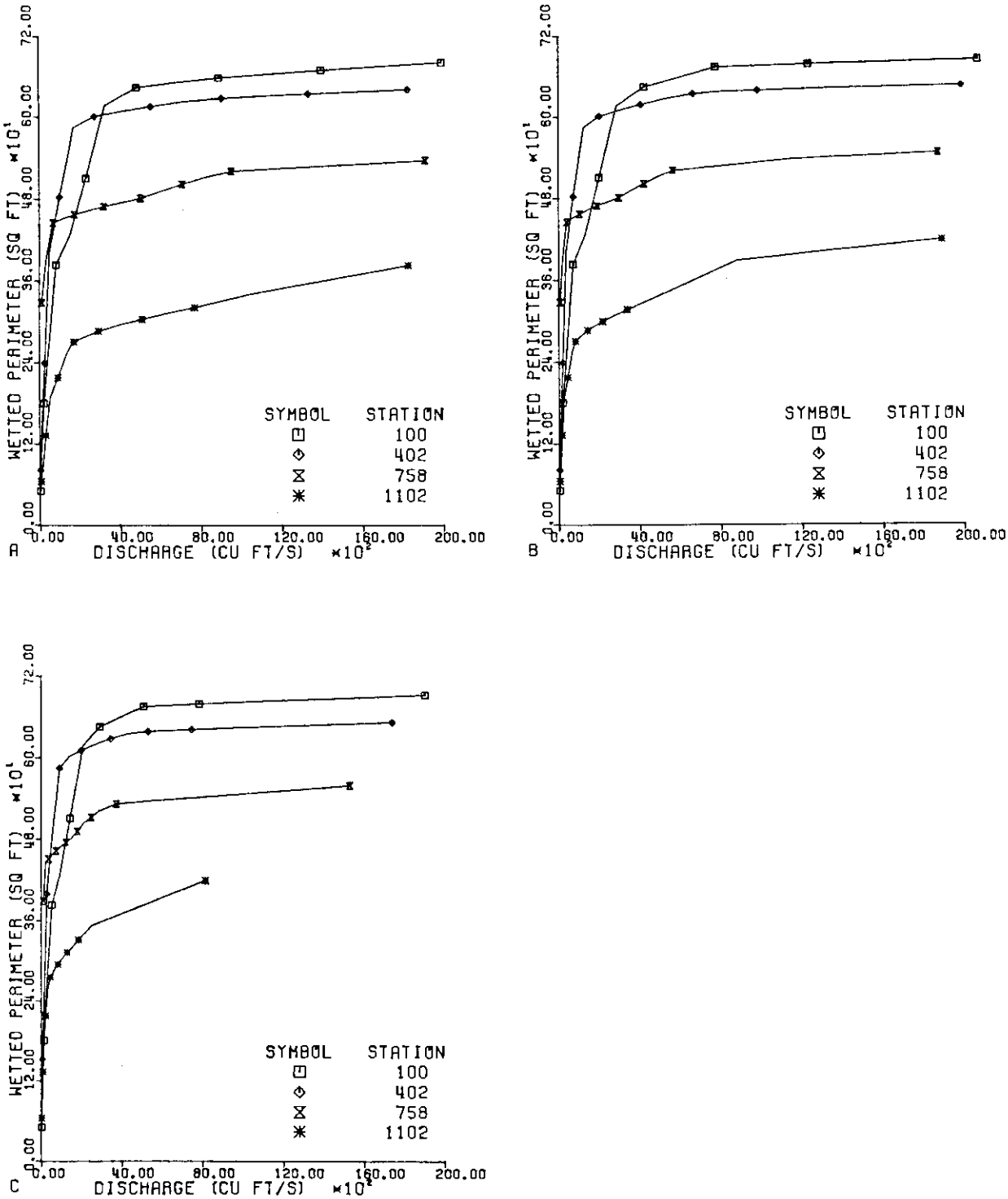


Figure A 16. South Fork Clearwater River discharge-wetted perimeter relationship predicted from data collected at (A) 640 cfs, and (B) 206 cfs.



igure A 17. Clearwater River discharge-wetted perimeter relationship predicted from data collected at (A) 17730 cfs, (B) 28350 cfs, (C) 34000 cfs, and (D) 35360 cfs.



igure A 18. Clearwater River discharge-wetted perimeter relationship predicted from data collected at (A) 19950 cfs, (B) 7340 cfs, and (C) 2510 cfs.

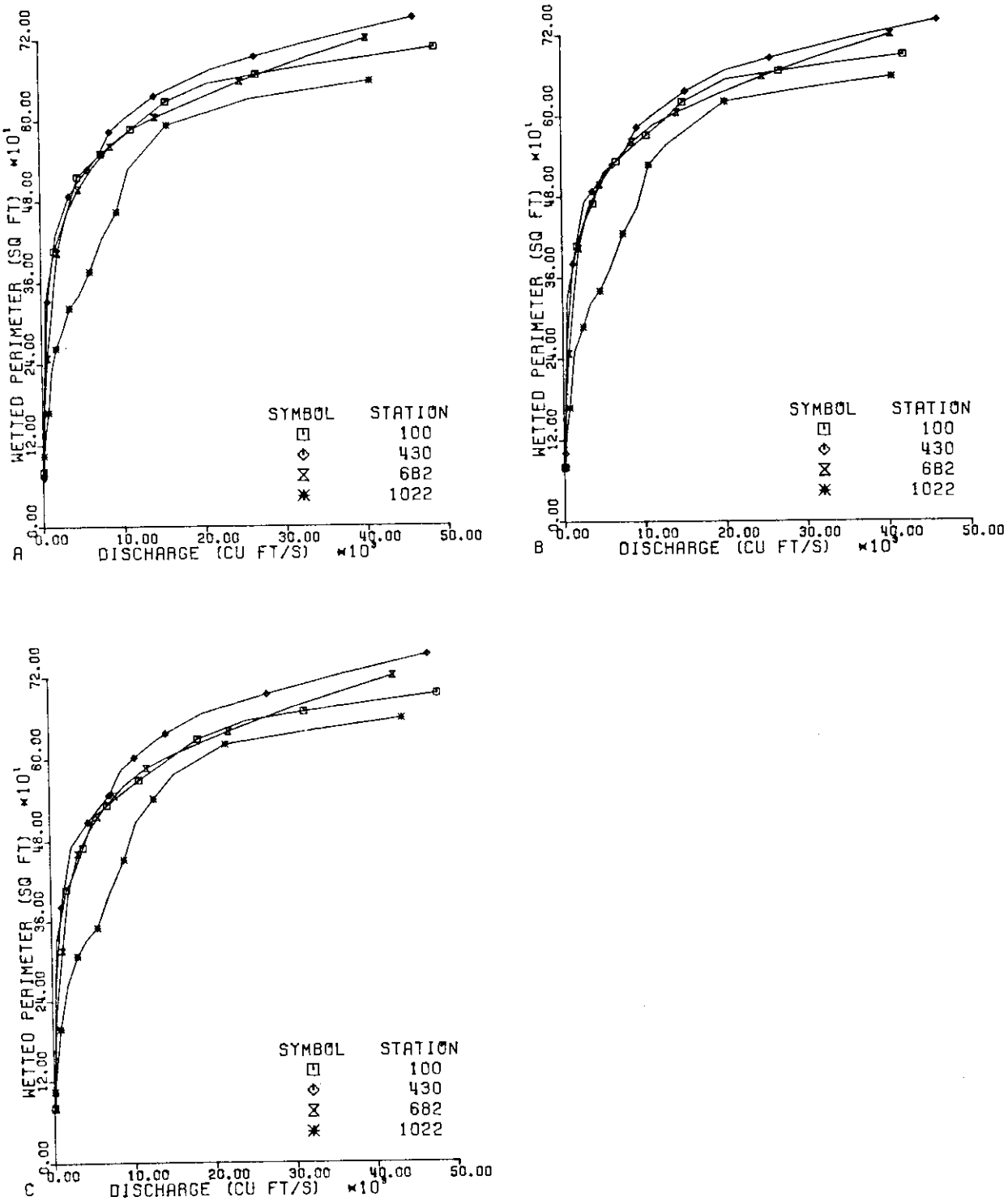


Figure A 19. Snake River discharge-wetted perimeter relationship predicted from data collected at (A) 17950 cfs, (B) 17450 cfs, and (C) 23600 cfs.

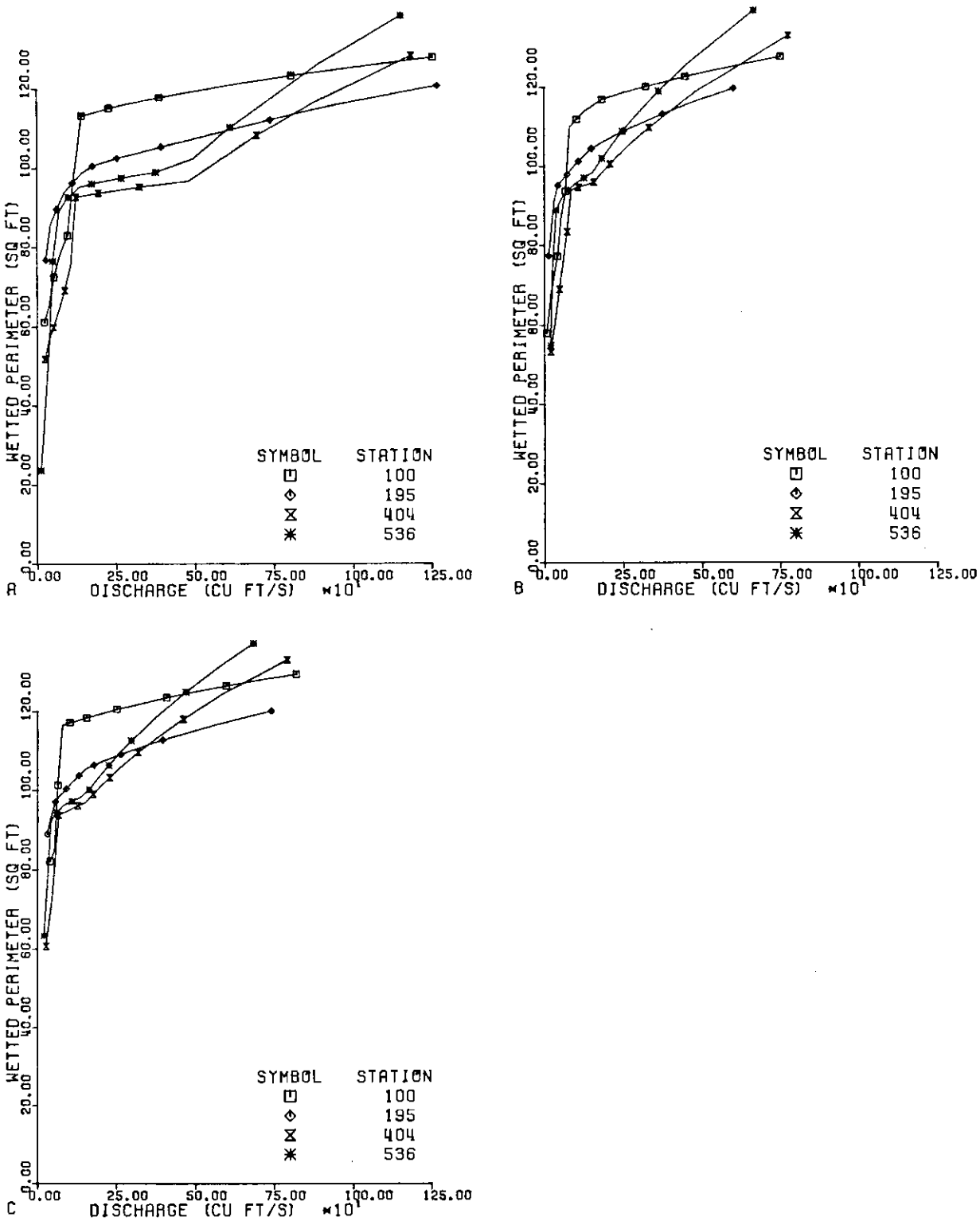


Figure A 20. Boise River discharge-wetted perimeter relationship predicted from data collected at (A) 480 cfs, (B) 159 cfs, and (C) 151 cfs.

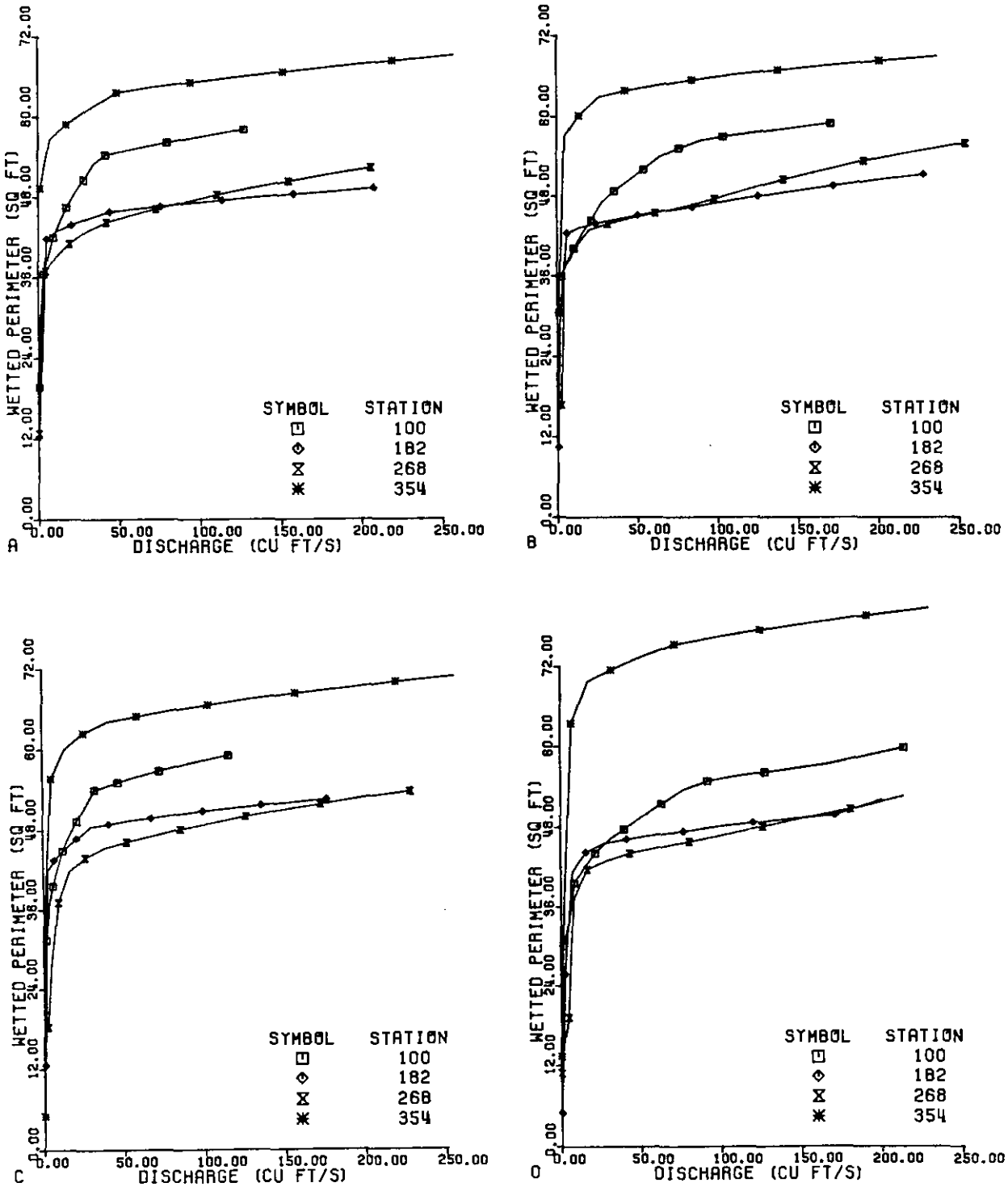


Figure A 21. Big Wood River discharge-wetter perimeter relationship predicted from data collected at (A) 38 cfs, (B) 89 cfs, (C) 32 cfs, and (D) 175 cfs.

Submitted by:

William D. Horton
Fishery Research Biologist

and

Tim Cochnauer
Senior Fishery Research Biologist

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

Jerry Conley, Director

Stacy Gebhards, Chief
Bureau of Fisheries

Jerry Mallet
Fishery Research Supervisor
Bureau of Fisheries