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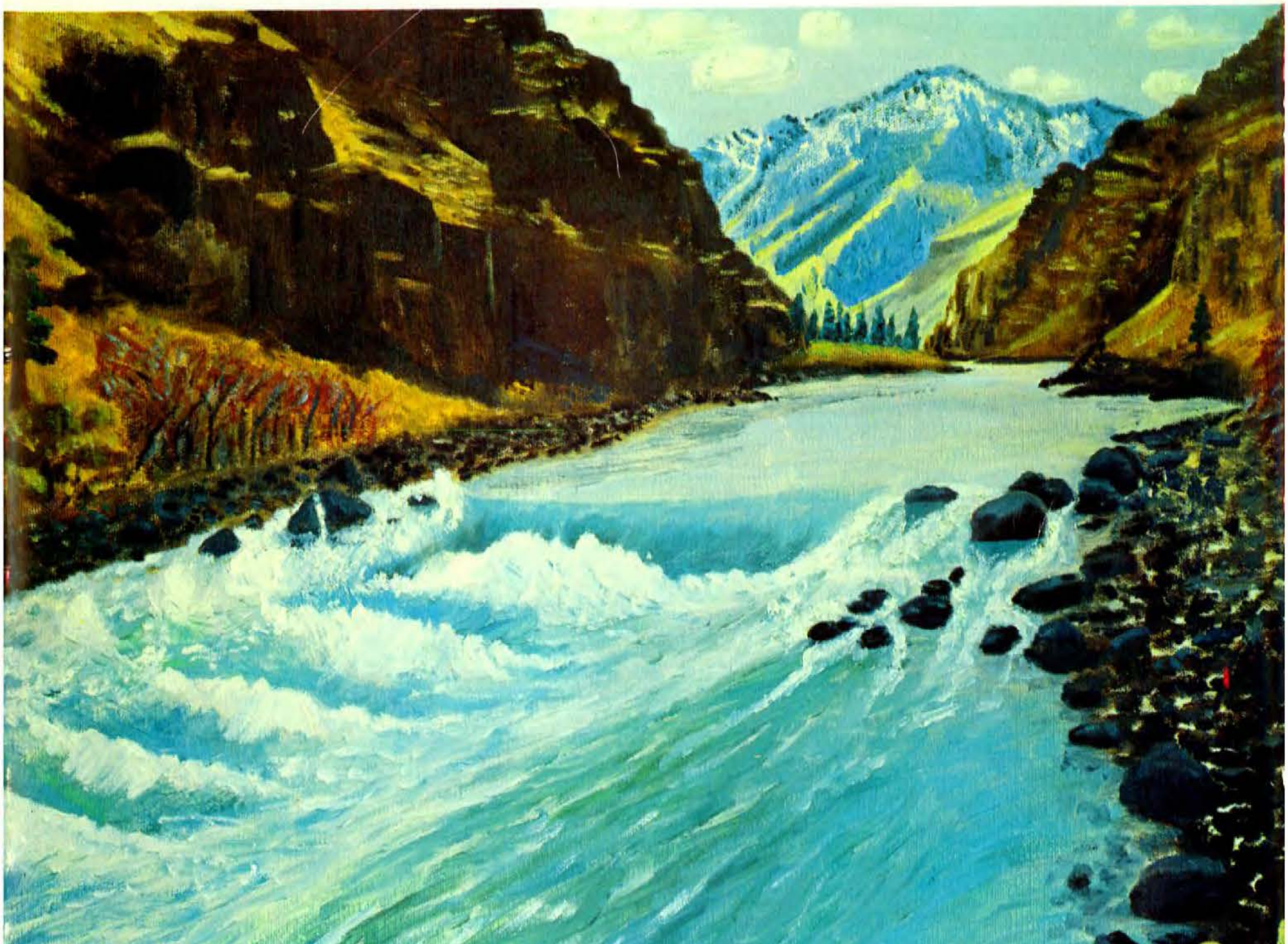

A REPORT OF THE HELL'S CANYON CONTROLLED FLOW TASK FORCE

Published July, 1974

PACIFIC NORTHWEST RIVER BASINS COMMISSION

1 COLUMBIA RIVER • P. O. BOX 9(6 • VANCOUVER, WASHINGTON / 98660

ANATOMY OF A RIVER

An Evaluation of Water Requirements for the
Hell's Canyon Reach of the Snake River
Conducted March, 1973

A multi-agency effort coordinated and edited by Keith Bayha, Bureau of Sport Fisheries and Wildlife and Charles Koski, National Marine Fisheries Service, under the auspices of the Pacific Northwest River Basins Commission's Comprehensive Coordinated Joint Plan Study of the Pacific Northwest.

Published July, 1974

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FRONTISPIECE

High elevation photo of
Hell's Canyon from Wild Sheep Rapids
looking downstream.

(Photograph by Charles Koski)

Raging cataract, mighty and arrogant,
You crash through steep canyon walls,
Then suddenly rest, in deep quiet pools,
To capture the sunlight and reflections from your shores.

Life-blood to the thirsty land,
I trespass to court the pleasures of your many moods
And seek respite for my weary soul.

Pat Lynch, 1973

ABSTRACT

Recognition of the lack of knowledge relating to the instream flow requirements of the Middle Snake River as a major constraint to water planning resulted in a precedent-setting effort in late March 1973, involving more than 30 State and Federal agencies and private entities. Seventy-nine specialists, distributed in nine camps located at specific sites along the 107-mile reach of the Snake River from Hell's Canyon Dam to Lewiston, Idaho, monitored the effects of five controlled flows on the biological community and man's non-consumptive uses of the river.

The total program involved studies of the time of travel of the stage wave and water mass, water quality, general recreation, white water boating, navigation and biological resources. Biological studies involved aquatic vegetation, benthic invertebrates and insect drift, stranding of insects, fish and other aquatic organisms, fish food habits and fishability, salmonid reproduction requirements, warm-water fish habitat, white sturgeon population, and wildlife.

New methodologies were applied in some of the above studies, notably a modification of the "Oregon Method" for evaluating salmonid reproduction requirements *(described in detail in Appendix 7.1)* and a modification of the Kanawha River Method for evaluating general recreation.

Also included are a review of the prestudy organization activity required for this unique study and a summary of the hydrological and hydropower operational factors now determining the river's character.

The lower level stream resource maintenance flow identified as desirable for salmonid fishes in the study reach was 12,000 cfs to 15,050 cfs, released from Hell's Canyon Dam. It is believed that other functional flow requirements, except hydro-power, in the study reach could also be met by this level of flow, providing rapid and severe fluctuations do not occur. The economic, environmental, and social impacts, both upstream and downstream from the study reach, were not assessed. It is recommended that this variable flow be evaluated as part of the Commission's Comprehensive Coordinated Joint Plan study to determine the beneficial and adverse affects of adopting such flows. The maintenance flow identified for this study reach, therefore, should not be construed as being recommended for implementation since studies are not complete.

PREFACE

The Pacific Northwest River Basins Commission, acting under the 1965 Water Resources Planning Act (PL 89-80), is preparing a "comprehensive, coordinated joint plan for water and related land resources." Plan formulation is a coordinated, cooperative venture involving the five Pacific Northwest States and 10 Federal Departments, each a full partner in the Commission. The study leading to selection of a plan will consider 10 or more beneficial uses of water and land, some of which are conflicting or even mutally exclusive under certain circumstances. The objective of the study is to select a plan which would be a guide to future stewardship and use of water, land, and related resources at Federal, State, and local levels. Thus, the plan and its implementation would have an impact upon the future quality of the overall environment and of human life in the Pacific Northwest.

Among major planning efforts currently underway are the Interior Department's Western U.S. Water Plan Study,[1] the Corps of Engineers' Columbia River and Tributaries Study, Department of Agriculture's Type IV Study of the Snake River Basin, Bureau of Reclamation's total water management studies of the Upper Snake and Boise-Payette River Basins and the State Water Plan studies of Idaho, Oregon, and Washington. These studies will have a significant impact on water management and use of the Snake River.

The lack of adequate instream-flow data was identified as a major constraint to effective water planning during the plan formulation phase of the recently completed Columbia-North Pacific Region Comprehensive Framework Study. Lack of information so basic as requirements for aquatic life, water quality, and navigation, as well as those for recreation and esthetic environment in the remote and undeveloped reach of Middle Snake River downstream from Hell's Canyon Dam, was one of the most critical data gaps. The Idaho and Oregon State Study Teams identified the reach of Snake River from Hell's Canyon Dam to Lewiston (referred to as the study area or Hell's Canyon reach) as one of the top priority areas to be studied.

Many decisions extending to areas far beyond Hell's Canyon hinged on, or would be related to, decisions to be made about flows and rates of flow change in the Canyon. Examples include decisions about consumptive and non-consumptive uses of water, from Jackson Lake in Wyoming across the fertile, but naturally arid, south of Idaho to the head of the Canyon; about power generation at private utility plants in the Canyon, and at Federal plants from Lower Granite Dam near Lewiston to Bonneville Dam at head of tidewater on the Columbia River; and about the possible dedication of Hell's Canyon in Idaho and Oregon, under S.2233 or a comparable legislative proposal, which would have nationwide significance.

Under those conditions, plan formulation is a challenge to the expertise and abilities of the Commission and of the participating Federal and State water and related land resource agencies. To meet that challenge, much work must be accomplished.

A considerable mass of information must be obtained, compiled, and analyzed in the light of public awareness and expressed public preferences. Some of the required information was available, or readily obtainable by standard, time-tested methods. Some was not available, and the data gap could not be filled within the limits of time and standard operating procedure.

[1] Although originally scheduled for completion in 1977, the "Westwide Study" was rescoped in early 1973 and is now in final report preparation stage.

This report describes a pioneering and precedent-setting effort in the field of data collection; a coordinated, cooperative study made by a multi-discipline, multi-agency team under the Commission's Idaho State Study Team and led by the Bureau of Sport Fisheries and Wildlife and the National Marine Fisheries Service. It outlines the planning which was required and the logistics involved as a guide to future planners of similar efforts.

It shows the constraints and limitations placed on the study by conditions beyond the control of the team, and how those constraints and limitations were managed so the study could be made. It emphasizes the cooperative approach to the study, in which the whole of the effort was greater than the sum of the individual parts. It sets forth the work which was planned, that which was accomplished, and by whom. It shows the costs involved, and how those costs were borne. It summarizes the findings of the study.

Finally, it sets forth, for use in formulation of the comprehensive joint plan and by all concerned, the conclusions reached by the Hell's Canyon Controlled Flow Task Force based on results of the study. Those conclusions about instream flow needs, the benefits from such flows, and the consequences of adopting other flows, will enable instream flows to be given proper consideration in planning for future water allocation and use in the Snake River Basin.

The controlled flow study was an essential step in the planning process in that it has provided natural resource planners with instream flow data for the Hell's Canyon reach of the Snake River. The study will make it possible to better relate the needs of the lower Snake with the water and related land problems of the upper Snake River Basin.

It is the hope of the Pacific Northwest River Basins Commission, the controlled flow study participants and the State study teams, that this report will be read and used by those with similar interests, needs, and responsibilities in other river basins. We hope it will provide the challenge, inspiration, and encouragement needed to resolve the problems encountered in collecting much-needed data on non-comsumptive uses of water.

Donel J. Lane, Chairman
Pacific Northwest River Basins Commission

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INTRODUCTION

Keith Bayha
Bureau of Sport Fisheries and Wildlife

The history of water use in the west and indeed the basic theory of western water law is "first in time—first in right." This concept served man well until recent years when population growth and the resulting increased demands on our water resources have produced conflicts in water allocation for beneficial uses of water.

Several attempts to develop a sound water plan for the future have been made or are currently underway. Each such effort quickly identified the need to quantify the water required to remain in the stream channel to support the values and uses we make of a river. We term this water the "instream flow requirement."

Lack of knowledge of the instream flow requirements is recognized as the major constraint to effective water planning. In other words, decisions about the amount of land which can be safely irrigated in southern Idaho in future years will be significantly impacted by the amount of water allowed to flow through the Hell's Canyon reach of the Snake River.

The flow which passes through Hell's Canyon is dependent initially upon the precipitation which falls on the upstream watershed thus annual variations in runoff are to be expected. Additionally, the rate at which the snowpack melts affects the magnitude and character of the spring runoff. Man's storage and diversion structures enable significant manipulation of the natural flow pattern. And lastly, Idaho Power Company's Brownlee-Oxbow-Hell's Canyon power dam complex provides the final control. Operation of these projects is influenced by power demand, upstream and downstream water requirements, and water supply. The frequency and magnitude of fluctuation in flow is primarily determinded by the extent of the hydro-peaking operation for these projects.

As stated earlier, water planners need to define the flow regime required for the beneficial, non-consumptive instream uses through this reach of the Snake River in order to develop sound plans for the future use of water and related land resources.

The purpose of this study was to establish the lower level instream flow requirements (and where possible the optimum flow) for fish and wildlife, water quality, navigation, and recreation in the Hell's Canyon reach of the Snake River. More specifically, the goal was to develop an envelope curve (summary curve) expressing the flow recommendations for all functions collectively for each half-month period of the year. Secondary objectives were the development and testing of methodologies on a large river.

Chapter 1 of this report outlines the planning and logistics involved in the study for the purpose of aiding those who may consider conducting a similar study.

Chapters 2 through 14 present the objectives, methods, results, and conclusions for each of the functional studies which relate to the physical environment, the series of trophic levels comprising the biological community, and man's uses of the river. Limitations and necessary qualifications of data interpretation are covered in the functional chapters.

Chapter 15 covers hydropower, an instream use which was not evaluated as part of the field studies since the relationship of flow to power generation was known. Included is information on the constraints and reservoir operations presently shaping the flow pattern downstream.

Chapter 16 summarizes the findings of the previous chapters and discusses the limitations of the functional studies. The interrelationships of the various uses are discussed, leading to a final recommendation embracing the instream flow requirements of all uses and resources considered. A short discussion on water supply examines the recommended flows in relation to the historic flows of record. Needs for further study are identified.

CHAPTER 1

STUDY INITIATION

Keith Bayha
Bureau of Sport Fisheries and Wildlife

HOW THE STUDY WAS CONCEIVED AND PLANNED

The Bureau of Sport Fisheries and Wildlife was charged with leadership responsibility for federal agencies for instream flow studies for the Western U.S. Water Plan Study. The Pacific Northwest River Basins Commission's Comprehensive Coordinated Joint Plan Study for the Pacific Northwest placed the lead role with Bureau of Sport Fisheries and Wildlife in Idaho, the National Marine Fisheries Services in Oregon, and the Washington Department of Ecology in Washington.

Initiation of planning for this study began September 14, 1972, when Keith Bayha, head of the Bureau of Sport Fisheries and Wildlife planning effort in Idaho; Charles Koski, National Marine Fisheries Service, and Ken Thompson, Oregon Game Commission (who had substantial experience in studying instream flow requirements for salmonid fishes), met to discuss approaches to studying instream water requirements in the Hell's Canyon Reach. They recognized that stabilized flows would be required because of the daily fluctuations resulting from operation for power generation at Idaho Power Company's Brownlee-Oxbow-Hell's Canyon Dam complex. A periodicity chart was prepared showing the critical time for the many factors to be considered in selecting dates for a controlled flow study *(Figure 1.1)*. This chart and a proposed flow release schedule were distributed to "all interested parties" on November 6, 1972, attached to a memorandum requesting comment. Response to that memorandum indicated agreement on the late March period for conducting the study because of minimum impact on resources and uses at that time. Interest from many agencies and disciplines was evident.

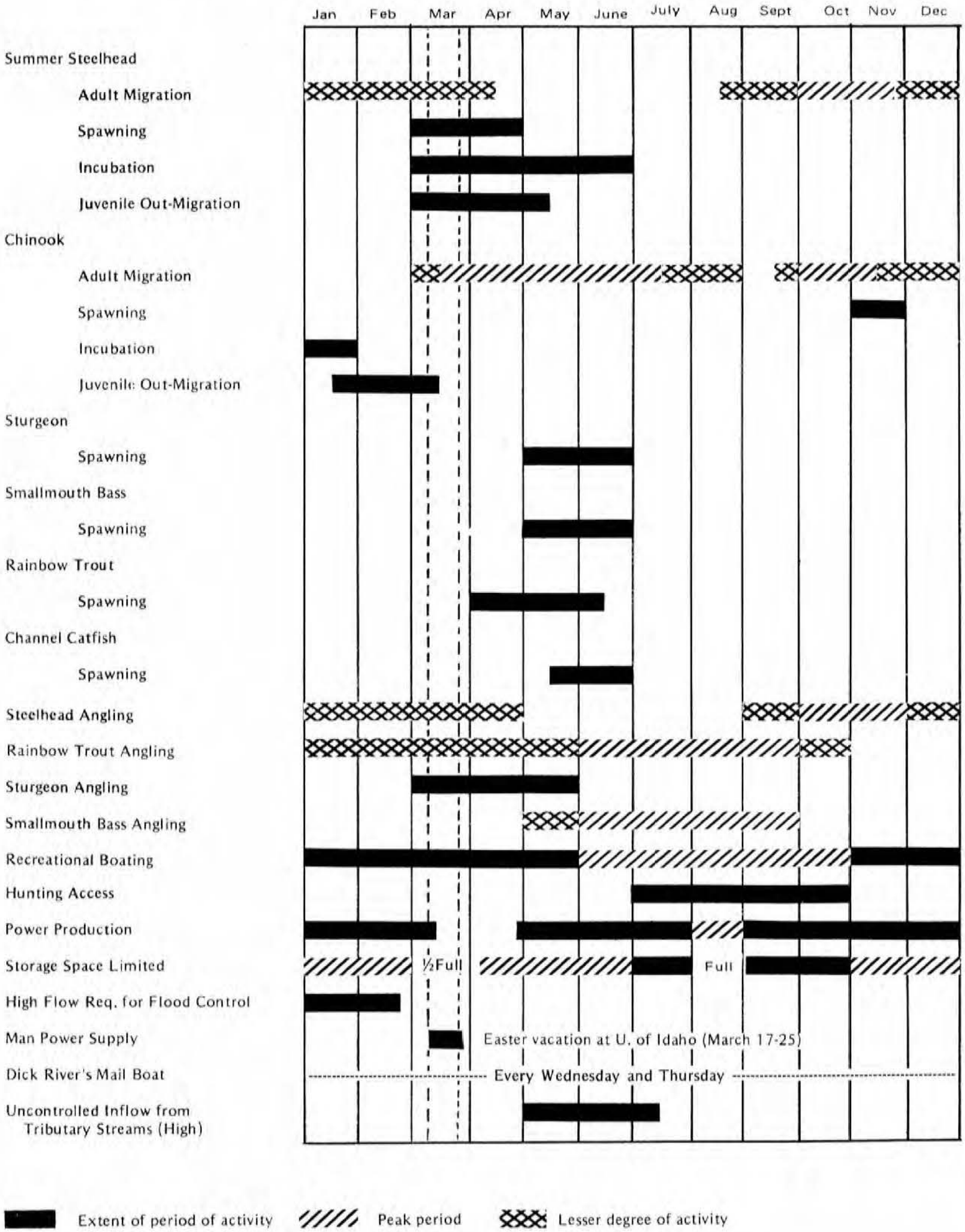
Initial efforts to develop a study plan indicated that substantial difficulties in arranging for the controlled releases would require multi-agency support. Foremost among the difficulties was the urgency of conducting the study during the spring of 1973 because projected power demands in relation to generating capacity would limit Idaho Power Company's flexibility in providing the flows in 1974 and thereafter. Therefore, scheduling of the study was accelerated. Scope of the study was expanded to include all interested agencies in an effort to mobilize the manpower required to examine all disciplines involved in man's instream use of the river and the aquatic ecosystem.

A draft plan of study was prepared and distributed on December 29, 1972. It called for a 7-day schedule of flows stepped down at 24-hour intervals from 18,000 to 1,000 cubic feet per second.

On January 9, 1973, more than 40 people from 24 Federal and State agencies met to discuss the plan of study and identify problems such a study faced. These included:

1. The proposed 7-day, 7-flow study would cost too much in lost power generation.
2. Drawing the flow down below 5,000 cfs probably would result in loss of support by state fishery agencies because of anticipated damage to fish populations.
3. Development of an electric power exchange agreement between Bonneville Power Administration and Idaho Power Company would be required to assure service to Idaho Power Company customers.
4. Federal Power Commission would require 30 to 45 days lead time for approval of a request to deviate from the license requirements regarding minimum flow and rate

Figure 1.1 Periodicity Chart Used in Selecting Time of Controlled Flow Study



of flow change.

5. Remoteness of the Canyon and length of the reach would necessitate helicopter support for successful completion of all investigations contemplated.
6. The public would have to be properly informed to gain local support and avoid damage to or loss of property, and possible loss of life during rapid flow changes, particularly flow increases at the end of the study.

Based on discussions at this January meeting, a second draft plan of study was prepared and distributed January 20 to an even larger group of agencies, including participants from the Idaho and Oregon State Study Teams. This draft called for a 5-day, 5-flow schedule with releases stepped down from 27,000 to 5,000 cfs. At the same time, negotiations were initiated between Idaho Power Company and Bonneville Power Administration to arrange for the exchange of electric power necessary to permit modification of the operation of the Brownlee-Oxbow-Hell's Canyon projects, to provide the programmed flows. Also, efforts to arrange for helicopter support from the U.S. Army at Fort Lewis, Washington, were begun, using the reasoning that while assisting the study, training in mountainous terrain could be accomplished.

The Idaho State Study Team reviewed the second draft plan of study and approved a resolution of study endorsement on January 31, 1973. February 1 a second planning meeting was held to reconcile comments on the January 20 draft plan of study and review progress in efforts to overcome the several major hurdles. At that time substantial problems remained, but consensus held the study was important and that we had no choice but to proceed with planning on the assumption everything would fall into place.

On February 5, a third draft of the plan of study was distributed. It included an appendix which addressed the requirements of the National Environmental Policy Act, and letters from agencies endorsing the study.

February 16, the Idaho Power Company sent its official request to the Federal Power Commission for permission to deviate from license stipulations to accommodate the proposed study. The Federal Power Commission published announcement of the request in the Federal Register on February 16. The Bonneville Power Administration-Idaho Power Company electric power exchange agreement was completed and sent to the Federal Power Commission on February 22 *(Exhibit A)*.

The pre-study public information effort included:

1. Review of study plans with professional fishery biologists attending the annual meeting of the Idaho Chapter of the American Fishery Society in McCall, Idaho, on January 26, 1973.
2. Three short television interviews in Lewiston, Idaho, between February 20 and March 1.
3. Direct contact with resident ranchers along the river on February 21 and 22.
4. Review of study plan stating purpose of study with Lewiston Chamber of Commerce's Fish and Wildlife Committee on February 23.
5. Similar review with Sierra Club leaders in Moscow, Idaho, on February 25.
6. Corps of Engineers' public notices of study schedule dated February 26 and March 15.
7. A half-hour T.V. interview aired in Boise on March 15.
8. Numerous news releases appearing in newspapers throughout the region during late February and early March.

On February 28, and March 1, a reconnaissance trip into the Canyon was made by boat by 14 people, including most who were to serve as functional team leaders. That trip was useful in selecting data collection sites and campsites. On March 3, arrangements were made with the manager of the Circle C Ranch to locate the main camp and heliport at Pittsburg Landing.

The period from March 5 to 16 was rather hectic. Status of helicopter support was indefinite and changed almost daily, which required additional changes in logistic preparation to accommodate a boat-supported alternative effort. On March 10 packets of memoranda which consitituted a supplement to the February 5 Plan of Study were distributed to participants, which included latest personnel assignments, arrival schedules of participants, and the study safety plan.

On March 16, the day prior to establishing field camps, word was received that the Federal Power Commission had approved temporary deviation from the license stipulations needed to permit the study. That same day, the Secretary of Defense approved the use of U.S. Army helicopters.

The latter decision resulted after two weeks of intensive effort, initiated by the Pacific Northwest River Basins Commission which saw the Pacific Northwest Congressional delegation urge a favorable decision from the Department of Defense. Solid expressions of support from the five Northwest Governors and the many agencies involved in water planning in the Northwest were of equal help. Costs of helicopter support were defrayed by reimbursement to the Army by Bureau of Sport Fisheries and Wildlife ($15,000), Corps of Engineers ($9,500), and Pacific Northwest River Basins Commission ($5,000). The remainder was absorbed by the military as training costs.

STUDY FORMAT

The study involved the reach of Snake River from Hell's Canyon Dam downstream to Lewiston, Idaho, a total of 107.7 river miles. Format of the study involved five controlled flows, each held stable for 24 hours. *Table 1.1* shows the flow levels and the programmed time of change for releases at Hell's Canyon Dam.

Table 1.1 Final Schedule for Controlled Releases

Date	Time	Flow
3/19		Stabilize near 27,000 cfs
3/20	Noon Mt. Std. Time	27,000 cfs
3/21	Noon Mt. Std. Time	Abrupt reduction to 18,000 cfs
3/22	Noon Mt. Std. Time	Abrupt reduction to 12,000 cfs
3/23	Noon Mt. Std. Time	Abrupt reduction to 7,700 cfs
3/24	Noon Mt. Std. Time	Abrupt reduction to 5,000 cfs
3/25	Noon Mt. Std. Time	Return rapidly to 27,000 cfs

For more detailed record of the actual flows observed, see Chapter 2.

A functional team approach was selected because instream flow requirements involve several uses and complex relationships of various ecosystem components. Complete study of those requirements demands expertise in a number of different disciplines. Since interested agency personnel had varying degrees of experience in the full range of those disciplines, their participation was welcomed and utilized in making up the functional teams.

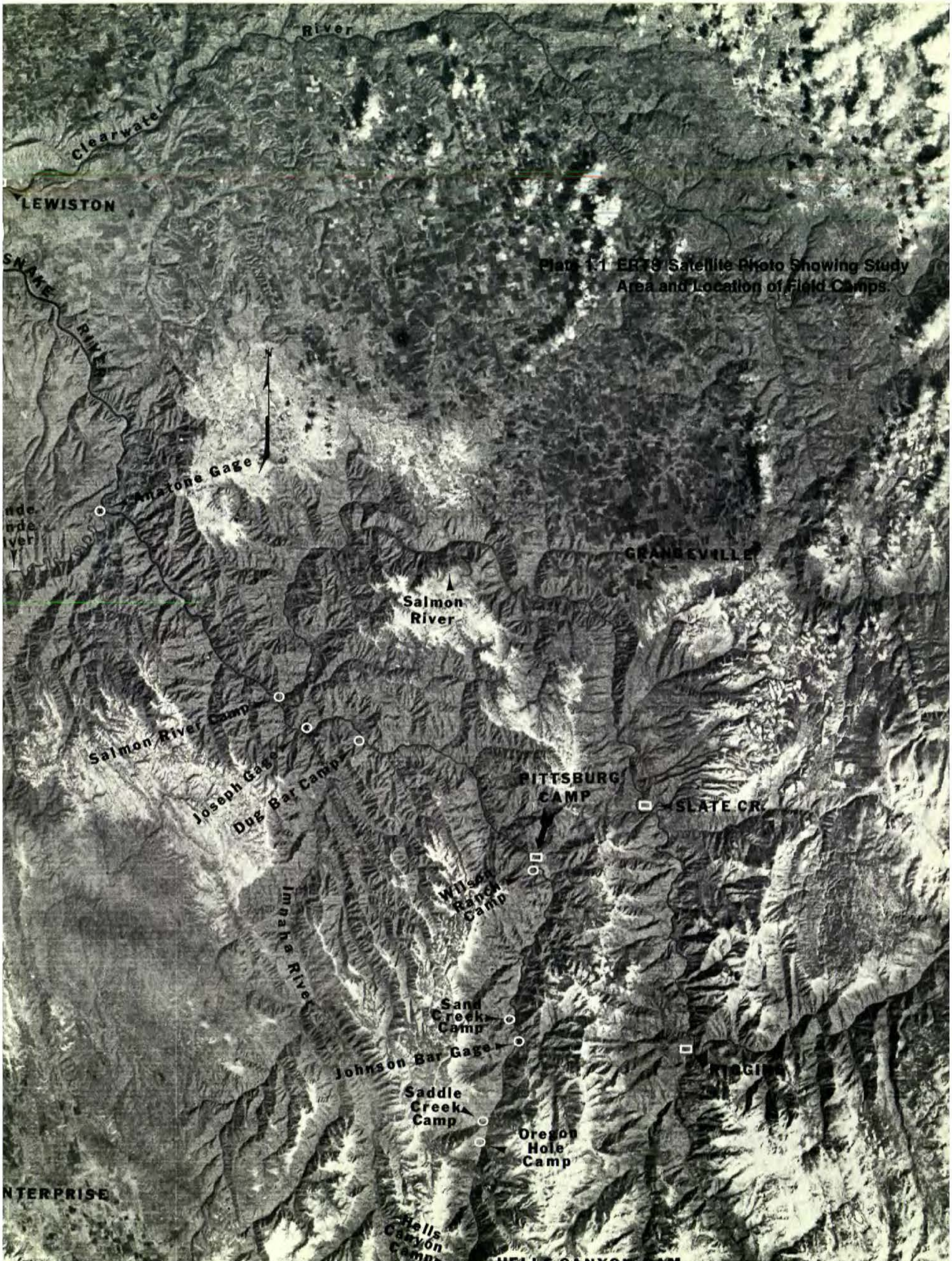


Plate 1.1 ERTS Satellite Photo Showing Study Area and Location of Field Camps.

The functional teams were led by individuals chosen by the study coordinator because of experience and indication of agency interest and support. Other team members were recruited by the team leader or, in some cases, assigned by the coordinator when the many agencies involved requested an opportunity to participate.

Selection of data-collection methods and compilation of data were responsiblilities of the study team leaders. Later writing assignments were delegated to the study team leaders.

LOGISTICS

Preparation for field activities presented as many problems as the planning for approval of the study. Placing 79 people in the remote Hell's Canyon in nine camps spread over 107.7 miles, with the necessary data collection, communication, transportation, food service equipment, and personal gear, was a major undertaking. The mechanics had to be put together in a short time, without firm knowledge the test could proceed, but on the assumption approval would be forthcoming. The multitude of agencies and their personnel worked together, each contributing what it had to offer: manpower, equipment, money, or expertise.

Personnel Distribution

Personnel distribution was a matter of identifying individuals with the proper professional expertise who had funding support from their agency and assigning them to the camps from which they could best accomplish their assignments. For the most part, functional team leaders carried that burden. The indeterminate transportation picture and individual schedule conflicts were the greatest problem. Personnel who participated in the field work are listed in *Exhibit B*.

Camp Locations

Camp locations were dictated by the needs of the functional teams and by the existence of available cabins. *Plate 1.1* shows the location of the nine field camps. One individual in each camp was assigned the task of solving logistical problems for the members of his camp. Exhibit C gives a description of each camp and a brief narrative on the manner in which it operated.

Plate 1.2 Transportation requirements of study personnel were met by a unique blend of 10 boats and 4 helicopters

Photo by Tony Whyte, Vancouver *Columbian*

Transportation

Transportation was a multi-agency effort also. Ten boats furnished by five agencies were employed at eight camps.

Air support was provided by the 9th Infantry Division of the U.S. Army at Fort Lewis, Washington. Four helicopters-three UH-IH (Huey) *(Plate 1.3) and a CH-47* (Chinook) *(Plate 1.4)*-were employed in data collection, personnel and equipment shuttle, and command and coordination missions. Missions were planned each evening by the flight commander and the study coordinator, on the basis of feedback on air-support needs from the respective functional team leaders *(Plate 1.5)*. Refueling logistics were handled by the Army through a private contractor who deployed a tanker truck at Slate Creek on the Salmon River, or at the Lewiston airport. Refueling at Slate Creek was limited on the second day of the study by low cloud cover which obscured the pass between Pittsburg Landing and Slate Creek *(Plate 1.6)*. The pilots flew their missions under the low clouds, but ended the day low on fuel. If the clouds hadn't lifted during the night, the helicopters would have been grounded. The only other refueling problem was a fuel truck breakdown which resulted in the loss of three hours of critical air time.

Photo by Ben Pulliam, National Marine Fisheries Service

Plate 1.3 The "Huey" was the workhorse of the study.

Photo by Charles Koski, National Marine Fisheries Service

Plate 1.4 CH-47 (Chinook) assisted white water boaters.

The U.S. Army aviators provided outstanding service through their flying skill and interest in the successful completion of the study objectives *(Plate 1.7)*. They did this while giving the highest priority to safety considerations and thorough maintenance of their aircraft *(Plate 1.8)*. Additional information on the helicopter support is contained in Capt. Pullum's after-action report *(Exhibit D)*.

Communication

Communications between the groups was essential. The Wallowa-Whitman National Forest provided radio equipment for each camp and personnel to man the relay facilities necessary to complete the network. The Forest Service gained significant knowledge of radio communication within the canyon during the course of the study.

Photo by Jim Graban, Idaho Fish & Game Department

Plate 1.5 Next day's mission being planned.

Photo by Keith Bayha, Bur. Sports Fisheries & Wildlife

Plate 1.6 Low hanging clouds, preventing refueling, created anxiety in scheduling.

The Idaho Fish and Game Department's radio network was useful as a backup system, but was limited to certain locations where reception was possible.

The U.S. Army's radio equipment within the helicopters allowed communications between aircraft within the range of their equipment.

Safety

A thorough safety plan was prepared and sent to all study participants prior to the field effort. Safety coordination was especially difficult because so many different agencies were involved in the study. The plan included instructions on emergency evacuation, the use of water craft, behavior of ground-based personnel around helicopters, and other activities. A medical doctor was part of the field crew and each camp had one person responsible for the safety of camp residents.

Press Relations

News media representatives were briefed and accommodated by an information officer and the resultant coverage was more than satisfactory. Monitored coverage of the study resulted in total lineage equivalent to a 12-page special section of a newspaper. Because of transportation limitations both to the study site and on site, more press representatives would have defeated the positive coverage achieved.

Photo by Charles Koski National Marine Fisheries Service

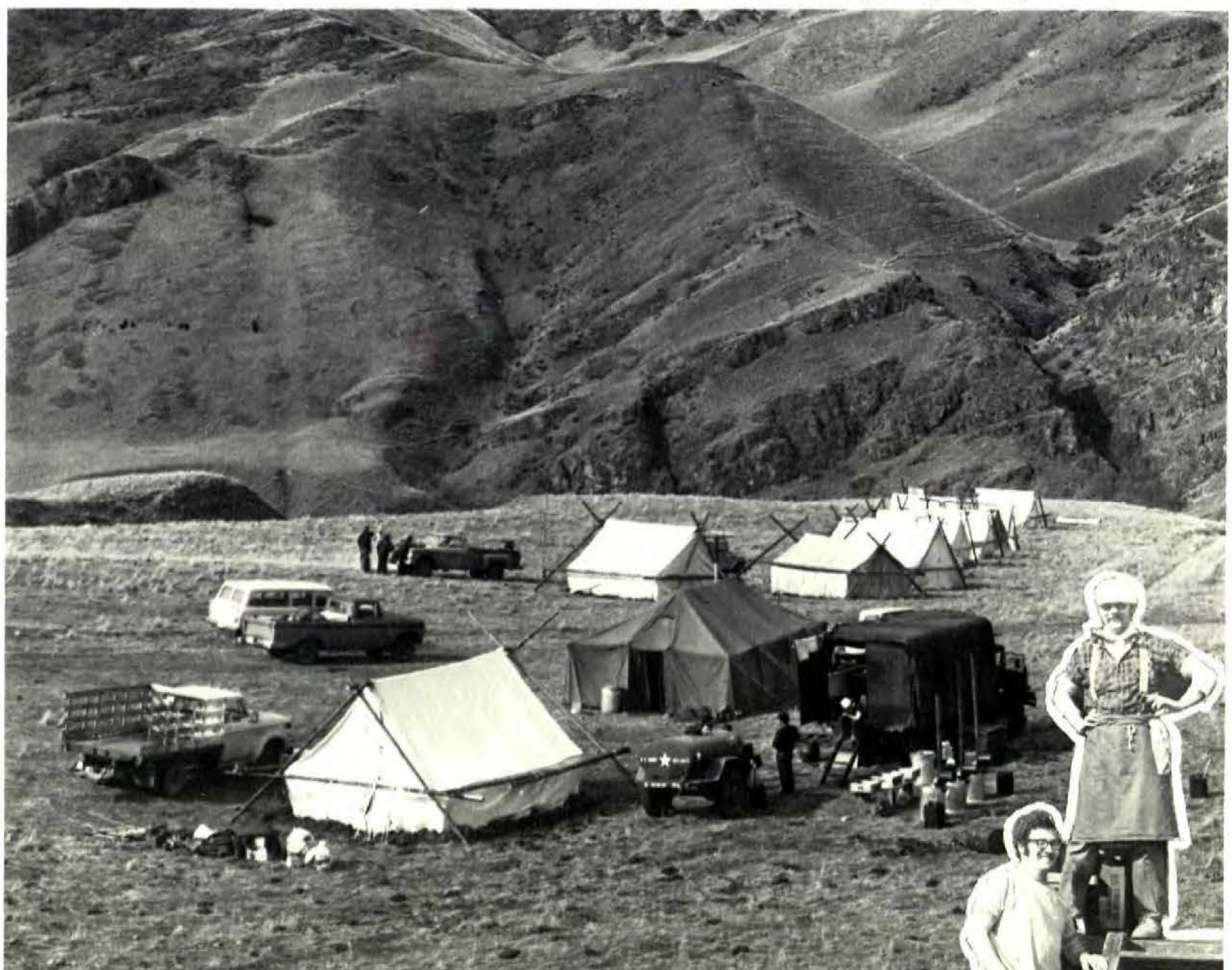
Plate 1.7 Aviator skill in treacherous terrain was demonstrated daily.

Public Involvement

The field study included three citizen kayakers who participated on the white water boating team using their own equipment. One of these men was Dr. Dee Crouch, an M.D. who acted as "physician in residence" *(Plate 1.9)*. Another was a professional white water outfitter and guide. The navigation team also had participation by professional outfitters. Three of the camps were located on private land through the cooperation of the ranchers. And, lastly,

Plate 1.9 Dr Dee Crouch

Plate 1.8 Thorough maintenance of the aircraft was given high priority



Photos this page by J. Graban, IF&G

Plate 1.16 The main camp at Pittsburg Landing was composed of U S Forest Service tents , Idaho National Guard mobile mess unit manned by two majors (inset at right) in food service from Boise State College public involvement in analysis of results and formulation of recommendations was provided through appointment to the task force of five citizens representing the resident ranchers, outfitters, the Idaho Water Users Association, Hell's Canyon Preservation Council, and Lewiston Chamber of Commerce *(see Exhibit E).*

STUDY COSTS

The controlled flow study had no specific funding source or budget. Some agencies were funded for instream flow studies in general through the Western U.S. Water Plan Study (Interior agencies), Comprehensive Coordinated Joint Plan Study (Federal agencies other than Interior), Columbia River and Tributaries Study (Corps of Engineers), U.S. Department of Agriculture Type IV Snake River Study (Soil Conservation Service), and State Water Plan Studies (some State agencies). Other participating agencies had to utilize on-going program funds.

Because of the urgency for doing the study in 1973 and the importance of filling the data gap, more than 24 agencies found justification to support their participation and, in some cases, certain activities of others.

The extent of involvement is shown in Table 1.2, which shows the actual cost and real costs. Actual costs are defined as those expenditures which would not have been made if the study had not been conducted. Real costs are actual costs plus the manpower, equipment, overhead, etc., which should properly be attributed to the study effort.

HOW THE STUDY RESULTS WERE COMPILED

Following the field activity, a report preparation task force (known as the Hell's Canyon Controlled Flow Task Force) was assembled by the study coordinator with approval of the Idaho State Study Team. Membership on that task force is shown in Exhibit E.

Writing assignments were made to the functional team leaders who analyzed the data and prepared drafts of their respective chapters.

The task force met on May 23, August 8 and 9, and a subcommittee met November 1, 1973. The team leaders presented their findings to the task force for discussion and analysis, with ultimate approval given to the chapter drafts.

Chapter 16, "Discussion, Conclusions, and Recommendations," was written by a task force subcommittee in accordance with the consensus of the full task force.

ACKNOWLEDGMENTS

The support and advice of Donel J. Lane, Chairman of the Pacific Northwest River Basins Commission, and Henry Stewart, Managerial Aide for the Idaho State Study Team, were greatly appreciated. Significant to success of the study was the broad support from the members of the State Study Teams and the agencies they represent.

Among the many individuals who assisted in the difficult task of preparing for this study, special recognition is given to Dick Nadeau, Marie Hayes, and James Nee, Bureau of Sport Fisheries & Wildlife, Boise. Paul Berg, BSF & W in Washington, D.C., assisted in the coordination at the Central Office level.

Marie Hayes and Pat Lynch, BSF & W, handled the significant typing chores involved in distributing the many report drafts. Charles Koski, NMFS, Boise, assisted the editor during the final stages of report preparation. Bill Catlin and Sandy Macarty, Pacific Northwest River Basins Commission, are responsible for the finished product, including typography, cover design and graphics, exclusive of photography.

Table 1.2 Estimated Costs of Hell's Canyon Controlled Flow Study

Agency	Actual Costs[1]	Real Costs[2]
Bureau of Sport Fisheries & Wildlife[3,4]	$19,240.45	$33,424.90
Bureau of Outdoor Recreation	425.00	3,200.00
Bonneville Power Administration	0	900.00
Bureau of Reclamation	630.00	3,791.00
Federal Power Commission	303.00	1,428.00
National Marine Fisheries Service[5,6,7]	19,481.00	25,881.00
U.S. Forest Service[8]	4,097.20	5,911.67
Soil Conservation Service[8]	1,000.00	1,000.00
Agricultural Research Service	0	150.00
Corps of Engineers[3,9]	21,692.00	27,710.00
Washington Dept. of Ecology	2,001.00	4,710.70
Idaho Water Resource Board	440.00	1,500.00
Idaho Fish & Game Department	986.04	3,164.76
Idaho Dept. of Water Administration	118.00	504.44
Idaho Dept. of Environmental & Community Services	3,700.00	4,100.00
Idaho Dept. of Parks & Recreation	182.68	755.98
Oregon Water Resources Board	207.73	611.32
Oregon Game Commission	1,917.73	7,218.48
Fish Commission of Oregon	325.00	800.00
Oregon Highway Dept.	125.00	425.00
Idaho Power Company[10]	0	8,200.00
U.S. Army	(13,149.00)[12]	7,446.00[11]
Pacific Northwest River Basins Commission[3]	6,749.42	8,043.51
Idaho Coop. Fishery Research Unit	0	1,331.10
University of Idaho[13]	0	2,968.00
Washington State University[14]	0	1,072.00
	$ 83,621.25	$ 156,242.86

[1] Actual Costs include expenditures which would not have accrued had the study not been made.

[2] Real Costs represent gross costs, and include actual costs plus salaries, overhead and expenses underwritten as training, or contributing to ongoing programs.

[3] Includes portion of $29,500 reimbursed to U.S. Army for helicopter support (BSF&W - $15,000, CE - $9,500, and PNRBC - $5,000).

[4] Includes $350 reimbursed to USGS for technical advice in planning and analysis in connection with time of travel study.

[5] Includes $7,000 contract for University of Idaho benthos study.

[6] Includes $1,000 transferred to CE to underwrite printing of enlarged aerial photos for use in fishery habitat analysis.

[7] Includes $10,000 transferred to PNRBC for coordination, special assistance and report preparation and publication.

[8] Includes contribution to special account set up by BSF&W to cover miscellaneous multi-agency expenses (USFS - $3,000, SCS - $1,000).

[9] Includes $928 transferred to BSF&W, who in turn underwrote participation by Washington State University in the aquatic vegetation study.

[10] Includes $6,000 contract with Seattle Marine Laboratories.

[11] Represents U.S. Army contribution over and above the $29,320 reimbursement identified in Footnote 3, and reported elsewhere.

[12] Total real cost for helicopter support of $36,946 minus $23,797 underwritten by the Army and justified as training, leaves $13,149. Army actually received $29,320 in reimbursement. Thus a surplus of $16,171 to be available to satisfy tort claim. Tort claim is not yet settled, so amount does not appear in cost totals.

[13] Represents costs of benthos study above the $7,000 contract with NMFS.

[14] Represents costs of aquatic vegetation study above the $928 contract with the Corps of Engineers.

Contract No. 14-03-37023

United States Department of the Interior

BONNEVILLE POWER ADMINISTRATION

P.O. Box 3621, PORTLAND, OREGON 97208

OFFICE OF
THE ADMINISTRATOR

In reply refer to: PCH

Exhibit A Power Exchange Agreement

Mr. Glenn J. Hall
Vice President, Power Operations & Engineering
Idaho Power Company
P. O. Box 770
Boise, Idaho 83701

Dear Mr. Hall:

In order to facilitate the controlled flow study by the Department of the Interior (Westwide Study) in the Hells Canyon Reach of the Snake River proposed for March 20-25, 1973, Bonneville is willing to exchange energy with the Company under the following terms and provisions:

1. Prior to March 20, 1973, the Company may deliver to Bonneville such amounts of energy as the Company determines are surplus to its needs and it desires to deliver. Such delivery will be scheduled at mutually agreeable times and rates.

2. During the period of the study, March 20-25, 1973, the Company may request from Bonneville the amounts of energy which the Company determines it needs on account of the controlled flow study to meet its system firm and interruptible loads plus its firm obligations to deliver power to other utilities. Bonneville shall schedule and deliver to the Company the requested amounts up to the otherwise unused capacity of Bonneville's generation and transmission facilities.

3. Bonneville will keep an account of any deliveries under 1 and 2 above.

4. Between March 25, 1973 and April 30, 1973, any balance of energy delivered under this letter agreement shall be returned to the party in whose favor the balance exists. Such return will be scheduled at times and in amounts which are mutually agreeable to the parties.

5. No charge will be applied to the delivery or return of energy under this letter agreement.

6. Provisions Required by Statute or Executive Order attached hereto as Exhibit A are hereby incorporated herein.

Sincerely,

(SEAL)

ACTING Administrator

ACCEPTED:

IDAHO POWER COMPANY

By ______________________

Title VICE PRESIDENT

Exhibit B

Participants in Field Activity of Hell's Canyon Controlled Flow Study

HELL'S CANYON DAM CAMP	FUNCTIONAL RESPONSIBILITY
Ben Pulliam, National Marine Fisheries Services, Boise	Photographer, dye study
Jim Winner, Idaho Department of Water Administration, Boise	Water quality, time of travel
Robert Steel, Seattle Marine Laboratory, Seattle	Water quality, benthos, fish population
Don Weitkamp, Seattle Marine Laboratory, Seattle	Water quality, benthos, fish population
Michael Colley, Seattle Marine Laboratory, Seattle	Water quality
David Loranger, Seattle Marine Laboratory, Seattle	Benthos
Max Katz, Seattle Marine Laboratory, Seattle	Fish population
OREGON HOLE CAMP	
Geoff Hogander, University of Idaho, Moscow	Sturgeon
Tom Hallback, University of Idaho, Moscow	Sturgeon
SADDLE CREEK CAMP	
Ken Thompson, Oregon Game Commission, Salem	Salmonids, photographer
Mike Golden, Oregon Game Commission, LaGrande	Salmonids
SAND CREEK CAMP	
John Coon, University of Idaho, Moscow	Sturgeon
Dave Hanson, University of Idaho, Moscow	Sturgeon
Jim Athearn, University of Idaho, Moscow	Sturgeon
Jake Szramek, Oregon Water Resources Board, Salem	Recreation, time of travel, photographer
Tom Welsh, Idaho Fish and Game, McCall	Photographer, white water rafting
Doug Erdman, Idaho Parks and Recreation Department, Boise	Recreation, white water rafting
Al Beam, citizen outfitter, Sun Valley	White water kayaking
Jim Leonard, citizen, Salmon	White water kayaking
Dee Crouch, M.D., citizen, Yakima	Medic, white water kayaking
WILSON RANCH CAMP	
Russell Biggam, University of Idaho, Moscow	Benthos, catchability
Marvin Hanks, University of Idaho, Moscow	Benthos, catchability
Jack Datisman, University of Idaho, Moscow	Benthos, catchability
William Fortis, University of Idaho, Moscow	Benthos, catchability
Jim Stanton, University of Idaho, Moscow	Benthos, catchability
PITTSBURG LANDING CAMP	
Keith Bayha, Bureau of Sport Fisheries & Wildlife, Boise	Study Coordinator
Chuck Koski, National Marine Fisheries Services, Portland	Assistant Coordinator, time of travel
Dick Nadeau, Bureau of Sport Fisheries & Wildlife, Boise	Camp leader
Ed Holland, U.S. Forest Service, Union, Oregon	Communications
Kerry Cripe, Boise State College, Boise	Cook
Kent Barnett, Boise State College, Boise	Cook
Mike Cleveland, Idaho National Guard, Boise	Cook's Assistant

PITTSBURG LANDING CAMP (cont.)	FUNCTIONAL RESPONSIBILITY
Bill Catlin, Pacific Northwest River Basins Commission, Vancouver	Press Officer
Jim Graban, Idaho Fish and Game, Boise	Movie and still photographer
Franklin Jones, Idaho Water Resource Board, Boise	Photographer
Gene Ralston, Idaho Dept. of Environmental and Community Services,Boise	Water quality
Dean Loomis, Idaho Water Resources Board, Boise	Water quality, time of travel
Merlyn Brusven, University of Idaho, Moscow	Benthos
Craig MacPhee, University of Idaho, Moscow	Catchability and benthos
Gary Bailey, Washington State University, Pullman	Vegetation
Pat Syms, Washington State University, Pullman	Vegetation
Herb Pollard, Idaho Fish and Game, Boise	Salmonid
Will Reed, Idaho Fish and Game, Boise	Salmonid
Ken Witty, Oregon Game Commission, Enterprise	Boat operator, catchability, stranding
Paul Burnett, U.S. Forest Service, Grangeville	Recreation
Terry Holubetz, Idaho Fish and Game, Boise	Spiny-ray fishery
Ernie Hesser, Corps of Engineers, Walla Walla	Navigation
Capt. Don Pullum, 9th Av. Btn., 9th Inf. Div., U.S. Army, Fort Lewis	Flight Commander
Capt. Marc Snook, " " " "	Huey pilot
1st Lt. Anthony Olenczuk " " "	" "
1st Lt. Bruce Chase " " " "	" "
CWO Robert Woodard " " " "	" "
WO Ronald McIntosh " " " "	" "
WO Bart McGhee " " " "	" "
TI SPG Jerry Mongrain " " " "	Technical Inspector
Sp. 5 Dennis Haza " " " "	Crew Chief (Huey)
Sp. 5 Sonny Westmore " " " "	" "
Sp. 4 Ralph Beckwith " " " "	" "
Capt. E. Poole, 10th Av. Btn., 9th Inf. Div., U.S. Army, Fort Lewis	Chinook pilot
CWO R. Nelson " " " "	" "
Sp. 5 S. Decker " " " "	Crew chief (Chinook)
Sp. 5 R. Higdon " " " "	" "

DUG BAR CAMP	
Merle Mews, Idaho Parks and Recreation Depatment, Boise	Recreation, photographer
Wayne Burck, Fish Commission of Oregon, Elgin	Salmonid
Duane West, Oregon Game Commission, LaGrande	Salmonid

SALMON RIVER CAMP	
Dwight Kilgore, Idaho Fish and Game, Lewiston	Boat operator, catchability
Jim Morris, Bureau of Outdoor Recreation, Seattle	Recreation, photographer
Rudy Ringe, University of Idaho, Moscow	Sturgeon
Rick Stowell, University of Idaho, Moscow	Sturgeon
John Dooley, Bureau of Reclamation, Boise	Water quality, time of travel

ANATONE CAMP	
Al Smith, Oregon Game Commission, Salem	Salmonid
Ron Lindland, Idaho Fish and Game, Lewiston	Salmonid
Dick Scully, Idaho Fish and Game, Lewiston	Salmonid
Bob Bishop, Washington Department of Ecology,	Salmonid, water quality
Jim Scott, Washington Department of Ecology, Olympia	Photographer, recreation, time of travel
Don Mathews, Corps of Engineers, Walla Walla	Navigation
Dean Hilliard, Corps of Engineers, Walla Walla	Navigation
Percy Karr, Missoula, contract pilot	Aerial photography
Lefty Swartz, Missoula, cameraman	Aerial photography

Exhibit C

Description of Field Camps

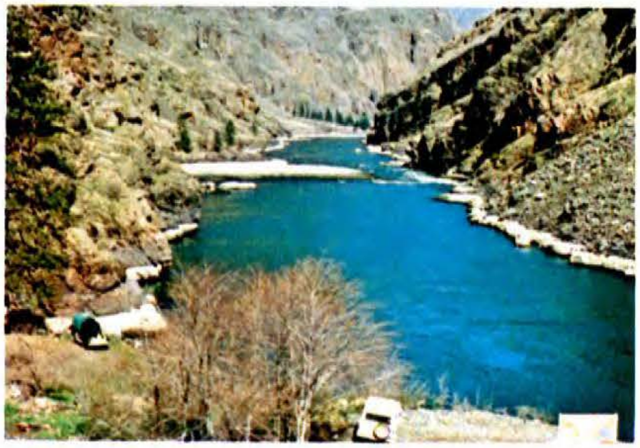


Photo by B. Pulliam, NMFS

Hell's Canyon Dam Camp (Rm 247.7) - Ben Pulliam, National Marine Fisheries Service, Camp Leader

This camp consisted of a 7-man group of investigators who worked in the first quarter mile below the dam and utilized commercial facilities at Oxbow, Oregon, for meals and lodging.

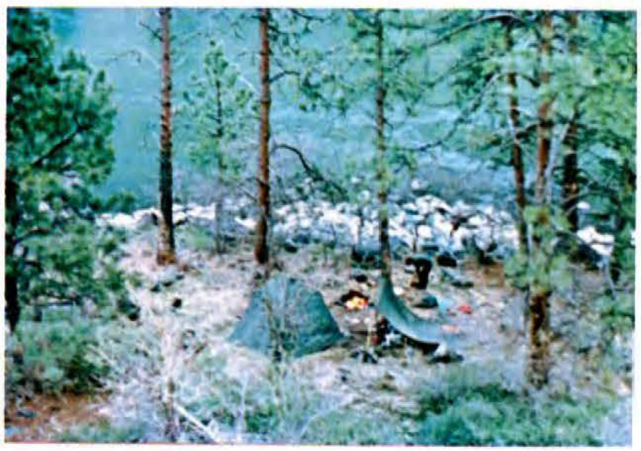


Photo by Geoff Hogander, Univ. of Idaho

Oregon Hole Camp (Rm 237.8) - Geoff Hogander, University of Idaho, Camp Leader

This camp consisted of a 2-man crew, a part of the sturgeon fishery team. They utilized a tent and boat and were self-sufficient, except for minor boat support from Ken Witty.

Photo by K Bayha BSF&W

Saddle Creek Camp (Rm 236.2) - Ken Thompson, Oregon Game Commission, Camp Leader

This 2-man crew, a part of the salmonid fishery team, utilized an existing U.S. Forest Service tent and boat and helicopter support.

Photo by C. Koski, NMFS

Sand Creek Camp (Rm 228) - Tom Welsh, Idaho Fish and Game Department and John Coon, University of Idaho, Camp Leaders

This camp consisted of ten men and utilized the Oregon Game Commission cabin and boat support. The white water boating crew originally assigned to Steep Creek campsite joined the Sand Creek Camp because of their dependence on support from the CH-47 helicopter, which could not land at nearby Steep Creek (Rm 229.0).

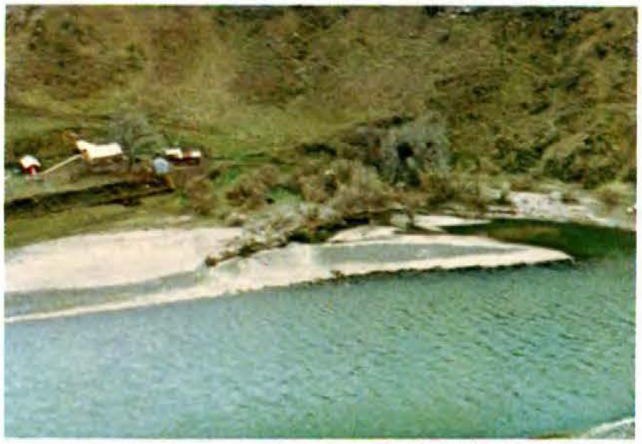


Photo by K. Bayha, BSF&W

Wilson Ranch Camp (Rm 214.7) - Russell Biggam, Camp Leader

This camp was located on the Lem Wilson property and consisted of tents used for lodging by five men of the benthos team who were required to collect samples around the clock. They crossed the river by boat for meals at Pittsburg Landing.

Photo by C. Koski NMFS

Pittsburg Landing Camp (Rm 213.8) - Dick Nadeau, Bureau of Sport Fisheries and Wildlife, Camp Leader

This was headquarters camp serving from 42 to 52 men during the course of the study and the base for the 15-man Army aviation team and their helicopters. The camp was located on Circle C Ranch property, through the courtesy of Dave Campbell, Manager.

Lodging in the form of 12 tents was provided by the Nez Perce National Forest. The Idaho National Guard was contracted to supply the required mess equipment, which consisted of a mobile mess unit, water trailer, and mess tent. Two students from Boise State College majoring in Food Services, contracted to handle the food supply and cooking chores. Two boats and the helicopters supported the data collection personnel.

Photo by Don Mathews, Corps of Engineers

Dug Bar Camp (Rm 196.7) - Wayne Burck, Fish Commission of Oregon, Camp Leader

This 3-man camp utilized commercial food and lodging facilities of Doug Tippett's Dug Bar Guest Ranch and depended upon boat and helicopter support.

Photo by K. Bayha, BSF&W

Salmon River Camp (Rm 188.2) - Dwight Kilgore, Idaho Fish and Game, Camp Leader

The cabin located at the mouth of the Salmon River served a 5-man crew. Camp personnel depended largely upon boat transportation. The cabin was made available by Ray Kernan of Lewiston. The crew based at this camp also collected data at China Bar (Rm 192.3).

Photo by C Koski NMFS

Anatone Camp (Rm 168.7-140.0) - Al Smith, Oregon Game Commission, Camp Leader

This camp consisted of seven men who utilized commercial food and lodging facilities in Lewiston and automobiles and boats for transportation. This crew worked on the Snake River between Lewiston and the mouth of the Grande Ronde River.

DEPARTMENT OF THE ARMY
Company B, 9th Aviation Battalion, 9th Infantry Division
Fort Lewis, Washington 98433

AMNLE-9-9AVN-CO B 16 April 1973

SUBJECT: After Action Report Hells Canyon Project

TO: Commanding Officer
9th Aviation Battalion
ATTN: S-3
Fort Lewis, Washington 98433

1. Purpose: to provide after action information concerning aviation support to the U. S. Department of Interior (DOI) in conduct of a major stream flow study on the Snake River from Hells Canyon Dam to the mouth of the Salmon River during period 19-27 March 1973.

2. General:

a. Company B, 9th Aviation Battalion received Hells Canyon mission, for planning, Friday, 9 March 1973 at approximately 1630 hrs (PST). The initial aircraft requirements was for five (5) UH-1H Helicopters with provisions for one (1) CH-47 to be attached from the 10th Aviation Battalion.

b. Immediately, flight crews were identified and special classes conducted on mountain flying techniques. Required support equipment was itemized and loading plans developed.

c. The approved mission (for three UH-1's and one CH-47 helicopters) was received approximately 1500 hours (PST) Friday, 16 March 1973. Departure from Fort Lewis was scheduled for 19 March 1973. Upon receipt of the warning order an apparent problem area was aviation fuel in the area of operation (AO). Because of the distance from Boise, and Lewiston, Idaho to the center of the AO it was not considered feasible to drive unit POL trucks from Fort Lewis to support the nine day exercise. The command decision was to purchase fuel from the civilian economy and, thus, utilization of the Government credit card was approved. After extensive coordination an agreement was reached with Boise Air Service (Mr. John Goodman) in the PM on 17 March 1973. Mr. Goodman agreed to preposition a fuel tanker at Slater Creek (Center of AO) on continuing basis @.58 per gallon plus .07 excise tax. This price was comparable to a quote from a Lewiston dealer who would not consider positioning in Slater Creek area; (indicated they could extend approximately thirty (30) miles south of Lewiston, ID).

d. The operation order was issued at 1500 hrs (PST) 17 March 1973. Loading plans were activated on 19 March 1973. Three (3) UH-1H helicopters and one (1) CH-47 helicopter departed Fort

Lewis, approximately 0900 hrs (PST) enroute to Lewiston, Idaho. The flight commander departed Lewiston to conduct a route reconnaissance of the Snake River to Pittsburg Landing, (proposed site of the base camp) while the remainder of the crew remained at Lewiston awaiting instructions from the reconnaissance party.

e. During the recon numerous power lines were spotted crossing the river at the canyon floor. An altitude of 2500 MSL was determined to be the safest altitude to avoid wires and afford a suitable altitude to make the limited forced landing areas in case of an emergency landing. Also, during the initial recon, it was determined that low level navigation along the winding Snake River was virtually impossible. You could not pinpoint the aircraft's exact location while using an aeronautical chart, scale 1:500,000.

f. Upon arriving at Pittsburg Landing, the flight commander met Mr. Keith Bayha, the study group coordinator (Fish & Wildlife Service, DOI). Mr. Bayha was advised that the helicopter support had arrived and was awaiting further instructions. The proposed parking areas were determined to be suitable.

g. The flight commander returned to Lewiston where current weather checks were made. The forecast was for high winds (40-50 knots with possible gusts to 60 knots). A decision was made to RON at Lewiston to secure the aircraft for the night. Mr. Bayha was provided a TWX, SUBJECT: Department of Interior Request for Army Helicopter Support for Stream Flow Study of Snake River which outlined the general parameters of our support to include Public Affairs Guidance. (Incl. 2).

h. At 0700 hrs (PST) 20 March 1973, the flight departed Lewiston for Pittsburg Landing and arrived at approximately 0730 hrs (PST). The days missions were discussed with Mr. Bayha. He was briefed on safety awareness for all members of his group who would be working near or around the aircraft. CPT Snook and LT Olenczuk were designated to plan a safety briefing for all the study group personnel and passengers.

i. Emergency evacuation by air in case of seriously injured personnel was discussed. Mr. Bayha advised that the Lewiston Hospital had been alerted and a heliport was located on the south side of the city. All pilots were informed of the location.

j. Communications was established at base camp with a PRC 25 (F.M.) radio. This set was found inadequate over 2 miles from base canp due to the limited line-of-sight range interference caused by winding canyon walls.

k. Subsequent daily missions were planned at the end of each days flying, usually after the study group coordinator received feed-back information from each river camp in order to place priorities on tasks to be accomplished. Due to the complexity of coordinating the entire 50 miles of river with several different aspects of the river study, missions were often altered or changed up to the last minute. These changes were essential in order to fully support the DOI project and remain on sc hedule, (see Incl 3 Daily Mission Synopsis).

l. Flying hours varied based on type missions, weather, and minor problems with refueling at Slater Creek. For detail break down of flight time per-day, per-type aircraft see Incl 4 (Daily Flying Hours and Sorties). Total actual mission time in direct support of River Study was 81.9 flying hours for three (3) UH-1H's and 11.0 flying hours for the CH-47. Mission time does not reflect enroute time to Pittsburg Landing and returning to Fort Lewis.

3. Problems Areas:

a. Air to ground communication was recurring because of terrain. A remote relaying transmitter could have improved communications.

b. Refueling was a minor problem when two contract tankers broke down. As a result, mission flight time was lost during refueling operations at Lewiston, which required additional flying hours the following day in order to meet desired mission schedule.

c. Navigation was virtually impossible when utilizing aeronautical charts, scale: 1:500,000. Pilots could not pinpoint exact locations on larger scale maps. Large scale maps, scale 1:50,000 or 1:250,000 were needed.

4. Conclusion:

a. Aviation support of the Hells Canyon Project was accomplished in a successful manner.

b. The training benefits received during this mission far exceeded the training aviators normally receive in a peace-time environment. Flight crews were able to put to practical use all aspects of mountain flying techniques and related aspects relative to operating on the floor of Hells Canyon. A mission of this nature builds confidence in the young aviators' ability and instills respect in his crew members and equipment.

c. The team work and cooperation demonstrated by the many different agencies taking part in this project contributed directly towards the safe accomplishment of DA support rendered to the DOI.

d. Subject mission had been in Army Channels since January 1973. The Aviation support had only minimum planning time prior to displacement. Confirmation for mission approval was received by supporting units approximately three (3) days prior to departure.

5. Recommendations:

a. Aviation units participating in missions of this nature be afforded maximum planning time when possible. This would enable supporting units to better coordinate with supported units.

b. Remote relay radio transmitters be established for continuos air-ground communications when operating in areas such as Hells Canyon.

c. Large scale maps (1:250,000 or larger) be furnished all crew members when navigation in terrain such as Hells Canyon is anticipated.

Donald M. Pullum

DONALD M. PULLUM
CAPT, IN
OIC HELLS CANYON PROJECT

DAILY MISSION SYNOPSIS WITH NUMBER OF FLYING HOURS AND SORTIES

	UH-1		CH-47	
	HOURS	SORTIES	HOURS	SORTIES
19 March Ft. Lewis to Lewiston	12.8	9	2.6	2
20 March CH-47 Logistical Support UH-1 - CMD & Control Group - LOG MISSION UH-1 - Photo Mission	13.1	30	1.6	4
21 March CH-47 - No fly WX UH-1 - CMD & Control Group UH-1 - Photo Mission	6.2	16	No Fly WX	
22 March CH-47 - Logistical Support UH-1 - CMD & Control Group UH-1 - Photo Mission UH-1 - Logistical Support	15.8	42	1.6	7
23 March CH-47 - Logistical Support UH-1 - CMD & Control Group UH-1 - Photo Mission - Log Mission	11.6	28	2.3	8
24 March CH-47 - Logistical Support UH-1 - CMD & Control Group - Photo Mission UH-1 - Photo Mission UH-1 - Logistical Support	15.6	32	3.7	8
25 March CH-47 - Logistical Support UH-1 - CMD & Control Group UH-1 - Photo Mission UH-1 - Logistical Support	18.2	54	1.0	3
26 March - Pittsburg Landing to Lewiston	3.2	5		
CH-47 - Logistical Support - Lewiston to Fort Lewis			4.1	4
27 March - Lewiston to Fort Lewis	12.3	9	NONE	—
TOTAL	108.8	225	16.9	36
ENROUTE	26.9		5.9	
MISSION TIME	81.9		11.0	

Exhibit E

Hell's Canyon Controlled Flow Task Force Members

Keith Bayha, Bureau of Sport Fisheries and Wildlife, Boise
Charles Koski, National Marine Fisheries Services, Portland
Ken Witty, Oregon Game Commission, Enterprise
Jim Morris, Bureau of Outdoor Recreation, Seattle
Cecil Thomas, U.S. Geological Survey, Boise
Dr. Craig MacPhee, University of Idaho, Moscow
Jack McLeod, Bureau of Reclamation, Boise
Larry Dean, Bonneville Power Administration, Portland
Wade B. Hall, Collaborator, Wallowa-Whitman National Forest, Baker
Bill Reese, Washington Department of Fisheries, Tumwater
Floyd Harvey, Outfitter, Lewiston
Jack Barnett, Idaho Water Users Association, Boise
Bruce Mitchell, Idaho Power Company, Boise
Terry Holubetz, Idaho Fish and Game, Boise
Jim Scott, Washington Department of Ecology, Olympia
Gene Ralston, Idaho Dept. of Environmental and Community Services, Boise
Merlyn Brusven, University of Idaho, Moscow
Dick Henry, Bureau of Reclamation, Boise
Gil Haycock, Idaho Water Resource Board, Boise (later replaced by Dean Loomis)
Doug Erdman, Idaho Department of Parks, Boise
Bill Platts, U.S. Forest Service, Boise
Wayne Burck, Fish Commission of Oregon, Elgin
Doug Tippett, Resident Rancher, Joseph, Oregon
Ken Thompson, Oregon Game Commission, Salem
Tom Welsh, Idaho Fish and Game, McCall
Don Mathews, Corps of Engineers, Walla Walla
Gary Bailey, Washington State University, Pullman
Rudy Ringe, University of Idaho, Moscow
Henry Stewart, Pacific Northwest River Basins Commission, Vancouver
Don Gipe, Environmental Protection Agency, Seattle
Bob Steel, Seattle Marine Labs, Seattle
Dick Farman, Hell's Canyon Preservation Council, Idaho Falls
Keith Stonebreaker, Fish & Wildlife Committee, Lewiston Chamber of Commerce, Lewiston
Jack Johnson, Oregon Water Resources Board, Salem
Clem Sterns, Pacific Northwest Power Company, Spokane

CHAPTER 2

TIME OF TRAVEL

C. H. Koski

National Marine Fisheries Service

Information about the time it takes the water level at downstream points to drop after a reduction in discharge at Hell's Canyon Dam was required in order to prepare study designs for the various functional study teams. The extent and timing of planned studies were dependent upon the rate shorelines became exposed and the duration of stable flows.

The controlled flow study also provided a good opportunity to study water mass[1] movement at the lower flows which differs considerably from the stage wave travel time.[2]

Data on water mass time of travel are important when considering aquatic life and water quality. For example, air temperatures in Hell's Canyon often range near 100° F. for long periods of time during the summer months. Possible releases of low quality water (i.e., high nutrient, algae blooms, low dissolved O_2, high N_2) from upstream impoundments during those periods, in combination with high air-water temperatures, could adversely affect aquatic life. The ability to predict the impact of such occurrences is in part dependent upon knowledge of the stage wave and water mass travel time. The objective of the time of travel study was twofold.

1. To determine the stage wave travel time and the rate of water level reduction at the various study sites and to compare these with the calculated predictions.
2. To determine the water mass time of travel and compare it to the stage wave time of travel. In addition, data collected on the water mass can be used to develop new projection factors for computing water mass travel time based on stage wave travel time.

METHODS

The stage wave travel time was estimated by three methods:

1. Calculated predictions by the USGS based on USGS stage gage measurements.

2. Actual stage gage tracings during the study. *(Figure 2.1)*

3. Individual observations at each of the study sites *(Plate 2.1)*.

Photo by K. Bayha, BSF&W

Plate 2.1 Observations of stage wave reduction was recorded at each site using improvised gages.

The water mass time of travel was estimated by three methods:

1. Calculated predictions by the USGS method based on stage gage readings multiplied by a

[1] Water mass time of travel: The time it takes a particular segment or volume of water to move a given distance.

[2] Stage wave: A phenomenon of pressure changes resulting from an increase or decrease in discharge which results in a translatory wave which moves through water at a greater velocity than that of the water particles.

1.2 factor.[3] This factor is commonly used by USGS when estimating water mass travel time in rivers of uniform shape and slope.

2. Rhodamine B dye was used to tag the water mass at the 7,700 cfs flow and the 5,000 cfs flow. A fluorometer and visual observations were used to track the dye *(Plate 2.2)*.

3. Oranges were used as a supplement to the other methods of estimating water mass time of travel. Oranges were selected as a floating indicator because they float low in the water and offer virtually no wind resistance, are easily seen and are bio-degradable. One gross of oranges was released at 0600 hours on the assumption that they would travel at approximately the same rate as the water mass and that an early morning release would provide maximum daylight time for recording movement. Releases were made at the 27,000 and 12,000 cfs flows.

RESULTS AND DISCUSSION

The stage wave form is shown in *Figure 2.1* which shows the actual trace made from gages located at Hell's Canyon Dam (RM 247.7), Johnson Bar (RM 230), Anatone gage (RM 167.2), and a temporary gage located at DeChennes Marine (RM 141.9). *Table 2.1* shows stage wave data collected at the various study sites.

Figure 2.2 shows the discharge at gaging stations on the main stem of the Snake River and compares them with the discharge of the principal tributaries during the period of this study.

Photo by J. Graban, IF&G

Plate 2.2 Biologist calibrates fluorometer which measures the concentration of fluorescent dye.

Generally, the stage wave reacted in accordance with the calculated predictions. The studies which were dependent upon knowing the time of water level reductions were performed successfully based on the calculated time. The difference between the observed and the calculated stage wave travel time was within the suggested $\pm$ 2.0 hours margin of error.

Some anomalies did occur, however, which could be a result of a number of factors. For instance, the hydraulic character of the river channel is probably emphasized at the reduced flows. Boulders and rubble which are deeply submerged at normal flows would be nearer to the surface as flows are reduced. This increased channel roughness, coupled with wide pool and eddy areas, would result in a slowing of the stage wave velocity. This would be particularly true upstream from Pittsburg Landing where the channel appears to be slightly wider. Downstream from Pittsburg Landing the channel appears to be generally narrower. As a result, the funneling effect would produce the increase in velocity which is indicated by the timing of the observed wave travel at China Bar (RM 192.3).

The calculated stage wave time is an average of the total reach, based on historical measurement at three gages, whereas observations were made at shorter intervals. There may be sufficient

[3] USGS Water Supply Paper 888, p. 156.

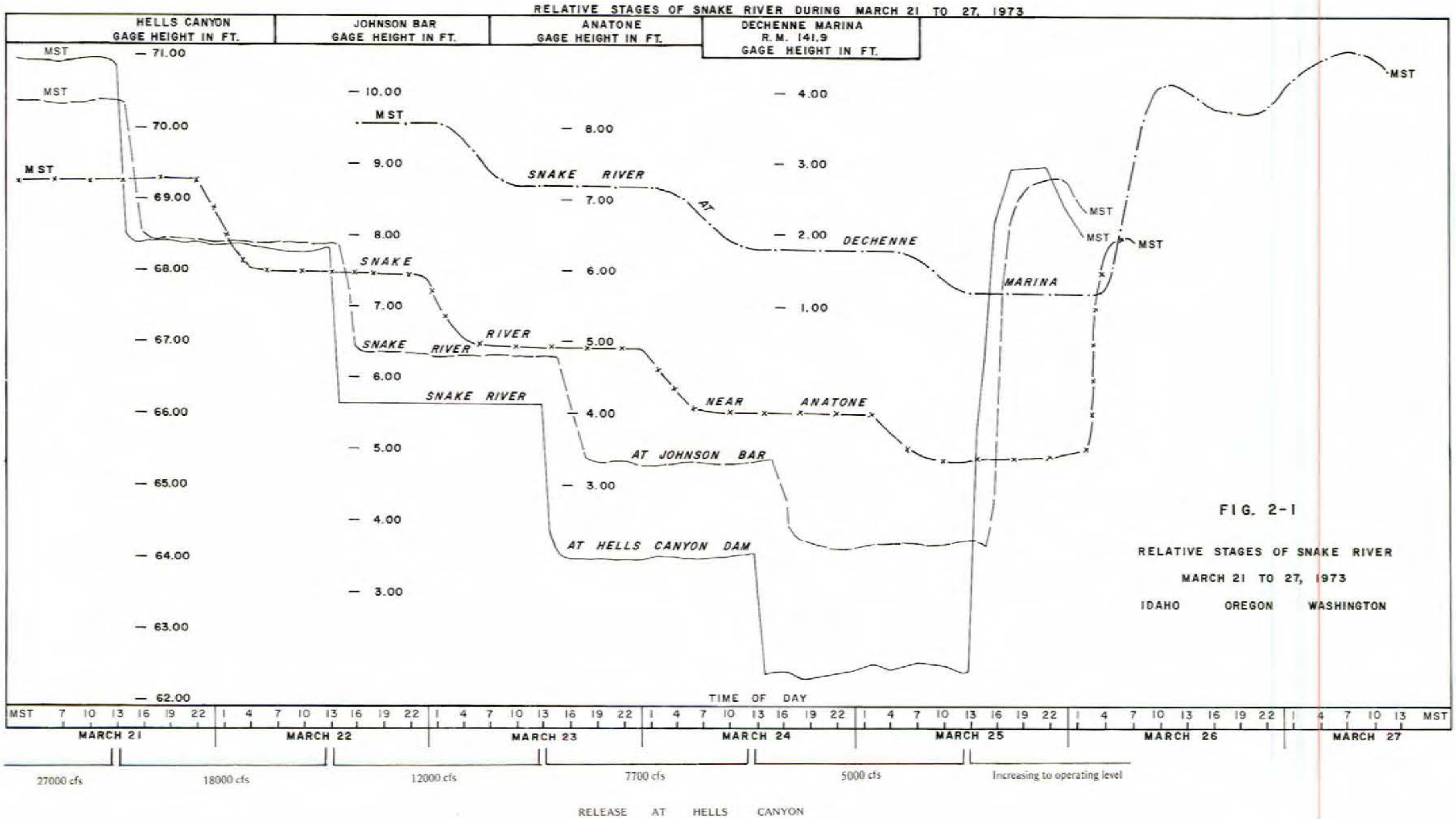


FIG. 2-1

RELATIVE STAGES OF SNAKE RIVER

MARCH 21 TO 27, 1973

IDAHO OREGON WASHINGTON

Table 2.1 Stage Wave Data, Snake River, Idaho, at 7,700 cfs, March 24-25, 1973

R.M.	Distance from HCD Miles	Time of arrival	Lapsed time to stabilization Hrs.	Min.	Estimated velocity of stage wave mph	fps
247	0	1200	3			
235	12	1315	1	28	9.6	14.4
230	17	1400	3		8.5	12.4
228	19	1410			8.7	13.6
215	32	1606	3	6	7.8	11.4
192	55	1730	5	30	10.0	14.6
164	83	2300	8		7.6	11.0

at 5,000 cfs, March 24-26, 1973

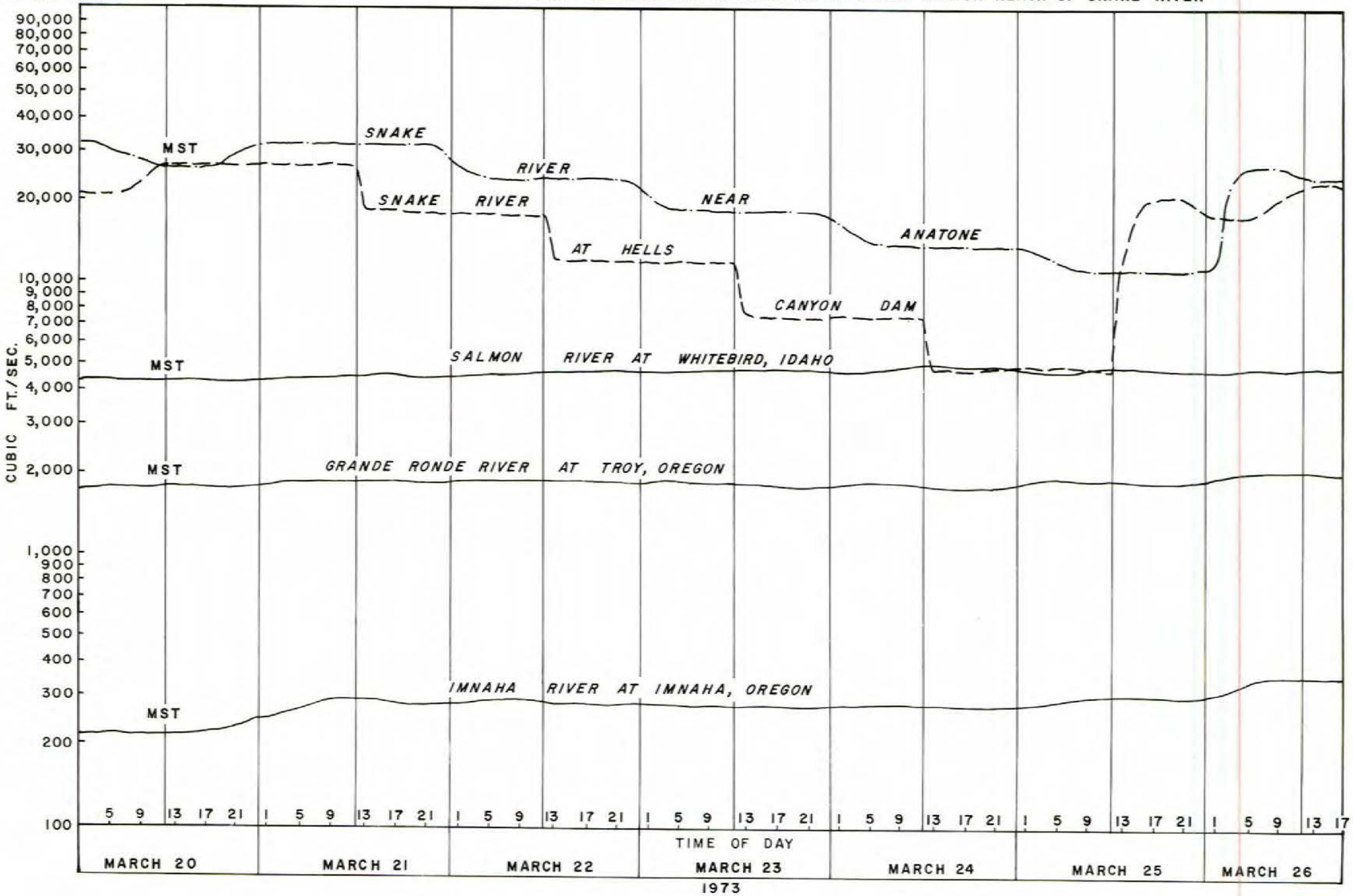
R.M.	Distance from HCD Miles	Time of arrival	Lapsed time to stabilization Hrs.	Min.	Estimated velocity of stage wave mph	fps
247	0	1200	1			
235	12	1345	3	40	6.8	10.3
230	17	1400	2		8.5	12.4
228	19	1415	1	15	8.4	12.4
215	32	1700	3		6.4	9.4
192	55	1730	5	30	10.0	14.6
164	83	0100	9		6.3	9.4

change in gradient between Pittsburg Landing and China Bar to account for an increased velocity through that reach. On the basis of this assumption, the stage wave velocity below China Bar might be expected to decrease and more nearly approach the calculated time at Anatone gage.

Another reason for the differences may be human error in establishing the exact timing of the receding water. Obviously, it is difficult, without continuous recording instruments, to determine the exact timing of a stage change that may take five hours to recede one foot. However, it appears that the method for calculating stage wave travel time used by USGS is relatively accurate as compared to visual observations.

The use of oranges as indicators of water mass movement was a failure. The oranges were

FIG. 2-2 DISCHARGE AT GAGING STATIONS ON MAIN FORK AND PRINCIPAL TRIBUTARIES IN HELLS CANYON REACH OF SNAKE RIVER



trapped in the rough shoreline and eddies and provided no significant data. The use of floats for determining water mass movement in anything but relatively straight, smooth channels would seem to be a futile procedure.

Although the water mass study using Rhodamine B dye was not a complete success, it has provided a valuable insight as to the nature of the Snake River at these low flows as well as background information for future studies of this type. Water mass travel data are shown in *Table 2.2.*

Table 2.2 Water Mass Travel Data, Snake River, Idaho, at 7,700 cfs, March 24-25, 1973

R.M.	Distance from HCD Miles	Time of arrival (dye)	Lapsed time Hours	Day of arrival (dye)	Velocity of water mass (dye) mph	fps
247	0	0600		24		
228	19	1500	9	24	2.1	3.1
215	32	0200	20	25	1.6	2.3
209	38	0900	27	25	1.4	2.0
205	42	1110	29	25	1.4	2.1
195	52	1615	34	25	1.5	2.2

at 5,000 cfs, March 24-26, 1973

R.M.	Distance from HCD Miles	Time of arrival (dye)	Lapsed time Hours	Day of arrival (dye)	Velocity of water mass (dye) mph	fps
247	0	2130		24		
229.5	17.5	1000	12.5	25	1.4	2.1
222	25	1645	19	25	1.3	1.9
188	59	1030	37	26	1.2	1.8

The predicted time of arrival of the dye mass at each of the sampling sites was calculated by increasing the stage wave time of travel by a multiplier factor of 1.2. The dye was released about ¼-mile below Hell's Canyon Dam at 0600 MST, about 17 hours after the 7,700 cfs flow had stablized. Calculated predictions of 7,700 cfs water mass time of travel indicated that the dye mass would arrive at each of the sampling stations during daylight hours without being overrun by the 5,000 cfs stage wave. However, this was not the case. It took about 9 hours for the leading edge of the dye to reach RM 228, 19 miles below the release point and only about 4 hours for the 5,000 cfs stage wave to reach the same station. In effect, only one hour was available for sampling the dye at the first station, RM 228, at the 7,700 cfs flow before the 5,000 cfs stage wave arrived.

On the basis of this data, the dye release time for the 5,000 cfs flow was adjusted from 0600 on March 25 to 2130 on March 24, 8½ hours after the 5,000 cfs stabilization of flow. This would then give more time to monitor the dye mass during daylight hours at the lower stations before the next stage wave. *Figure 2.3* shows the relationship of the water mass time of travel for the 7,700 cfs and 5,000 cfs flows.

The leading edge of the dye injected into the 7,700 cfs controlled flow traveled 52 miles in 34 hours, which is an average velocity (V_{d1}) of about 1.5 miles per hour or 2.2 fps. Assuming the centroid of the dye lagged four miles behind the leading edge, the average velocity (V_{d2}) of the water mass was about 1.4 miles per hour or 2.1 fps. This compares favorably with V_m, the average of cross-sectional velocities of past record taken at Hell's Canyon Dam (RM 247.7), China Bar (RM 192.3) and near Anatone (RM 167) of 3.8 fps. Thus, the ratio of V_m to V_{d2} is 3.8/2.1 or 1.8:1.

The velocity of a stage wave (U) can be estimated from the relation $U=1.3\ V_m$, where V_m is a representative mean velocity in a natural channel. The data shows that the stage wave at 7,700 cfs traveled 82 miles in about 11 hours which gives a stage wave velocity (U_m) of 7.6 miles per hour or 11 fps. From the formula $U_m=1.3\ V_m$, V_m then would equal 8.5 fps. The ratio of 8.5 fps to 2.1 fps, the measured rate of movement of the dye mass, is 4.0:1. The inference based on Water Supply Paper 888 is evidently a poor one and is grossly over simplified for conditions in the Snake River below Hell's Canyon Dam.

According to the dye study, there is a wide discrepancy between the calculated prediction and actual water mass time of travel. In future studies of rivers of similar configuration, a different prediction factor will be required if flow predictions are based on stage wave travel time.

An important factor which was not taken into consideration in predicting the water mass movement in Hell's Canyon was the variable slope and roughness of the channel. There was no ready basis for making this estimate, however, the following formulas, which include "c" (Celerity), should account in part for channel configuration.

The stage wave velocity is given as $U=c+V_m$, "c", the celerity $=\sqrt{gD}$, where g = acceleration of gravity (constant - 32.2 fps/ps) and D = the hydraulic depth. D is the area of a representative cross-section divided by the top width. Using this approximation for the flood wave and the cross-sections of past records at the gaging stations in the study reach gives a stage wave velocity of 19 fps. The ratio of 19 fps to 11 fps, the measured wave velocity is 1.7:1. This appears reasonable and is practically the same as 1.8:1, the ratio of V_m to V_{d2}.[4]

Since these ratios are so near the same, it appears, on the basis of these limited data, that the ratio of the wave velocity to the measured wave velocity using the Chow method is a good indicator of the ratio of V_m to V_{d2}. However, the wave velocity is a poor indication of the time of travel of the water mass. The ratio of wave velocity as measured to the velocity of water mass movement is 11/2.1 or 5.5:1.

Summarizing, on the basis of the data, an empirical method of estimating water mass time of travel in this reach of the Snake River appears to be as follows:

[4] *Open Channel Hydraulics*, by Ven Te Chow, p. 556.

1. Determine the stage wave velocity using the formula $U = c + V_m$. Determine V_m by averaging the mean cross sectional velocities at the desired discharge at the three gaging stations or best combination available in the reach.

2. Determine the measured rate of travel of a stage change (U_m) from the records of the gaging stations.

3. Find the ratios of the velocity U, from step 1, to velocity, U_m from step 2 above.

4. V_m, as determined in step 1, divided by the ratio from step 3 is a good estimate of the velocity of the centroid of the dye and thus the water mass movement in the reach.

DISCUSSION

The decision to do a water mass time of travel study was made late in planning. Flow schedules and volume had already been established and it was too late to change them. Therefore, the planning for the water mass study had to be tailored to the controlled flow schedule. If the calculated water mass time of travel had been correct, the entire tagged water mass could have been sampled during daylight hours to the mouth of the Salmon River. However, as indicated on *Figure 2.3*, the water mass moved much slower than the calculated predictions and the next stage wave overtook the leading edge of the dye mass within about 20 miles of the dam. Even with the adjustment of the dye drop time for the 5,000 cfs flow (2130 instead of 0600 the next day), the subsequent reduction of water mass velocity as a result of reduced water volume did little to improve the sampling time.

Samples and observations taken downstream from RM 228 have been affected by the following stage wave at each flow. These samples have been unadjusted and included even though they do not accurately represent the movement of the water mass sampled.

By the time the dye mass reached the first sampling station (RM 228), it was approximately 8 miles long. This could be because the river bed is composed of large boulders, slow moving pools and abrupt rapids, thus causing the dye mass to trail out over a long distance. The leading edge of the dye mass was used as the indicator of the water mass because it was easily identified, both from aerial observations and fluoremeter monitoring. The centroid of the dye mass is commonly used in most studies, but because the dye mass was spread out so far, the peak was difficult to estimate. In addition, timing became a critical factor since the next stage wave overtook each dye mass and transportation of personnel and equipment by helicopter after dark was not practical.

A night monitoring station was manned at the Pittsburg Landing base camp (RM 213.8) for the 7,700 cfs flow. The predicted time of arrival was about 1230 on the 24th, however, the leading edge did not arrive until 16 hours later at 0200 on the 25th with the peak occurring about 0500. Monitoring was terminated at 0600 on the 25th because the 5,000 cfs dye drop was due to arrive at RM 228 and the equipment and personnel needed to be moved to that station.

Aerial observations and water samples were obtained throughout the study. These provided data for those reaches where the fluorometer was not available.

Observations below the Salmon River camp (RM 188.2) were not made because the study period did not last long enough. The river had returned to normal operations by Monday the 26th about the time the water mass would have been in this reach.

Although there are many swift rapids in Hell's Canyon, the average velocity of the water mass

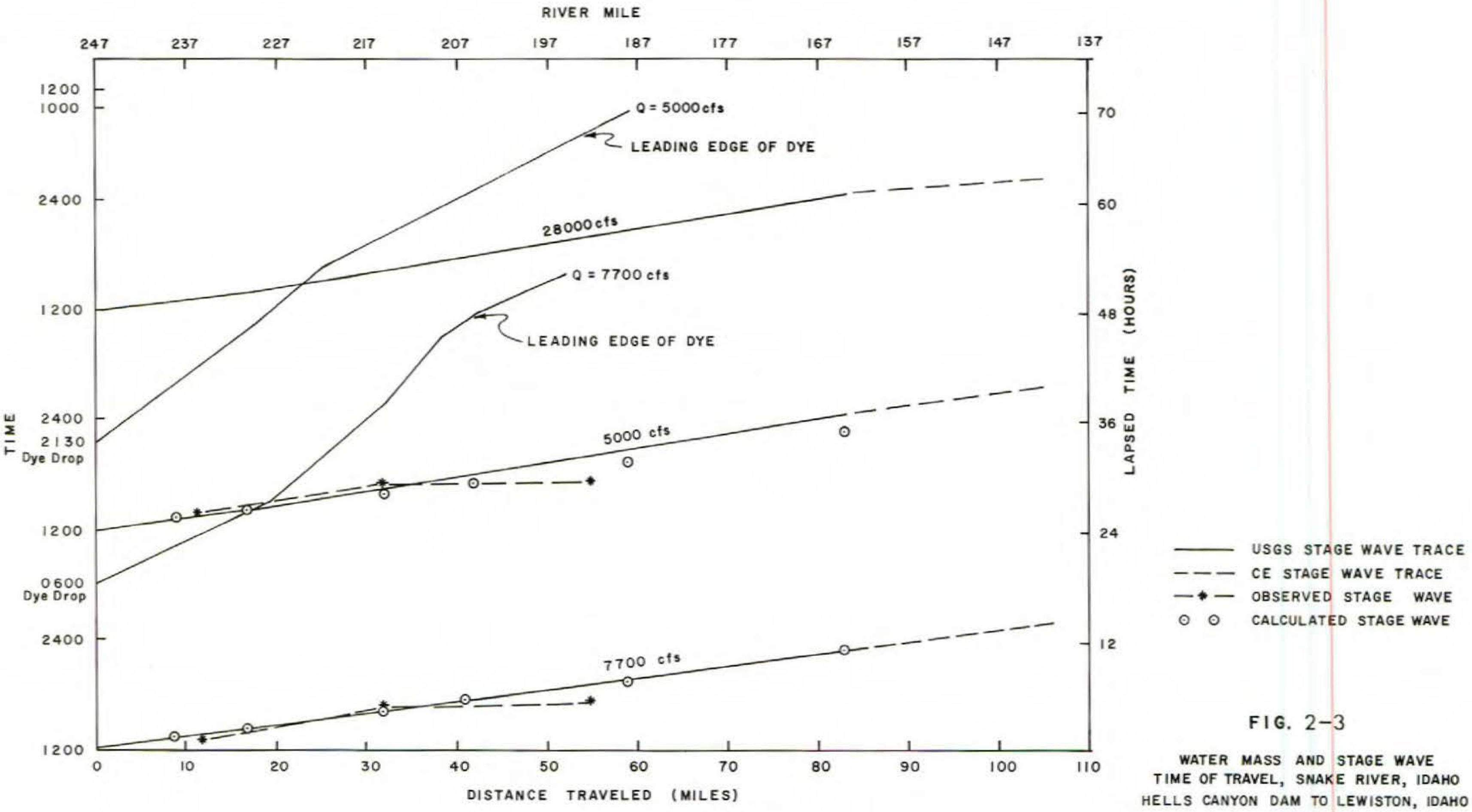


FIG. 2-3

WATER MASS AND STAGE WAVE
TIME OF TRAVEL, SNAKE RIVER, IDAHO
HELLS CANYON DAM TO LEWISTON, IDAHO
MARCH 24, 25, 26, 1973

is relatively slow. According to the measured data, the stage wave travels at an average of 12.9 fps at 7,700 cfs and 11.4 fps at 5,000 cfs compared to an average water mass velocity of 2.3 fps and 1.7 fps, respectively *(Tables 2.1 and 2.2)*.

Using the four steps outlined earlier in this chapter, the water mass time of travel can be approximated for higher flows at Hell's Canyon Dam such as those expressed as minimum and optimum flows in Chapter 7 (Salmonids).

	DISCHARGE IN CFS		
	10,000	14,200	23,400
V_m	4.76	5.67	6.81
D_m	8.4	9.7	12.4
$c = \sqrt{gD_m}$	16.4	17.6	20.0
$U = V_m + c$	21.2	23.3	26.8
U_m	10.2	11.1	14.7
U/U_m	2.0	2.1	1.8
V_m /Ratio (fps)	2.4	2.7	3.8

These computations for the flow at Hell's Canyon Dam outline the data required for making predictions of flow velocities. As can be seen, these predictions closely approximate the measured readings during the study. Flow volume would need to exceed 14,200 cfs before an appreciable increase in velocity occurs.

A summary of similar computations for the same flows utilizing three USGS measuring sections shows the following:

Ratio / Station	Discharge — CFS		
	10,000	14,200	23,400
U/U_m /Ratio			
Hell's Canyon Dam gage	2.0	2.1	1.8
China Bar	2.0	2.0	1.7
Anatone gage	2.0	2.0	1.6
V_m /Ratio			
Hell's Canyon Dam	2.4	2.7	3.8
China Bar	2.2	2.4	3.6
Anatone gage	1.9	2.0	3.2
Average Water Mass Velocity (fps)	2.2	2.4	3.5

The average velocity as computed for the 10,000 cfs flow as shown above is slightly less than the measured average of the 7,700 cfs flow. This may be because there were no actual measurements taken of the water mass movement between the Salmon River (RM 188.2) and the lowermost gaging station which is located near Anatone (RM 167.2) from which the computations were made.

These data indicate that the water mass time of travel varies within a relatively narrow range between 10,000 cfs and 14,200 cfs with an appreciable increase to 3.5 fps at 23,400 cfs. The data also show no significant increase in velocity between the 5,000 cfs flow and the 14,200 cfs flow. Considering this slight increase in velocity, the volume of water moving through Hell's Canyon then becomes more important when considering atmospheric heat accumulation and other potential pollutants.

CONCLUSIONS

It would appear that the breaking point for increasing velocities of the water mass would be somewhere between 14,200 and 23,400 cfs. Whether this velocity and water volume would be sufficient to maintain a reasonably cool and clean river is open to speculation and future study.

Additional studies are needed in Hell's Canyon to verify the formula expressed in this chapter and to establish the actual flow required to increase the velocity of the water mass through the canyon. More measuring sections should be established within shorter reaches of the canyon so that accurate predictions at all flows could be made. Air and water temperature data should be collected in order to model future temperature regimes.

Although the data presented in this chapter are not conclusive, they do form a basis for future study and identify the types of data required for a complete analysis of the Snake River flows.

ACKNOWLEDGMENTS

All participants in the controlled flow study maintained vigilance for floating oranges, dye mass and receding water levels; however, special assistance was received from Dean Loomis, Idaho Water Resource Board; Jake Szramek, Oregon Water Resources Board; Ben Pulliam, National Marine Fisheries Service; Jim Winner, Idaho Department of Water Administration; John Dooley, Bureau of Reclamation and Jim Scott, Washington Department of Ecology. Cecil A. Thomas, U.S. Geological Survey, assisted in the analysis and discussion of results. Also, appreciation is extended to the Washington Department of Ecology for the use of a flourometer and also to the Northwest Watershed Research Center, U.S. Department of Agriculture, for the use of a flourometer and the donation of a quantity of Rhodamine B dye.

CHAPTER 3
WATER QUALITY

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INTRODUCTION

Water quality is directly related to streamflow. In flowing streams, natural constituents in water generally increase in concentration with a decrease in flow, whereas the total load carried by the stream increases with greater flow. Water temperature responds more rapidly to changes in air temperature at low flows. Flow partly determines water-mass travel time, which also influences water quality. Lower flows increase travel time, which causes a given mass of water to be retained longer in a particular reach of the stream.

The controlled-flow period between March 20 and March 25, 1973, provided a good opportunity to study the effect of flow on water quality in the Snake River from Hell's Canyon Dam to the mouth of the Grande Ronde River. The data obtained during the study are not completely adequate on which to base a minimum flow recommendation for maintenance of water quality; nevertheless, the information greatly supplements previously available water quality information for that area.

METHODS

Five primary water quality monitoring stations were established at the following locations:

1. 0.5 mile below Hell's Canyon Dam, RM 2.47.2
2. Pittsburg Landing Camp, RM 213.8
3. Joseph Gage (China Bar) above the Imnaha River, RM 192.3
4. 0.2 mile above the Grande Ronde River, RM 168.9
5. 7.5 miles below the Grande Ronde River, RM 161.2

Field observations of dissolved oxygen, temperature, pH and specific conductance were made at the five primary stations every two hours or whenever possible from early morning until late afternoon at each of the regulated flows. Samples for laboratory analysis were taken at all primary stations at Hell's Canyon Dam discharges of 27,000 cfs, 12,000 cfs, and 5,000 cfs.

Samples for lab analysis were also collected from the following secondary stations one or two days before the controlled flow period:

1. Brownlee Reservoir at the Dam, RM 285.0
2. Hwy. 71 bridge below Brownlee Dam, RM 284.5
3. Oxbow Reservoir at the Dam, RM 273.0
4. Bridge below Oxbow Dam, RM 270.0
5. Hell's Canyon Reservoir at the Dam, RM 247.7

Photo by B. Pullium, NMFS
Plate 3.1 Technicians taking dissolved oxygen reading.

6. Imnaha River near mouth, RM 191.7, 0.1 above mouth
7. Salmon River near mouth, RM 188.2, 0.1 above mouth
8. Grande Ronde River near mouth, RM 168.7, 0.1 above mouth

All water samples taken for laboratory analysis were frozen as soon as possible and later taken to the Idaho Department of Environmental and Community Services Central Laboratory in Boise for analysis. All field and laboratory analyses were made in accordance with APHA-AWWA Standard Methods.

Seattle Marine Laboratory's personnel made nitrogen saturation determinations in Brownlee, Oxbow, and Hell's Canyon Reservoirs and at several other locations *(see Figure 3.1)* during the study. All reservoirs and forebays were sampled at horizontal and vertical intervals. All stations below Hell's Canyon Dam were surface samples. At each station dissolved nitrogen and oxygen concentrations were determined and the time, temperature, and depth recorded. At some stations pH and alkalinity were also measured.

RESULTS AND DISCUSSION

The results of the daily water quality observations at the five primary stations are shown in *Tables 3.1 through 3.5.*

The waters of the reservoirs are homogeneous in March. Therefore no changes in the chemistry of the water released from these reservoirs was expected during the week-long study.

The weather conditions during the study varied from cool and rainy the first two days of the study to warm and clear during the last three days. Air temperature observations were made at the Hell's Canyon Dam station. The air temperatures observed are shown in *Table 3.1.*

The unstable weather and variation in daily air temperature makes interpretation of the daily water quality observations difficult. Water temperature and dissolved oxygen increased somewhat more on the days which were clear and warmer than on those which were cloudy and cool. None of the daily observations showed a change in water quality that could be attributed to a change in flow.

Care must be taken when comparing daily observations made at one station to those at another station. Unfortunately, equipment was not cross calibrated before the study and some discrepancies may have been caused by the use of different standards for instrument calibration.

The laboratory analyses of water samples taken at the primary stations at discharges of 27,000 cfs, and 5,000 cfs are shown in *Tables 3.6 through 3.10.* All parameters analyzed were well within the water quality standards established for primary contact recreation water. There are no significant variations in the concentrations of consituents analyzed.

The analytical results of water samples from the Imnaha, Salmon, and Grande Ronde Rivers are shown in *Tables 3.11.* The analyses indicate the water in these three major tributaries to be of high quality.

Tables 3.12 through 3.14 show the laboratory analyses of water samples from above and below Brownlee, Oxbow and Hell's Canyon Dams, taken prior to the controlled flow period. The water in that area is also of good quality. The data do not indicate what conditions would be during warm summer months, but earlier papers describe summer reservoir conditions.[1]

Seattle Marine Lab data *(Table 3.15)* show that nitrogen levels in the reservoirs and forebays stayed relatively consistent from top to bottom. There was a very slight increase in nitrogen levels from Brownlee to Hell's Canyon Dam, and a slightly larger increase below Hell's Canyon Dam, increasing downriver. Water was not spilled over the dams at any time during or immediately prior to the study.

CONCLUSIONS

The field observations and laboratory analyses of Snake River water from Brownlee Dam to the mouth of the Grande Ronde River showed the water to be of high quality.

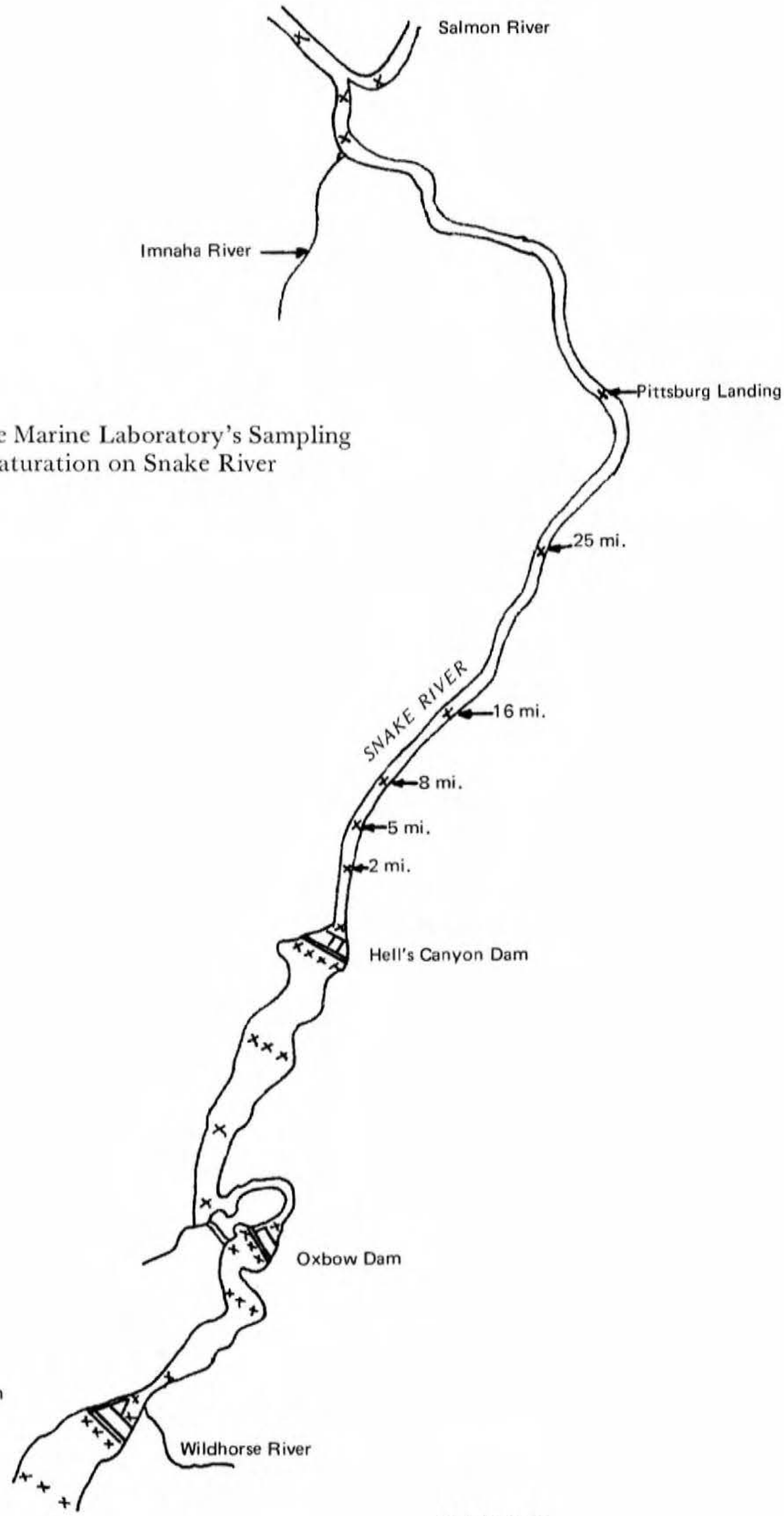
The water quality data collected during the controlled flow period indicate no significant change in water quality attributable to a decrease in flow during the study. Water quality data needed to supply a minimum flow recommendation should be collected at different seasons of the year at fairly constant flows sustained for several days. Since the biological community of a stream greatly influences water quality, and sudden changes in flow disrupt the biological community, flows should be sustained long enough to produce a stable community before comparisons between flows are made.

ACKNOWLEDGMENTS

The following personnel were involved in the field study and collection of water samples: Jim Winner, Idaho Department of Water Administration; Dean Loomis, Idaho Water Resource Board; John Dooley, U.S. Bureau of Reclamation; Bob Bishop and Jim Scott, Washington Department of Ecology; Gene Ralston, Idaho Department of Environmental and Community Services; and personnel from Seattle Marine Laboratories, consultants to Idaho Power Company.

[1] Ebel, W. and Koski, C, *Physical and Chemical Limnology at Brownlee Reservoir*, 1962. Fishery Bulletin No. 2, Vol. 67, U.S. Fish & Wildlife Service.

Figure 3.1 Schematic Map of Seattle Marine Laboratory's Sampling Locations for Nitrogen Saturation on Snake River



X Indicates Sample Locations.

Not To Scale

Table 3.1 Daily Water Quality Data

Snake River Below Hell's Canyon Dam

Date	Flow (cfs)	Time (MST)	Weather	Air Temp.(C°)	Water Temp.(C°)	D.O.(ppm)	pH	Cond. (umhos)
3/21/73	27,000	0600	Rain	7.0	6.5	11.2	8.3	269
"	"	0800[1]	"	----	6.5	11.2	8.3	269
"	"	1000	"	----	6.5	11.2	8.3	269
"	18,000	1210	"	7.4	6.5	11.6	8.3	271
"	"	1400	"	----	6.7	11.6	8.3	270
3/22/73	"	0800	Cloudy	7.7	6.5	11.2	8.3	269
"	"	1000	"	----	6.5	11.2	8.3	269
"	"	1150	"	----	6.6	11.3	8.3	269
"	12,000	1210	"	11.5	6.7	11.3	8.3	269
"	"	1400	"	12.0	6.7	11.2	8.3	270
3/23/73	"	0800[1]	Clear	8.1	6.7	11.1	8.3	268
"	"	1000	"	9.9	6.7	11.1	8.3	268
"	"	1150	"	13.0	6.9	11.2	8.3	268
"	7,700	1210	"	13.0	6.9	11.2	8.3	268
"	"	1400	"	----	7.0	11.4	8.3	269
3/24/73	"	0800	"	5.2	6.5	11.2	8.3	265
"	"	1000	"	6.8	6.5	11.2	8.3	265
"	7,700	1150	"	14.0	7.0	11.4	8.3	265
"	5,000	1210	"	14.0	7.0	11.4	8.3	265
"	"	1400	"	14.8	7.1	11.8	8.3	265
3/25/73	"	1000[1]	"	12.2	6.9	11.5	8.3	268
"	"	1150	"	----	7.2	11.8	8.3	270
"	"	1215	"	16.5	7.2	12.0	8.4	272
"	18,000	1400	"	----	7.5	11.4	8.4	271
3/26/73	24,000	1000	Partly Cloudy	7.0	6.7	11.2	8.3	269

[1] Water sample for routine chemical analysis was taken.

Table 3.2 Daily Water Quality Data

Snake River at Pittsburg Landing

Date	Flow[1] (cfs)	Time (MST)	Water Temp.(C°)	D.O.(ppm)	pH (Field)
3/21	27,000	0900	7	11.3	8.6
3/21	27,000	1115[4]	7	11.3	8.6
3/21	17,000	1315	7	11.6	8.4
3/21	27,000[2]	1515	7	11.6	8.4
3/21	18,000	1700	7	11.6	8.4
3/22	18,000	0700	7	11.2	8.4
3/22	18,000	1000	7	11.9	8.5
3/22	18,000	1300	7	12.0	8.6
3/22	18,000[2]	1600	7.2	12.0	8.4
3/23	12,000	0800	7	12.0	8.4
3/23	12,000	1000	7	12.0	8.4
3/23	12,000	1200[4]	7	12.2	8.4
3/23	12,000	1520	7.2	12.4	8.5
3/23	12,000[2]	1700	7.1	12.0	8.5
3/24	7,700	0700	7	12.0	8.5
3/24	7,700[2]	1830	8	12.4	8.3
3/25	5,000	0700	7	11.6	8.3
3/25	5,000	1315[4]	7.5	12.2	8.3
3/25	5,000[3]	1820	7	12.4	8.3

[1] Estimated from release at Hell's Canyon Dam

[2] Water stage dropping

[3] Water stage rising

[4] Water sample for routine chemical analysis was taken

Table 3.3 Daily Water Quality Data
Snake River at Joseph Gage

Date	Flow[1] (cfs)	Time (MST)	Water Temp.(C°)	D.O.(ppm)	pH (Field)	Sp. Cond. (Field)
3/21	26,600	0930	7.8	11.5	7.2	480
3/21	26,300	1200	7.8	11.4	7.2	440
3/21	26,500	1400	7.8	11.7	7.5	440
3/21	26,500	1600	7.8	11.9	7.2	440
3/21	26,300	1745	7.8	11.7	7.1	440
3/22	18,600	0900[2]	7.8	11.5	7.2	440
3/22	18,500	1100	7.8	11.7	7.2	430
3/22	18,500	1720	7.8	11.7	---	440
3/23	12,900	0915[2]	7.8	11.7	7.4	430
3/23	12,800	1200	7.8	11.8	7.4	430
3/23	12,600	1600	8.3	12.7	7.6	410
3/24	8,200	0930	7.8	11.7	7.2	430
3/24	8,200	1130	7.8	11.6	7.2	420
3/24	8,200	1345	8.3	12.0	7.8	420
3/24	8,200	1530	8.3	12.1	---	430
3/25	5,500	1230[2]	8.3	11.8	7.3	430

[1] Calculated by U.S.G.S.

[2] Water sample for routine chemical analysis was taken.

Table 3.4 Daily Water Quality Data
Snake River Above Grande Ronde River

Date	Flow[1] (cfs)	Time (MST)	Water Temp.(C°)	D.O.(ppm)
3/21	30,000	1400[2]	7.5	11.6
3/22	22,000	1400[2]	7.9	11.9
3/23	17,000	1330[2]	7.9	11.8
3/24	12,000	1300[2]	8.2	11.5
3/25	9,500	1315[2]	8.7	11.7

[1] Flow estimated by subtracting discharge from Grande Ronde from gage reading near Anatone.

[2] Water sample for routine chemical analysis was taken.

Table 3.5 Daily Water Quality Data
Snake River Below Grande Ronde River

Date	Flow[1] (cfs)	Time (MST)	Water Temp.(C°)	D.O.(ppm)
3/21	32,000	1130[2]	7.8	11.4
3/22	24,000	1100[2]	7.6	11.5
3/23	18,800	1100[2]	7.7	11.5
3/24	14,000	1030[2]	7.6	11.4
3/25	11,500	1050[2]	8.2	11.1

[1] At U.S.G.S. gage near Anatone 1.2 miles downstream from Grande Ronde River.

[2] Water sample for routine chemical analysis was taken.

Table 3.6 Results of Laboratory Analysis

Snake River Below Hell's Canyon Dam

	March 21	March 23	March 25
Flow (cfs)	27,000	12,000	5,000
Temp. °C	6.5	6.7	6.9
pH (Field)	8.3	8.3	8.3
pH (Lab)	7.8	7.8	7.7
Sp. Cond. (Lab)	345	335	305
D.O.	11.2	11.1	11.5
BOD_5	0.5	0.1	0.1
COD	2.8	0.8	4.4
Turbidity	19	19	20
Solids, Sus.	28	20	20
Solids, Tot.	388	344	324
Alkalinity ($CaCO_3$)	144	148	156
Hardness ($CaCO_3$)	160	160	156
Calcium	37	34	42
Carbon, Org.	0.40	0.10	0.30
Chloride	20	16	20
Iron	0.06	0.07	0.04
Magnesium	16	18	12
Manganese	0.01	0.01	0.01
Nitrate	3.7	3.7	3.5
Nitrite	0.050	0.050	0.005
Nitrogen, Kjel.	1.2	0.4	1.2
Ammonia	0.2	0.1	0.2
Phosphate, Inorg.	0.01	0.01	0.01
Phosphate, Ortho.	0.01	0.01	0.01
Phosphorus, Tot.	0.065	0.062	0.072
Potassium	2.8	2.4	2.5
Sodium	37	32	34
Sulphate	30	29	29

Table 3.7 Results of Laboratory Analysis

Snake River at Pittsburg Landing

	March 21	March 23	March 25
Discharge at Dam (cfs)	27,000	12,000	5,000
Temp. °C	7.0	7.0	7.5
pH (Field)	8.6	8.4	8.3
pH (Lab)	7.5	7.7	7.7
Sp. Cond. (Lab)	325	300	340
D.O.	11.3	12.2	12.2
BOD_5	0.5	0.4	2.7
COD	6.8	8.4	6.8
Turbidity	20	22	13
Solids, Sus.	20	16	28
Solids, Tot.	340	340	372
Alkalinity ($CaCO_3$)	156	144	140
Hardness ($CaCO_3$)	160	144	152
Calcium	32	40	34
Carbon, Org.	0.55	0.75	0.60
Chloride	18	18	16
Iron	0.03	0.06	0.07
Magnesium	19	11	16
Manganese	0.01	0.01	0.01
Nitrate	3.2	3.1	3.5
Nitrite	0.010	0.020	0.070
Nitrogen, Kjel.	2.8	4.2	5.2
Ammonia	0.1	0.1	0.4
Phosphate, Inorg.	0.01	0.01	0.01
Phosphate, Ortho.	0.01	0.01	0.01
Phosphorus, Tot.	0.056	0.075	0.147
Potassium	2.8	2.3	3.4
Sodium	38	32	39
Sulphate	28	25	31

Table 3.8 Results of Laboratory Analysis

Snake River at Joseph Gage

	March 22	March 23	March 25
Flow (cfs)	18,600	12,900	5,500
Temp. ^{o}C	7.8	7.8	8.2
pH (Field)	7.2	7.42	7.28
pH (Lab)	7.9	7.7	7.9
Sp. Cond. (Lab)	275	300	250
D.O.	11.5	11.7	11.8
BOD_5	0.3	0.8	0.8
COD	3.6	5.2	1.6
Turbidity	15	21	20
Solids, Sus.	20	32	44
Solids, Tot.	336	336	284
Alkalinity ($CaCO_3$)	140	136	108
Hardness ($CaCO_3$)	168	148	128
Calcium	40	34	32
Carbon, Org.	0.30	0.45	0.20
Chloride	20	20	14
Iron	0.01	0.04	0.08
Magnesium	16	15	12
Manganese	0.01	0.01	0.01
Nitrate	3.0	3.1	2.5
Nitrite	0.002	0.060	0.003
Nitrogen, Kjel.	2	2	1.2
Ammonia	0.1	0.2	0.1
Phosphate, Inorg.	0.01	0.01	0.01
Phosphate, Ortho.	0.01	0.01	0.01
Phosphorus, Tot.	0.098	0.06	0.15
Potassium	2.8	1.7	2.3
Sodium	34	26	32
Sulphate	29	26	18

Table 3.9 Results of Laboratory Analysis

Snake River Above Grande Ronde River

	March 21	March 22	March 23	March 24	March 25
Flow (cfs)	30,000	22,000	17,000	12,000	9,500
Temp. ^{o}C	7.5	7.9	7.9	8.2	8.7
pH (Field)	----	----	----	----	----
pH (Lab)	8.0	8.0	8.2	8.2	8.3
Sp. Cond.	260	245	205	225	235
D.O.	11.6	11.9	11.8	11.5	11.7
BOD_5	0.4	0.3	0.8	0.3	0.5
COD	8.6	7.9	8.6	7.5	8.2
Turbidity	16	8	16	9	6
Solids, Sus.	20	24	20	12	12
Solids, Tot.	260	248	224	228	264
Alkalinity ($CaCO_3$)	128	116	116	112	120
Hardness ($CaCO_3$)	128	120	108	108	112
Calcium	27	26	22	24	26
Carbon, Org.	0.88	0.70	0.95	0.66	0.60
Chloride	16	16	12	14	14
Iron	0.01	0.01	0.01	0.07	0.06
Magnesium	14	13	12	12	12
Manganese	0.01	0.01	0.01	0.01	0.01
Nitrate	3.1	2.9	2.3	2.3	2.1
Nitrite	0.011	0.008	0.006	0.006	0.005
Nitrogen, Kjel.	1.6	1.9	2.6	2.6	3.1
Ammonia	0.3	0.2	0.2	0.2	0.3
Phosphate, Inorg.	0.06	0.01	0.01	0.01	0.01
Phosphate, Ortho.	0.05	0.01	0.01	0.01	0.01
Phosphorus, Tot.	0.036	0.042	0.039	0.036	0.046
Potassium	1.7	1.8	1.6	2.2	1.6
Sodium	20	26	24	30	24
Sulphate	23	18	14	12	11

Table 3.10 Results of Laboratory Analysis
Snake River Below Grande Ronde River

	March 21	March 22	March 23	March 24	March 25
Flow (cfs)	32,000	24,000	18,800	14,000	11,500
Temp. °C	7.8	7.6	7.7	7.6	8.2
pH (Field)	----	----	----	----	----
pH (Lab)	8.7	7.7	8.7	9.0	7.9
Sp. Cond. (Lab)	260	235	210	190	225
D.O.	11.4	11.5	11.5	11.4	11.1
BOD_5	0.4	0.4	0.3	0.5	0.3
COD	7.9	9.6	6.7	8.6	7.8
Turbidity	8	8	12	9	6
Solids, Sus.	24	24	28	20	8
Solids, Tot.	276	244	232	212	244
Alkalinity ($CaCO_3$)	104	108	140	88	112
Hardness ($CaCO_3$)	100	100	96	80	108
Calcium	19	24	21	16	27
Carbon, Org.	0.75	0.80	0.78	0.70	0.63
Chloride	16	16	16	14	10
Iron	0.01	0.01	0.01	0.06	0.03
Magnesium	12	10	11	10	10
Manganese	0.01	0.01	0.01	0.01	0.01
Nitrate	3.0	2.5	2.5	2.3	1.9
Nitrite	0.001	0.009	0.007	0.006	0.005
Nitrogen, Kjel.	2.1	2.6	1.2	2.6	3.1
Ammonia	0.2	0.2	0.2	0.2	0.3
Phosphate, Inorg.	0.01	0.01	0.01	0.01	0.01
Phosphate, Ortho.	0.01	0.01	0.01	0.01	0.01
Phosphorus, Tot.	0.039	0.039	0.042	0.007	0.049
Potassium	1.6	2.0	1.5	2.2	1.9
Sodium	24	28	24	31	28
Sulphate	22	15	14	12	10

Table 3.11 Results of Laboratory Analysis
Major Tributaries to Snake River Below Hell's Canyon Dam, March 21, 1973

	Imnaha River	Salmon River	Grande Ronde River
Flow (cfs)	285	4,500	1,850
Temp. °C	----	----	7.8
pH (Field)	----	----	----
pH (Lab)	7.9	8.9	9.0
Sp. Cond.	125	315	70
D.O.	----	----	11.9
BOD_5	0.5	0.7	0.4
COD	12.0	7.6	4.8
Turbidity	3	16	3
Solids, Sus.	4	36	4
Solids, Tot.	140	340	72
Alkalinity ($CaCO_3$)	72	140	60
Hardness ($CaCO_3$)	82	152	44
Calcium	19	34	11
Carbon, Org.	1	0.55	0.50
Chloride	4	20	4
Iron	0.11	0.09	0.01
Magnesium	8	16	4
Manganese	0.01	0.01	0.01
Nitrate	0.7	3.4	0.7
Nitrite	0.001	0.010	0.002
Nitrogen, Kjel.	4.8	3.6	2.4
Ammonia	0.1	0.1	0.1
Phosphate, Inorg.	0.01	0.05	0.01
Phosphate, Ortho.	0.01	0.04	0.01
Phosphorus, Tot.	0.042	0.075	0.046
Potassium	0.4	2.4	0.4
Sodium	3	34	3
Sulphate	4	29	1

Table 3.12 Results of Laboratory Analysis

Snake River Above and Below Brownlee Dam, March 20, 1973

	Brownlee Reservoir	Below Brownlee Dam
Flow (cfs)	----	19,900
Temp. °C	6.8	6.8
pH (Field)	8.5	8.4
pH (Lab)	8.0	7.9
Sp. Cond. (Lab)	345	350
D.O.	10.9	11.0
BOD_5	0.4	0.2
COD	10.8	1.6
Turbidity	18	21
Solids, Sus.	24	8
Solids, Tot.	384	392
Alkalinity ($CaCO_3$)	156	148
Hardness ($CaCO_3$)	164	160
Calcium	37	38
Carbon, Org.	0.90	0.22
Chloride	16	18
Iron	0.13	0.06
Magnesium	17	15
Manganese	0.02	0.01
Nitrate	3.7	3.7
Nitrite	0.030	0.010
Nitrogen, Kjel.	4.2	1.1
Ammonia	0.5	0.3
Phosphate, Inorg.	0.01	0.01
Phosphate, Ortho.	0.01	0.01
Phosphorus, Tot.	0.088	0.124
Potassium	2.6	2.8
Sodium	32	35
Sulphate	26	28

Table 3.13 Results of Laboratory Analysis

Snake River Above and Below Oxbow Dam, March 20, 1973

	Oxbow Reservoir	Below Oxbow Dam
Flow (cfs)	----	20,100
Temp. °C	7.0	6.8
pH (Field)	8.45	8.33
pH (Lab)	7.6	7.6
Sp. Cond.	335	330
D.O.	11.1	11.1
BOD_5	0.3	0.1
COD	15.6	1.2
Turbidity	22	18
Solids, Sus.	12	8
Solids, Tot.	360	360
Alkalinity ($CaCO_3$)	144	152
Hardness ($CaCO_3$)	156	168
Calcium	37	37
Carbon, Org.	1	0.20
Chloride	20	20
Iron	0.14	0.10
Magnesium	15	18
Manganese	0.01	0.01
Nitrate	3.5	4.0
Nitrite	0.020	0.04
Nitrogen, Kjel.	4.8	0.8
Ammonia	0.1	0.1
Phosphate, Inorg.	0.01	0.01
Phosphate, Ortho.	0.01	0.01
Phosphorus, Tot.	0.134	0.091
Potassium	3.0	2.2
Sodium	36	30
Sulphate	29	30

Table 3.14 Results of Laboratory Analysis

Snake River Above and Below Hell's Canyon Dam, March 20, 1973

	Hell's Canyon Reservoir	Below Hell's Canyon Dam
Flow (cfs)	----	27,000
Temp. °C	7.0	6.6
pH (Field)	8.35	8.35
pH (Lab)	8.1	7.9
Sp. Cond. (Lab)	350	350
D.O.	10.8	11.0
BOD_5	0.3	0.1
COD	1.6	9.2
Turbidity	8	23
Solids, Sus.	12	28
Solids, Tot.	380	368
Alkalinity ($CaCO_3$)	156	160
Hardness ($CaCO_3$)	172	170
Calcium	38	37
Carbon, Org.	0.22	0.75
Chloride	20	20
Iron	0.10	0.02
Magnesium	18	20
Manganese	0.01	0.01
Nitrate	3.9	3.7
Nitrite	0.010	0.14
Nitrogen, Kjel.	0.8	4.2
Ammonia	0.1	0.2
Phosphate, Inorg.	0.10	0.01
Phosphate, Ortho.	0.06	0.01
Phosphorus, Tot.	0.173	0.065
Potassium	2.5	2.1
Sodium	34	30
Sulphate	29	35

Table 3.15 Dissolved Gas Data, Idaho Power Company - Hell's Canyon, Snake River, March 15 Through March 25, 1973

DATE	STATION	N_2 Analysis Van Slyke		O_2 Analysis Winkler		Temp	pH	Alkalinity	REMARKS
		ppm	% Sat	ppm	% Sat				
3/15/73	BROWNLEE DAM RESERVOIR Left quarter point	19.2	97	10.0	83	7.2			at boat ramp surface
3/15/73	" "	19.2	94	9.6	78	6.1			mid - 100'
3/15/73	" "	19.6	92	6.8	52	4.2			bottom not reached 195'
3/15/73	Centerline:	20.3	103	10.0	83	7.3	8.1	159.0	surface
3/15/73	" "	18.5	92	9.7	79	6.6			mid - 85'
3/15/73	" "	19.6	93	7.9	61	4.4			bottom - 170'
3/15/73	Right quarter pnt:	18.5	94	10.0	83	7.4			surface
3/15/73	" "	18.4	92	9.9	82	6.9			mid - 55'
3/15/73	" "	18.5	93	10.0	83	7.2			bottom - 105'
3/15/73	Left quarter pnt:	17.7	90	10.1	84	7.5			next to dam surface
3/15/73	" "	18.6	92	9.7	79	6.4			mid - 85'
3/15/73	" "	19.5	92	7.6	59	4.4			bottom - 175'
3/15/73	Centerline:	18.2	93	10.0	84	7.7			surface
3/15/73	" "	18.5	91	9.7	79	6.2			mid - 100'
3/15/73	" "	19.8	93	6.4	49	4.3			bottom not reached 195'
3/15/73	BROWNLEE DAM RESERVOIR Right quarter pnt:	18.4	93	10.0	83	7.4			surface
3/15/73	" "	18.4	92	9.9	82	7.0			mid - 20'
3/15/73	" "	18.3	92	9.9	82	7.0			bottom - 40'
3/17/73	WILD HORSE RIVER	19.8	93	11.9	92	4.2	8.0	44.6	just up from confluence - surface
3/17/73	BROWNLEE DAM SPILLWAY	19.9	99	10.2	84	6.9			no spill, surface
3/17/73	BROWNLEE DAM POWERHOUSE	18.5	93	10.1	83	6.9			surface
3/17/73	3 MI. DOWN RIVER Left side:	18.6	93	10.3	84	6.9			surface
3/17/73	" "	18.8	94	10.3	84	6.9			bottom - 10'
3/17/73	Centerline:	18.3	92	10.2	84	6.9	8.3	157.5	surface
3/17/73	" "	18.5	93	10.2	84	6.9			bottom - 10'
3/17/73	Right side:	18.7	94	10.4	85	6.9			surface
3/17/73	" "	19.2	96	10.3	85	6.9			bottom - 5'
3/17/73	SULFUR SPRINGS Right quarter pnt:	20.4	104	11.0	92	7.4			surface
3/17/73	" "	19.8	99	11.0	90	7.0			mid - 20'
3/17/73	" "	19.7	99	10.8	90	7.2			bottom - 40'
3/17/73	SULFUR SPRINGS Centerline:	19.7	100	10.8	90	7.5			surface
3/17/73	" "	19.5	98	10.7	88	6.9			mid - 45'
3/17/73	" "	19.6	99	10.9	91	7.3			bottom - 90'
3/17/73	Left quarter pnt:	19.2	98	10.9	91	7.4			surface
3/17/73	" "	19.2	97	10.7	89	7.0			mid - 25'
3/17/73	" "	19.1	96	10.8	89	7.0			bottom - 45'
3/17/73	OXBOW DAM FOREBAY Right side:	19.3	97	10.8	89	6.9			surface

Table 3.15 Continued

DATE	STATION	N2 Analysis Van Slyke ppm	N2 Analysis Van Slyke % Sat	O2 Analysis Winkler ppm	O2 Analysis Winkler % Sat	Temp	pH	Alkalinity	REMARKS
3/17/73	Oxbow Dam Forebay, Rt. side: (cont.)	19.7	98	10.8	89	6.8			mid - 35′
3/17/73	" "	20.2	101	10.7	88	6.9			bottom - 70′
3/17/73	Centerline right side:	19.8	99	10.9	90	6.8			surface
3/17/73	" "	19.7	99	10.9	89	6.8			mid - 45′
3/17/73	" "	19.9	100	------	---	6.8			bottom - 90′
3/17/73	Centerline, left side:	19.9	100	10.9	89	6.8	8.3	159.7	surface
3/17/73	" "	19.6	98	10.8	89	6.8			mid - 45′
3/17/73	" "	19.8	99	10.8	89	6.8			bottom - 90′
3/17/73	OXBOW DAM FOREBAY Left side:	20.6	103	10.9	90	6.8			surface
3/17/73	" "	19.7	99	10.9	89	6.8			mid - 45′
3/17/73	" "	19.7	99	10.9	89	6.8			bottom - 90′
3/18/73	OXBOW INTAKE POWERHOUSE Up river, ¼ point:	18.7	96	10.7	90	7.7			surface
3/18/73	" "	19.4	97	10.5	87	7.0			mid - 35′
3/18/73	" "	19.7	99	10.7	88	6.9			bottom - 75′
3/18/73	Centerline:	18.9	96	10.8	90	7.6			surface
3/18/73	" "	19.3	97	10.5	87	7.1			mid - 35′
3/18/73	" "	19.2	96	10.6	88	7.0			bottom - 75′
3/18/73	Down river, ¼ point:	19.2	97	10.7	89	7.4			surface
3/18/73	" "	19.4	97	10.6	88	7.1			mid - 10′
3/18/73	" "	19.2	97	10.8	89	7.1			bottom - 25′
3/18/73	OXBOW SPILLWAY FOREBAY:	19.8	103	11.0	94	8.4			surface
3/18/73	OXBOW FOREBAY, Right side:	19.7	101	10.9	92	7.9			surface
3/20/73	HELL'S CANYON PARK Right side:	19.6	98	10.6	88	7.0			surface
3/20/73	" "	19.1	96	10.6	88	7.0			mid - 25′
3/20/73	" "	19.7	99	10.6	87	7.0			bottom - 55′
3/20/73	Centerline:	19.2	96	10.6	87	7.0	7.6	153.3	surface
3/20/73	" "	19.3	97	10.5	87	7.0			mid - 25′
3/20/73	" "	19.1	96	10.6	87	7.0			bottom - 50′
3/20/73	Left side:	19.4	97	10.7	88	7.0			surface
3/20/73	" "	19.7	99	10.7	88	7.0			mid - 20′
3/20/73	" "	20.1	101	10.6	88	7.0			bottom - 40′
3/20/73	OXBOW DAM Powerhouse, below dam:	20.0	101	10.5	87	7.0			surface
3/20/73	" "	18.9	95	10.3	85	7.1			bottom - 20′
3/20/73	Spillway side, below dam	21.5	108	13.2	109	6.9			surface
3/20/73	HELL'S CANYON DAM RESERVOIR BELOW HWY. BRIDGE	21.0	106	10.3	85	7.1	7.9	155.6	surface
3/20/73	" "	19.4	98	10.3	85	7.1			bottom - 10′

Table 3.15 Continued

DATE	STATION	N2 Analysis Van Slyke		O2 Analysis Winkler		Temp	pH	Alkalinity	REMARKS
		ppm	% Sat	ppm	% Sat				
3/22/73	2 MI. DOWN RIVER FROM HELL'S CANYON DAM	19.7	99	11.0	91	7.2	8.2	155.0	surface
3/22/73	5 MILES DOWN RIVER	19.6	99	11.4	95	7.3			surface
3/22/73	16 MILES DOWN RIVER	20.6	104	11.5	96	7.5			surface
3/22/73	PITTSBURG LANDING	19.7	100	11.7	98	7.5			surface
3/22/73	100' BELOW IMNAHA RIVER CONFLUENCE	19.5	100	11.6	98	7.9	7.7	141.5	surface
3/22/73	SNAKE RIVER ¼ MILE ABOVE SALMON RIVER CONFLUENCE	20.8	108	11.6	99	8.6			surface
3/22/73	SNAKE RIVER 2 MILES BELOW SALMON RIVER CONFLUENCE	19.3	101	11.5	100	8.9			surface
3/22/73	SALMON RIVER 100' ABOVE CONFLUENCE SNAKE RIVER	19.6	99	11.6	97	7.3			surface
3/22/73	20 MILES UP RIVER SALMON RIVER	19.8	98	11.7	95	6.4	7.8	79.8	surface
3/23/73	HELL'S CANYON DAM FOREBAY Left side:	19.2	96	10.7	88	7.1			surface
3/23/73	" "	19.3	97	10.5	87	7.0			mid - 50'
3/23/73	" "	19.7	99	10.5	86	7.0			bottom - 100'
3/23/73	Centerline, left:	19.3	97	10.5	87	7.1			surface
3/23/73	" "	19.4	97	10.5	86	7.0			mid - 65'
3/23/73	" "	19.4	97	10.5	86	7.0			bottom - 130'
3/23/73	HELL'S CANYON DAM FOREBAY Centerline, right:	19.2	97	10.6	88	7.3	8.2	155.7	surface
3/23/73	" "	19.4	98	10.4	86	7.1			Mid - 85'
3/23/73	" "	19.2	97	10.4	86	7.0			bottom not reached - 170'
3/23/73	Right side:	19.3	97	10.6	88	7.3			surface
3/23/73	" "	18.8	94	10.5	87	7.1			mid - 85'
3/23/73	" "	19.2	96	10.4	86	7.1			bottom not reached - 170'
3/23/73	HELL'S CANYON DAM POWERHOUSE	20.8	105	10.8	90	7.5	8.3	155.9	surface
3/25/73	BEFORE RAISING RIVER LEVEL 5,000 CFS	20.0	102	11.0	92	7.6			surface
3/25/73	1 HOUR AFTER BEGINNING TO RAISE LEVEL	19.8	101	10.7	90	7.8			surface

CHAPTER 4
AQUATIC VEGETATION

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INTRODUCTION

An analysis of the plankton and periphyton of the Snake River was undertaken during the controlled flows of March 21 to March 26. The objectives were: 1. to determine the effects of the different flows on the number and type of planktonic algae, 2. to identify the periphytic algae, and 3. to estimate the biomass of the periphyton.

Periphyton (algae growing on the river bed) is the base of the food chain in most rivers providing a direct food source for herbivorous fish, such as suckers and carp, and providing cover and food for aquatic insects. Aquatic insects, in turn, are eaten by carnivorous fish such as trout and bass. Plankton (free floating algae) in a river originates as periphytic algae which is detached from the substrate and carried by the flow, or as true planktonic algae which grow and multiply in slow flowing stretches of the river and lakes in the river drainage. Plankton contributes to the turbidity of a river and also provides a food source for herbivorous organisms and detritus feeders when it settles on the river bed.

This study was unique in that it was possible to sample to a depth of 1.5m (5 ft.) without resorting to underwater sampling techniques and the zones of growth were evident as the water receded.

MATERIALS AND METHODS

Plankton

One liter samples of water for plankton analysis were collected at the study site on the Oregon side of the Snake River across from Pittsburg Landing - RM 214.7 *(Plate 4.1)* The samples were collected during stable and changing flows and preserved with formalin. In the laboratory, the samples were concentrated 5:1 with a Foerst centrifuge. The algae in the concentrated samples were counted in a one milliliter Sedgewick-Rafter counting cell at 160 magnifications.

Periphyton

A transect method adapted from Blum (1957) was used to determine the sampling points at the study site (RM 214.8). On March 21, when the river flow was stabilized at 27,000 cfs, a base stake was driven at the water margin and a sample was taken. Samples were taken thereafter as the water receded and the substrate became exposed. Samples were taken on a transect perpendicular to the river flow at 3.05m (10 ft.) intervals to 27.4m (90 ft.) and at 1.5m (5 ft.) intervals thereafter to a linear distance of 32m (105 ft.). A steel stake was driven into the bottom at each measured interval and one subsample taken at the stake. Subsamples were also taken at 3.05m upstream

Photo by Corps of Engineers, Walla Walla Dist.

Plate 4.1 Study area of Pittsburg Landing and Wilson Bar. The periphyton transect is within circle.

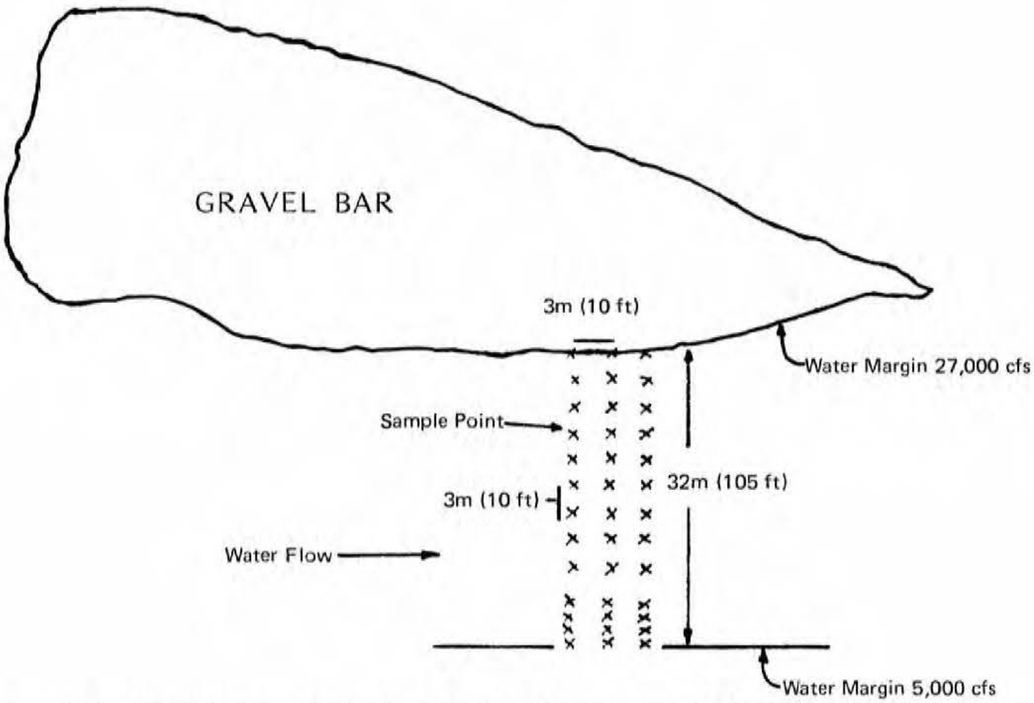

Figure 4.1 Periphyton Transect on Wilson's Bar, Snake River (River Mile 214.7).
The figure is not drawn to scale.

and downstream from the stake *(Figure 4.1)*. The three subsamples were combined to make the sample for each interval.

A plastic cylinder similar to the metal cylinder of Young (1945) was used to delineate a sample area of 10 cm^2 *(Plate 4.2)*. The plastic cylinder was 3.2 cm (1.3 inches) high and 3.56 cm (1.4 inches) in diameter. One rim of the cylinder was ringed with a flexible silicone rubber sealant 3 mm thick. In taking samples, the cylinder was pressed against the substrate and the surface inside the cylinder brushed with a stiff nylon brush or scraped with a knife *(Plate 4.3)*. The enclosed surface was flushed with distilled water and the distilled water was then aspirated into a plastic bottle. The samples were preserved with a formalin-alcohol-glycerin preservative.

Sample depths were estimated by use of steel stakes marked with a base level at the 27,000 cfs flow. Sample depths were measured from this base level as the flow was reduced and the water level dropped.

In the laboratory, the samples were blended for a few seconds to break up the clumps and filaments of algae and attached diatoms. The samples were then brought up to a known volume. A one milliliter subsample was drawn off while the sample was being mixed with a magnetic stirrer and placed in a one milliliter Sedgewick-Rafter counting cell. The algae

Photo by Gary Bailey, W.S.U.
Plate 4.2 Materials used to collect periphyton samples.

Photo by K. Bayha, BSF & W
Plate 4.3 Periphyton samples were collected for later analysis.

were counted at 160 magnifications. A 1:10 dilution was made when the algae were extremely numerous.

A separate differential count was made on each sample by counting 100 or 200 algae cells at 360 magnifications.

Dry weights were estimated by drying 10 to 50 milliliter sample aliquots for 48 hours at 100 C in tared crucibles. The crucibles were cooled to room temperature in a desiccator and then weighed.

RESULTS AND DISCUSSION

Plankton

Plankton counts show only small variation between flows *(Table 4.1)*. There was an increase in the number of *Diatoma vulgare* while the flow was increasing from 5,000 to 27,000 cfs. *Diatoma vulgare* comprised 18 to 61% of the attached algae *(Table 4.3)* and the increase in numbers during the increasing flow was probably due to the diatoms being detached during low flows.

Asterionella, Cyclotella, Fragilaria, Melosira, Chlorella, Pandorina, Peridinium, and *Scenedesmus* are planktonic genera (Prescott 1962, Hynes 1970)and the dominance of these organisms showed that most of the plankton was coming from the reservoir rather than from the river substrate.

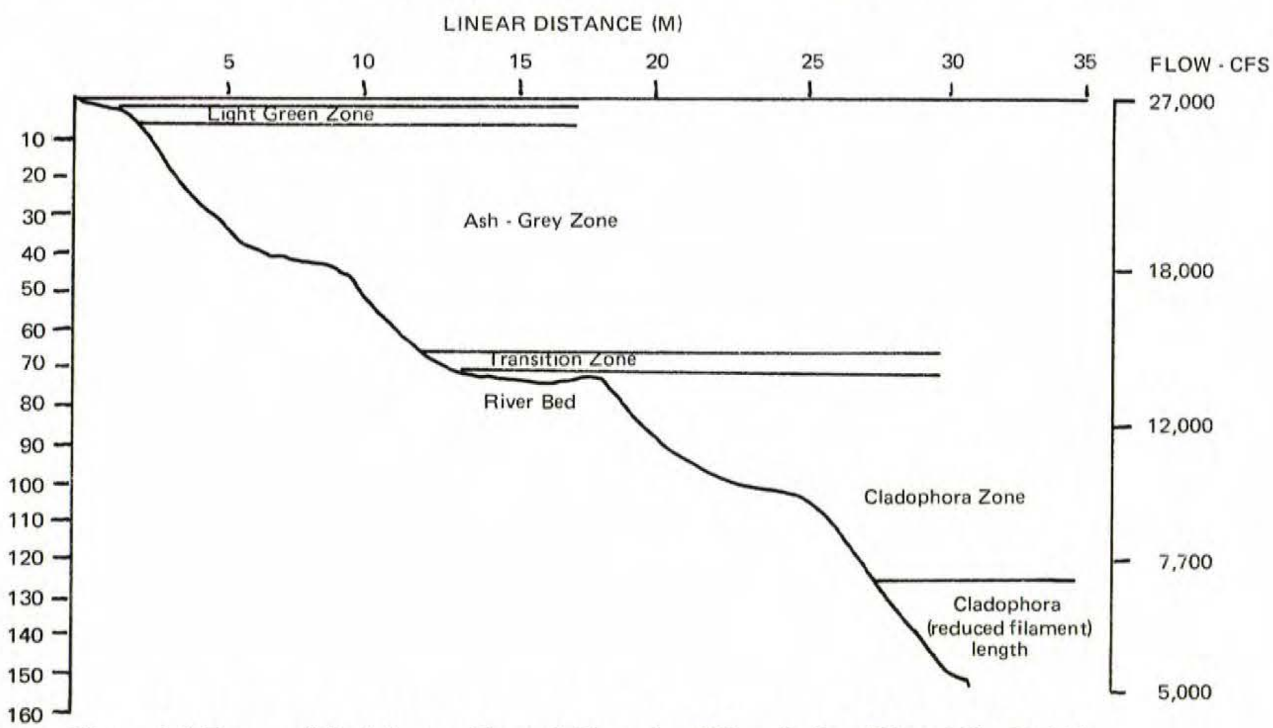

Figure 4.2 Zones of Periphyton Growth Found at Wilson's Bar (River Mile 214.7) During Hell's Canyon Controlled Flow Study (March 21-26, 1973).

Table 4.1 Planktonic algae counts of the Snake River (Wilson's Bar - River Mile 214.8) during Hell's Canyon controlled flow study (March 21 -26). Melosira sp., a filamentous alga, is counted with five cells equal to one unit and Pandorina sp., a colonial alga, is counted with eight cells equal to one unit.

Flow Regime (cfs)	Stable	Changing 27000-18000	Stable 18000	Changing 18000-12000	Stable 12000	Changing 12000-7700	Stable 7700	Changing 7700-5000	Stable 5000	Changing 5000-27000	Stable 27000
	ALGAE CELLS PER MILLILITER										
Chrysophyta (Diatoms)											
Asterionella sp.	1228	1214	981	1152	899	1255	1070	940	1338	1454	1447
Cyclotella sp.	144	158	233	220	178	364	377	254	247	247	542
Cymbella sp.	14				7			7	14	27	7
Diatoma vulgare	7	7	7	27		14	7	21	7	357	41
Fragilaria sp.	75	62	137	34	41	21	34		41	27	7
Gomphonema sp.	8	1	4	22	1	11	10	2	6	5	6
Melosira sp.	21	14	14	21	10	11	13	22	11	14	4
Navicula sp.	69	82	103	110	110	69	96	117	89	130	240
Rhoicosphenia curvata	33	6	17	5	6	44	38	19	28	22	28
Suriella sp.	14	14	21	7	14	7			14	14	
Synedra sp.	14	7	7	14	27	34	41	21	14	55	27
Chlorophyta (Green)											
Chlorella sp.	41	34	34	69	69	14	7	41	55	7	14
Pandorina sp.				7		7	7	7			
Peridinium sp.			7								
Scenedesmus sp.		7		14			7	7			14
Protozoa	7			7							

Table 4.2 Periphyton counts of samples collected at Wilson's Bar (River Mile 214.7) during Hell's Canyon controlled flow study (March 21-26). The depth was measured from water level at 27000 cfs.

Depth in Centimeters (Inches)	0 (0)	7.6 (3)	38.1 (15)	48.3 (19)	68.6 (27)	74.9 (29)	76.2 (30)	91.4 (36)	105.4 (42)	130.8 (52)	147.3 (58)	151.9 (60)	154.9 (61)
	ALGAE CELLS PER SQUARE CENTIMETER												
Chrysophyta (Diatoms)													
Asterionella sp.	0.02	57		57	28	124		17	23	2	8	3	9
Cyclotella sp.				86	428	193	77	114	34		8	14	3
Cymbella sp.		57	29			64		17	11			3	
Diatoma vulgare	0.43	457	543	543	772	451	663	189	114	106	150	137	100
Fragilaria sp.	0.09	57	200	114		81				2	3		
Gomphonema sp.	0.14	1286	2086	86	68	60	45	7	2	103	7	26	143
Melosira sp.				1	68			17		5	2	23	3
Navicula sp.	0.09	1057	114	6802	3983	1749	1509	205	549	216	111	363	183
Rhoicosphenia curvata	0.11	257	57	314	343	523	480	79	228	91	62	236	120
Suriella sp.					28	98	48		11	2	3	3	3
Synedra sp.				57	31		23	34	11	2		3	
Chlorophyta (Green)													
Chlorella sp.		143	200	143									
Cladophora sp.					9	75	50	82	48	94	51	57	194
Mougeotiopsis sp.	0.14	29	57	33									
Protococcus sp.		71	3	6									
Cyanophyta (Blue-Green)													
Oscillatoria sp.	0.08	2612	829	171	292	338	675	120		6	16		7
Lyngbya sp.	0.40	1037	2215	11									

Table 4.3 Differential counts and dry weight of periphyton collected at Wilson's Bar (River Mile 214.7) during Hell's Canyon controlled flow study (March 21-26). The depth was measured from water level at 27000 cfs.

	PERCENTAGE ABUNDANCE												
Depth in Centimeters (Inches)	0 (0)	7.6 (3)	38.1 (15)	48.3 (19)	68.6 (27)	74.9 (29)	76.2 (30)	91.4 (36)	105.4 (42)	130.8 (52)	147.3 (58)	151.9 (60)	154.9 (61)
Chrysophyta (Diatoms)													
Asterionella sp.	5	1	2	1	2	0.5	1			1	1	6	
Cyclotella sp.					1	3		6	1	2	4	2	
Cymbella sp.	3		1	2			1	3					
Diatoma vulgare	28	29	22	19	19	35	41	33	23	28	61	18	31
Fragilaria sp.	4	5	3	4		1.5		1	1		2		1
Gomphonema sp.	14	31	41	3	1	1.5	1	1	1	3	1	3	2
Melosira sp.						0.5		4	2				4
Navicula sp.	2	4	1	52	61	31.5	31	27	29	36	10	36	20
Rhoicosphenia curvata	16	5	1	10	10	18.5	20	11	36	26	10	28	18
Suriella sp.			1		1	2.5		3	1	3	3		2
Synedra sp.					1	0.5		2					
Chlorophyta (Green)													
Chlorella sp.	4	13	8	9									
Cladophora sp.						0.5	5	7	5		6	5	22
Mougeotiopsis sp.	12												
Protococcus sp.													
Cyanophyta (Blue-Green)													
Oscillatoria sp.	4	11	11		4	4.5		2	1	1	2	2	
Lyngbya sp.	8	1	9										
	DRY WEIGHT (Grams Per Square Meter)												
	16.7	146.7	138.3	160.0	705.0	1137.5	1411.7	505.0	276.7	148.3	126.0	201.7	231.7

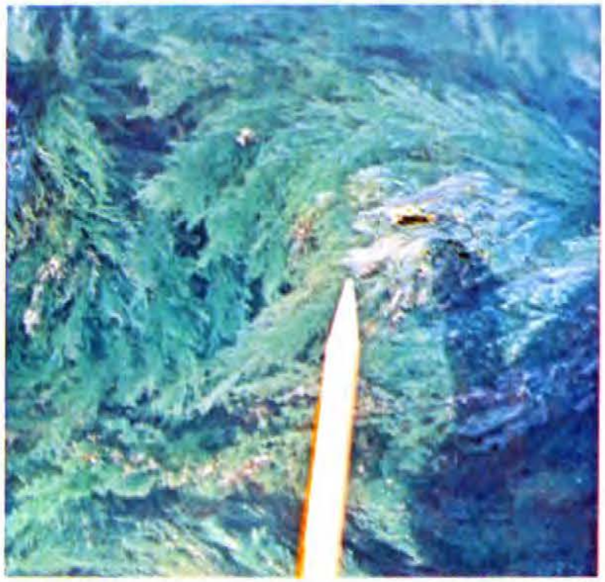

Photo by G. Bailey, W.S.U.

Plate 4.4 *Cladophora sp* utilizing entire rock surface for attachment.

Periphyton

Field observations as the water receded revealed a faint light green growth on the substrate between 1.0 and 7.6 cm (0.4 and 3 inches) depths. A grey-white colored zone was present to the 68 cm (27 inch) depth and then a dark green zone to the 155 cm (61 inch) depth *(Figure 4.2).*

The first sample taken at the water margin during the 27,000 cfs flow showed very few organisms *(Table 4.2).* This indicates that this substrate was only recently submerged.

The light green of the next zone was due to *Mougeotiopsis sp., Protococcus sp.,* and *Lyngbya sp.* Flows prior to the start of the study were less than 27,000 cfs and this light green zone was probably the water margin of the prior flow.

The ash-grey color of the next zone was due to diatom frustules encased in a filamentous matrix. The matrix appeared to be bleached cell wall material, possibly from a heavy growth of *Cladophora sp.* which was dried or frozen during exposure at low flow. The matrix and frustules fromed a crust-like substance on the surface of the rocks in this zone. The crust-like material came off in flakes when sampled and the flakes were not completely broken down when these samples were blended. The transition between this zone and the next occurred between 68 cm (27 inches) and 75 cm (30 inches) depth.

Cladophora sp. (water blanket), a filamentous branching green alga was the dominant form of the dark green zone. Diatoms in this zone were attached to the *Cladophora sp.* filaments. Dry weights of this zone *(Table 4.3)* reflect more accurately the dominance of *Cladophora sp.* than do the algae counts or differential counts. One *Cladophora sp.* cell measures 0.390 by 0.104 mm but *Diatoma vulgare,* one of the dominant diatoms, measures only 0.052 by 0.015 mm. The numbers of *Cladophora sp.* counted do not show the high biomass due to this alga.

At depths of 75 cm (30 inches) to 131 cm (52 inches) the appearance of the substrate was of a solid blanket of *Cladophora sp.* extending downstream far past the point of attachment. Rock surfaces in this zone were completely utilized by *Cladophora sp.* for attachment *(Plate 4.4).* From 131 cm to 155 cm (61 inches) the *Cladophora sp.* filaments were shorter and only the upstream edge of the rocks were utilized for attachment *(Plate 4.5).* This decrease in filament length and the attachment on the upstream edge may be due to light limitation or increased water velocity at the greater depths. Filamentous algae such as *Cladophora sp.* usually attach

Photo by G. Bailey, W.S.U.

Plate 4.5 *Cladophora sp* with shortened filaments and upstream attachment.

first to the upstream edge of rocks, but the reason for this is not known. One possibility is the reduced current velocity on the upstream edge. Filamentous algae attached to the upstream edge can grow in the boundary layer (area of reduced velocity on the rock surface) and in the relatively still water behind the rock. Greater water velocities reduce the height of the surface boundary layer and the shorter filaments found in this study may have been due to turbulence breaking off the longer filaments.

CONCLUSION

Riffle areas are typically the areas of highest productivity in rivers, and the study area of Wilson's Bar (RM 214.7) is probably an area of maximum productivity and algae biomass in the Hell's Canyon section of the Snake River.

The algae biomass present at any one time (standing crop) may correlate closely with algae production, but biomass and production are not synonomous. In areas of heavy grazing by fish or invertebrates the biomass present may be small but productivity high and, conversely, in areas of low grazing biomass may be high but productivity low.

The algae biomass and species present in rivers usually show seasonal variations and flow is only one of the many environmental factors causing these variations. On the basis of this study, no predictions can be made as to the effects of flow on kinds and number of algae in the river.

ACKNOWLEDGMENTS

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CHAPTER 5

BENTHIC INSECTS

(Effects of Water Fluctuation on Benthic Insects)

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INTRODUCTION

Regulated flow reductions in the Snake River during March 20-25, 1973, provided an opportunity for investigating their effects on benthic (bottom dwelling) insects in a large river system. As insects are sensitive to environmental changes and represent intermediate links in the food chain, their role is integral in the support of a viable fishery. Periodic and/or regular flow alterations would be expected to have potentially detrimental effects to aquatic insects, altering natural community assemblages and food chain relationships.

OBJECTIVES

This study was conducted to provide basic information on the ecological effects of water fluctuations on river benthos. Three objectives were established:

1. determine standing crop of benthic insects at different flow stages,
2. determine drift rates of principal insect species at various flow stages and
3. determine fate of bottom organisms stranded above the water line as a result of decreased flows.

PROCEDURES

Two stations were established approximately 300 yards apart, on the Oregon side of the Snake River across from Pittsburg Landing (RM 214.7). The shoreline at each station had a gentle slope (east exposure) with a rubble bottom *(Plates 5.1 and 5.2)*, and provided generally satisfactory sampling conditions. The study was conducted on consecutive days between March 19-26. Discharge at Hell's Canyon

Photo by Dr. Merlyn Brusven, Univ. of Idaho

Plate 5.1 Cobble substrate of Site II near Pittsburg Landing.

Photo by Dr. Brusven, U of I

Plate 5.2 Shoreline zonation is shown at Site I.

Dam was approximately 27,000, 18,000, 7,700, 5,000 and 27,000 cfs for March 20-26 respectively. During March 19-20, flows were irregular (21,400-27,000 cfs); baseline data were taken at this time prior to programmed flow reductions.

Photo by Dr. Brusven, U of I

Plate 5.3 Bottom sampling device used to measure standingcrop.

Photo by Dr. Brusven, U of I

Plate 5.4 Drift nets used to collect insects.

Benthic Standing Crop Analysis

Benthic insects were sampled with a cylindrical, square-foot bottom sampler *(Plate 5.3)*. Three samples were taken transectionally at noon (1200 hour) at each station in water depths of 9-14 inches during each flow stage. At depths greater than 14 inches, sampling was difficult and often prohibitive. Samples were individually preserved in 70% ethanol and later analyzed.

Insect Drift Analysis

Insect drift (i.e. number and kind of insects drifting/unit width of stream/unit time) was taken with two 1 X 2 foot drift nets (pore size 0.8 mm), placed approximately 2 feet apart in 1-1.5 feet of

Photo by Dr. Brusven, U of I

Plate 5.5 Belt transect used to measure insect migration and stranding.

Photo by Dr. Brusven, U of I

Plate 5.6 Enclosure device used to sample insect mortality due to stranding.

water, 15-25 feet from shore *(Plate 5.4)*. The specific placement of the nets was determined by the nature of the substrate, depth of water and safety conditions for operating the nets.

One-hour grab samples were taken and preserved in 70% ethanol every four hours during the seven-day study. The 24-hour sampling schedule permitted monitoring of indigenous diel cycles of insects and possible effects of flow changes on drift.

Discharge through drift nets was determined for each flow stage. To permit more equitable comparisons of flow-drift relationships, drift was enumerated on the basis of number of insects/ft^3 of water passing through the nets. During the 4-5 p.m. flow change it was occasionally necessary to reposition the nets after 30 minutes to avoid net dewatering. In the event of the latter, new discharges through the nets were determined and averaged for the 1-hour period.

Shoreline Migration and Stranding

A gridded belt transect was used to measure benthic migration and stranding during the dewatering period. The belt was 12 inches wide, 20 feet long and made of 1/16 inch wire hardware cloth with 4-inch mesh *(Plate 5.5)*. If dewatering caused shoreline exposure of greater than 20 feet, a second belt was attached to the first to extend its length. Observations and recording of stranded insects was initiated at the onset of the unstable flow period which occurred at approximately 4 p.m. at Pittsburg Landing. This stage change represented a delay of about 4 hours from Hell's Canyon Dam, where the discharge was regulated. Belt studies during each receding flow period were conducted for 1 1/2 hours. This interval did not necessarily encompass the entire time between flow stages. At discharges of 7,700 and 5,000 cfs, the "time of travel" of the stage wave was delayed and the rate of dewatering less extreme than at higher flows.

Rate of dewatering was determined by measuring changes in exposed surface with time on the gridded belt. Only insects noted above the waterline and effectively dewatered were recorded. Additionally, general behavioral observations of insects in the shallow watered zone were noted.

Fate of stranded insects after exposure periods of 24, 48, 72 and 96 hours was determined with a 3 ft^2, 4-inch high metal ring placed approximately in the middle of each dewatered zone *(Plate 5.6)*. The device formed an effective enclosure permitting quantitative enumeration of dead and living insects. Only half of the enclosure area was sampled on a given day. The area was meticulously sampled to a depth of approximately 3 inches with the aid of a small scraper and forceps. Sieving was impractical because of potential destruction of dead, desiccated insects. Not all zones received the same sampling intensity because of the lowest flow stage (5,000 cfs) was dewatered for only 24 hours before the flow was restored to the river's pretest discharge of approximately 27,000 cfs.

Insects were counted and identified to species when possible. Questionable specimens were preserved and returned to the laboratory for confirmation.

RESULTS AND DISCUSSION

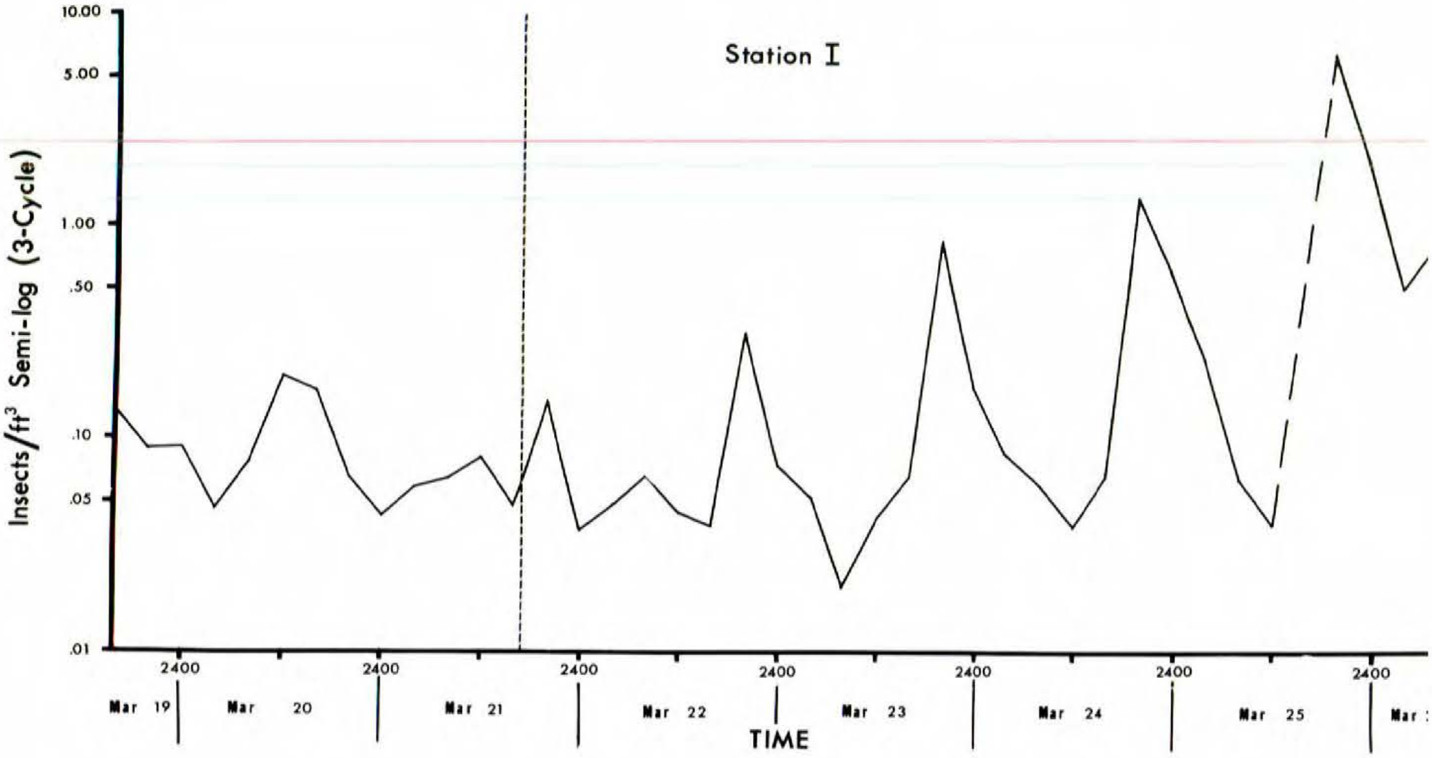
Standing crop and insect drift results indicate that the Hell's Canyon reach of the Snake River is rich in insect life *(Table 5.1; Figure 5.1)*. The richness was further evident by the abundance of algae which became exposed during dewatering (see Chapter 4). The algal zones in conjunction with substrate undoubtedly played important roles in the distribution and abundance of aquatic insects.

Table 5.1 Number, Volume (m1)/ft2 and relative Composition of Benthis Insects at 5 Flow Stages at Sites I & II in the Hell's Canyon Reach of the Snake River, Idaho

Site I	March 20 27,000 cfs (variable)				March 21 27,000 cfs (variable)				March 22 18,000 cfs				March 23 12,000 cfs				March 24 7,700 cfs				March 25 5,000 cfs			
	#/ft2	m1/ft2	% comp* #	% comp* vol.	#/ft2	m1/ft2	% comp* #	% comp* vol.	#/ft2	m1/ft2	% comp* #	% comp* vol.	#/ft2	m1/ft2	% comp* #	% comp* vol.	#/ft2	m1/ft2	% comp* #	% comp* vol.	#/ft2	m1/ft2	% comp* #	% comp* vol.
EPHEMEROPTERA	8.67	.067	7.26	20.49					3.33	.027	1.88	5.96	8	.05	4.43	11.18	24	.067	11.16	9.02	26.33	.11	12.13	15.68
Baetis parvus	7.33		6.14						.33		.19		6.67		3.69		21.3		9.91		24		11.06	
Epeorus albertae																								
Ephemerella heterocaudata													.33		.18		.33		.15		.67		.31	
Ephemerella inermis									1.67		.94						.67		.31		.33		.15	
Rithrogena hageni																	.33		.15		1		.46	
Stenonema sp.	1.33		1.12						1		.56		.33		.18									
Tricorythodes minutus									.33		.19		.67		.37		1.33		.62		.33		.15	
DIPTERA	105.67	.193	88.55	59.02	64	.1	99.5	97	154.67	.193	87.38	42.61	138.67	.167	76.91	37.36	122	.163	56.74	21.94	149.67	.283	68.97	40.33
Antocha sp.									.33		.19													
Chironomidae larvae	87.67		73.47		59		91.75		146.67		82.86		135.33		75.06		111		51.63		125		57.6	
Chironomidae pupae	17.67		14.81		5		7.75		7.67		4.33		2.67		1.48		5		2.32		8.67		4.0	
Empididae																	.33		.16		.33		.15	
Simulium larvae	.33		.27										.67		.37		.67		.31		1.33		.61	
Simulium pupae																	5		2.32		14.33		6.6	
TRICHOPTERA	5	.067	4.19	20.49	.33	.003	.5	3	13	.173	7.35	38.19	21.67	.153	12.01	34.23	47.3	.373	22	50.2	32.3	.257	14.89	36.62
Glossosoma sp.													.33		.18		1		.46		2.33		1.07	
Hydropsyche sp.	5		4.19		.33		.5		13		7.35		19.67		10.91		44.67		20.77		28.67		13.21	
Leucotrichia sp.													1.67		.92		1.67		.77		1.33		.61	
LEPIDOPTERA									6	.06	3.39	13.24	12	.077	6.65	17.23	21.67	.14	10.08	18.84	8.33	.05	3.84	7.13
Parargyractus sp.									6		3.39		12		6.65		21.67		10.08		8.33		3.84	
COLEOPTERA																					.33	.0017	.15	.24
Cleptelmis ornata																					.33		.15	
Heterlimnius corpulentus																								
Zaitzevia parvula																								
TOTAL	119.34	.327			64.33	.103			177	.453			180.34	.447			214.97	.743			216.96	.7017		

Site II	March 20 27,000 cfs (variable)				March 21 27,000 cfs (variable)				March 22 18,000 cfs				March 23 12,000 cfs				March 24 7,700 cfs				March 25 5,000 cfs			
	#/ft2	m1/ft2	% comp* #	% comp* vol.	#/ft2	m1/ft2	% comp* #	% comp* vol.	#/ft2	m1/ft2	% comp* #	% comp* vol.	#/ft2	m1/ft2	% comp* #	% comp* vol.	#/ft2	m1/ft2	% comp* #	% comp* vol.	#/ft2	m1/ft2	% comp* #	% comp* vol.
EPHEMEROPTERA	4	.013	3	5	1	.007	3	11.11	63.33	.607	10	20	47.33	.163	16.36	10	37	.15	18	16	89.66	.403	39.4	40.3
Baetis parvus	3.67		3		.67		2		59.67		.094		42.33		14.63		33		16		84.66		37.2	
Epeorus albertae													.33		.11									
Ephermerella heterocaudata									1.67		.003		1.33		.46		3.0		1.4		3.67		1.6	
Ephemerella inermis									1.33		.002		.67		.23		.33		.2		33		.1	
Rithrogena hageni																	.33		.2		.67		.3	
Stenonema sp.									.67		.001		.67		.23		.33		.2		.33		.1	
Tricorythodes minutus	.33		.3		.33		1						2.0		.69									
DIPTERA	109	.117	89	62	34	.053	96	84.13	390.67	.7	65	24	107.67	.167	37.22	10.2	116.67	.26	56	27	103	.293	46.2	29.25
Antocha sp.																								
Chironomidae larvae	90.3		74		28.33		80		371.33		61.5		102.33		35.37		95.67		46		91.33		40.2	
Chironomidae pupae	18.67		15		5.67		16		17.67		2.9		3.33		1.15		6.67		3		2.33		1	
Empididae													.33		.11									
Simulium larvae									1.33		.2		.67		.23		13.67		6.7		11.67		5.1	
Simulium pupae									.33		.05		1.0		.34		.67		.3		17.67		7.7	
TRICHOPTERA	8.3	.09	7	32	.33	.003	1	4.76	143.67	1.6	24	54	114.33	1.153	39.52	70	46.67	.477	22.4	50	30	.293	13	29.25
Glossosoma sp.													1.67		.6		1		.5					
Hydropsyche sp.	8.3		7		.33		1		143.67		24		111.33		38.48		45		21.6		30		13	
Leucotrichia sp.													1.33		.5		.67		.3					
LEPIDOPTERA	.67	.003	.5	1					5.67	.047	1	2	19	.15	6.56	9	8	.063	3.8	7	.67	.007	.3	.7
Parargyractus sp.	.67		.5						5.67		1		19		6.56		8		3.8		.67		.3	
COLEOPTERA													1	.005	.34	.3					1	.005	.4	.5
Cleptelmis ornata																								
Heterlimnius corpulentus													.67		.23						.67		.3	
Zaitzevia parvula													.33		.11						.33		.1	
TOTAL	121.97	.283			35.3	.063			603.34	2.954			289.33	1.638			208.34	.95			224.33	1.001		

* Percent composition by volume calculated only at ordinal level.



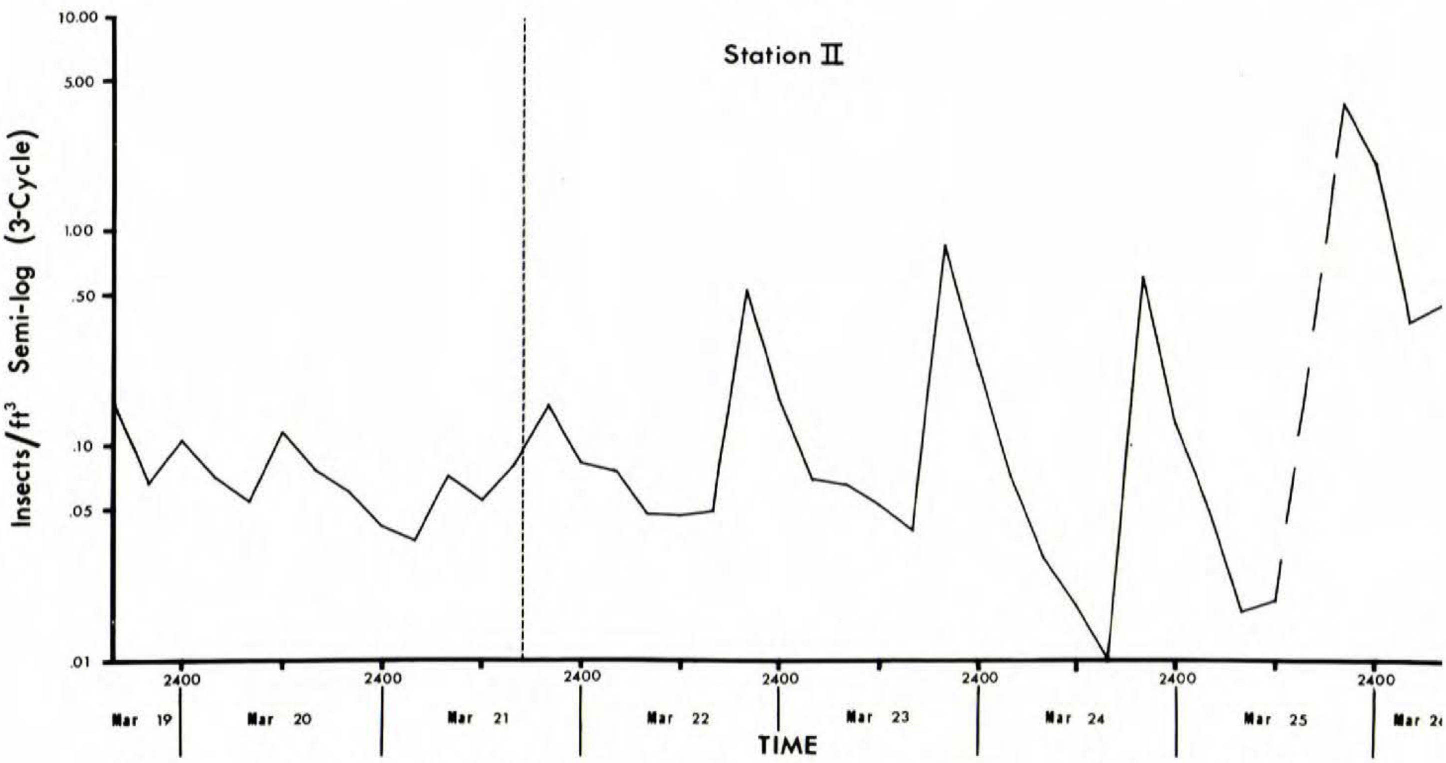


Figure 5.1 Total insect drift (all species) at Station I and II. Values expressed in numbers/ft^3 of water through drift nets in Hell's Canyon, 1973.

Standing Crop

The standing crop of insects was noticeably variable at the different flow stages *(Table 5.1)*. Fifteen species (exclusive of the dipteran family Chironomidae) were taken in bottom samples. Because the taxonomy of chironomids (midges) is poorly known, a definitive appraisal of that group was not possible (cursory examination revealed at least 13 species). Next to Diptera, Ephemeroptera (mayflies) was the most diverse group, being represented by 7 species; however, it was the third most abundant order next to Diptera and Trichoptera (caddisflies) at most flow stages.

During stable flow periods of March 20 and 21, a decrease in standing crop was noted on March 21 for both stations, decreasing nearly 2 to 3.4 times for Stations I and II, respectively, for total numbers. We believe previous unstable flows disrupted the normal colonization cycle at that location and accounted for the decrease in benthos on March 21. Although stable flows of 27,000 cfs were programmed for a 24-hour period prior to flow reductions, last-day adjustments (21,000-27,000 cfs range) for power generation left the shoreline conditions unstable prior to the taking of noon bottom samples.

Highest standing crops (measured in volume and numbers) were obtained at stable flow periods of 18,000, 12,000, 7,700 and 5,000 cfs. Slight increases were noted at each successive flow stage at Station I, while a decrease was noted at site 2 following a high standing crop at the 18,000 cfs flow stage. Low values obtained at flow stages of 7,700 and 5,000 cfs probably represent sampling error. At lower flow stages, the rubble at Station II graded to boulder, the size exceeding 10 inches in diameter. Rocks of this size could restrict abundance and also preclude effective sampling when they represent the preponderant substrate. Stranding data *(Figure 5.2)* supports this assumption, particularly during the unstable flow period of 12,000 and 7,700 cfs. During the 7,700 to 5,000 cfs reduction, relatively few stranded insects were recorded. This was believed due to the delayed and more subtle dewatering cycle.

Notable differences in benthic composition were evident between the two sites *(Table 5.1)*, particularly at the 18,000 cfs stage and lower. Diptera, especially Chironomidae larvae, represented the highest compositon in numbers and in most cases volume (volume used here as a measure of biomass) for Station I, except during the 7,700 cfs flow stage where Trichoptera constituted the largest volume (50%) while only representing 22% of the total number of insects. A similar relationship was noted at the same time period at Station II; however, mayflies, especially *Baetis parvus,* became a significant component in the community. Mayflies ranked third behind Diptera and Trichoptera in density and volume, while becoming the dominant biomass group at the 5,000 cfs flow stage at Station II. A similar trend was not noted at Station I.

The aquatic pyralid lepidopteran, *Parargyractus* sp., became prevalent at intermediate and lower flow stages. It was most abundant where filamentous algae carpeted the rocks, i.e. *Oscillatoria* in the ash-grey zone and *Cladophora* at the 12,000 to 5,000 cfs stages *(Figure 5.3)*.

The alga study conducted by Bailey (Chapter 4, Aquatic Vegetation) established distinct alga zonation. The zonation propounded by Bailey is in general agreement with that of ours *(Figure 5.3)*. The most conspicuous alga belt was the *Cladophora* zone which appeared as a dark green carpet over the rocks. Numerous insects were observed in this filamentous mat.

Most insect life, with the exception of chironomids, abounded in regions not experiencing daily water fluctuations. This generally encompassed the mid-region of the ash-gray zone (approximately 18 feet) to and including that portion of the *Cladophora* zone (83 feet; 5,000 cfs) sampled

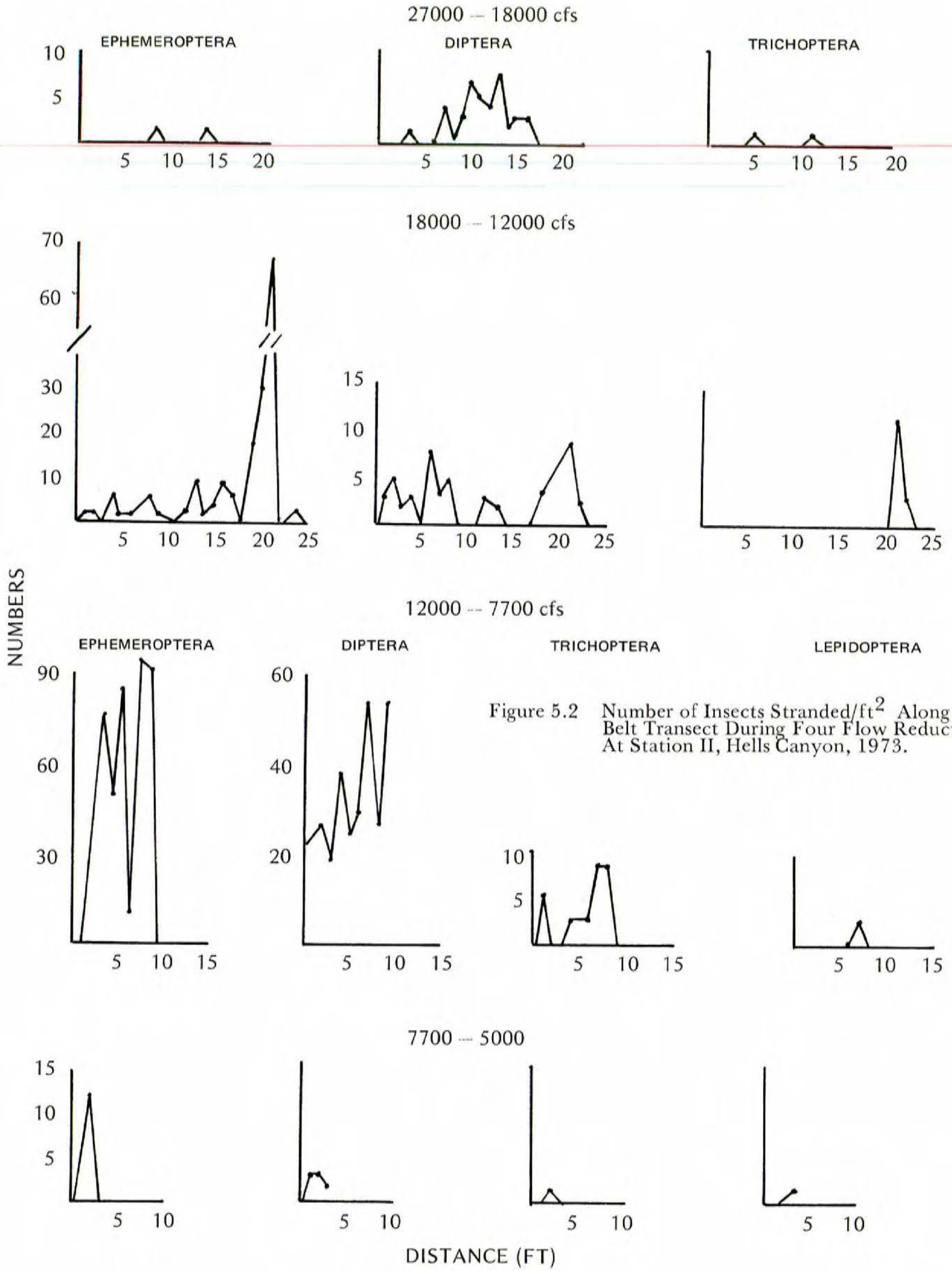


Figure 5.2 Number of Insects Stranded/ft^2 Along A Belt Transect During Four Flow Reductions At Station II, Hells Canyon, 1973.

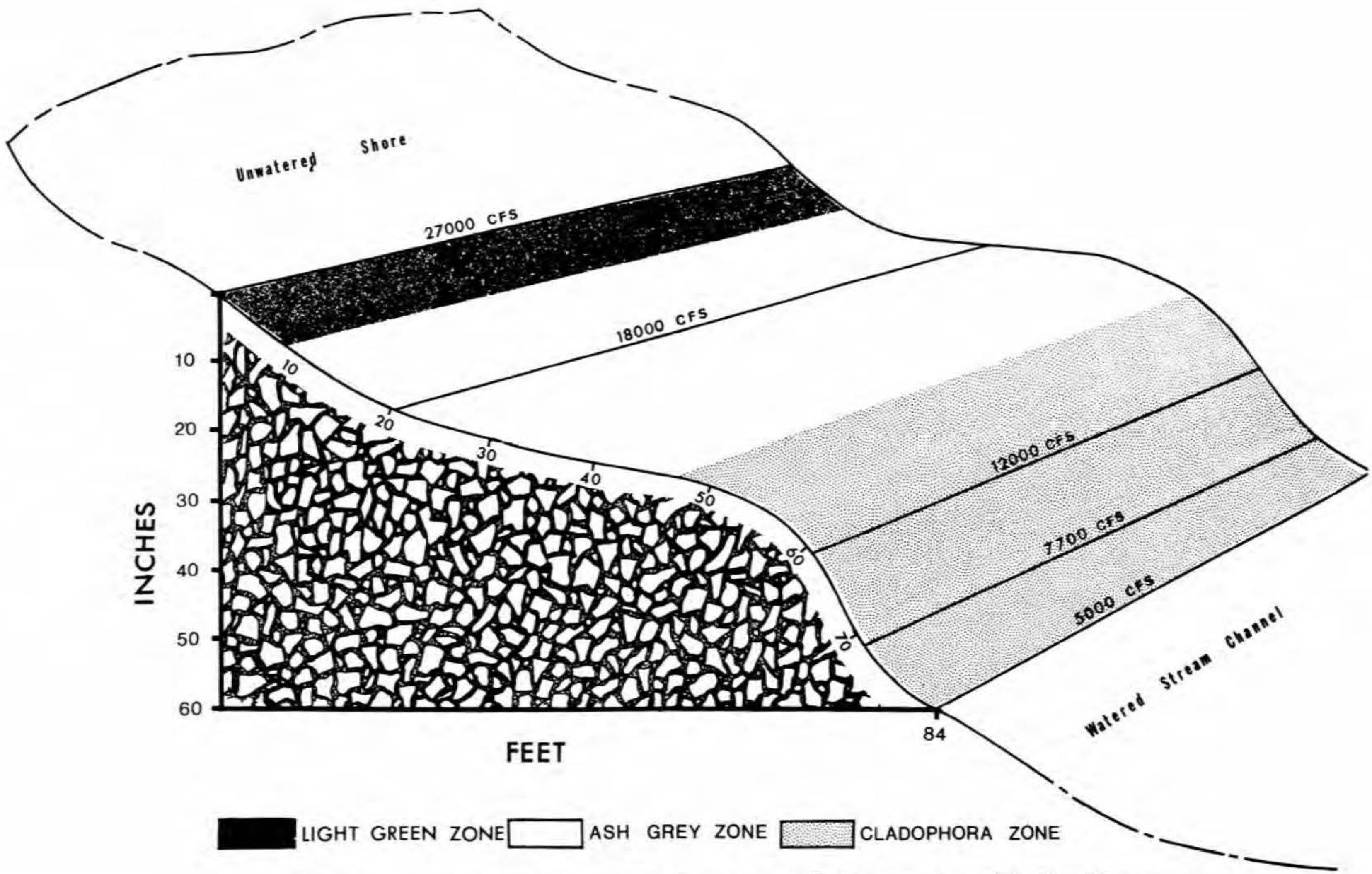


Figure 5.3 Schematic view of shoreline configuration and algal zonation of Station II, near Pittsburg Landing, Hell's Canyon, 1973.

(Figure 5.3). The filamentous carpet of algae made available numerous niches, not present in the upper zone of fluctuation. It is anticipated that the zone would be higher or lower at different times of the year depending upon hydroelectric power demands. Further, the zone may be wide or narrow depending on the slope of the shore.

Insect Drift

Drift serves as a potential means of survival for insects experiencing shoreline dewatering of rivers and streams by permitting them to colonize more tenable habitats. Most stream insects have a diel cycle with nighttime drift far exceeding daytime drift (Anderson 1967, Brusven 1970, Waters 1962 and others). Additionally, drift has been shown to change as a result of increases and decreases in discharge (Anderson and Lehmkuhl 1968).

Drift results from the two stations on the Snake River indicated an obvious diel cycle *(Figure 5.1)* with nighttime peaking. The amplitude of drift peaks was low during the pre-flow alteration period of March 19 to 4 p.m., March 21.

Drift progressively increased during the nights following daytime flow alteration, culminating in an abrupt increase during March 25-26 when the flow was restored to 27,000 cfs. The noticeable change in amplitude of drift is believed related to composition of drifting insects and zonational distribution *(Table 5.1; Figure 5.1).* During the pre-test period of March 19-21, standing crop and drift were largely composed of chironomids. Brusven (1970) and others have reported this dipteran group having rather uniform drift, i.e., not having a conspicuous diel cycle. As new, lower-level shorelines formed, mayflies, caddisflies and a pyralid lepidopteran became more prevalent in both drift and bottom samples.

No abrupt increase in drift was noted during the unstable flow period of 4-5 p.m., March 21-26 (no samples taken 4-5 p.m., March 26,during restoration of flows to 27,000 cfs). This suggests that insects did not actively drift during this daylight period in order to avoid stranding. It is believed that the rapidity at which the gently sloping shoreline dewatered caused considerable stranding of insects due to the low velocity at or near the shore-water interface, thus, reducing the chance of drifting.

Abrupt flow changes from 5,000 to 27,000 cfs on March 25 caused nearly a 10-fold increase in drift. All benthic species were affected. High drift increase is believed to be the result of catastrophic flow increases.

Shoreline Stranding

Both the enclosure and belt transect techniques revealed appreciable stranding of aquatic insects as a result of reduced flows *(Figure 5.2; Table 5.2).* During the initial flow reduction from 27,000 to 18,000 cfs, chironomids (Diptera) were the only insects recorded in significant numbers. This is closely correlated with the standing crop in that zone *(Table 5.1).* The belt transect revealed greatest stranding during the flow change from 12,000 to 7,700 cfs; principally Ephemeroptera and Diptera were recorded. While caddisflies (Trichoptera) were the dominant standing crop form *(Table 5.1),* they were not readily observed as stranded. Data obtained from the enclosure technique, however, revealed substantial numbers of *Hydropsyche* sp. (Trichoptera) stranded *(Table 5.2).* We believe the ability of this insect to seek protective seclusion under rocks and in algal mats precluded superficial observation of them during the dewatering period. In similar manner, we believe the lepidopteran, *Parargyractus* sp.,escaped visual observation during dewatering.

Table 5.2 Number of Insects Per Square Foot Dead (d) and Alive (a) After 24, 48, 72, 96, and 120 Hours of Exposure From Four Fluctuation Zones at Wilson Ranch Site (Site II), Hell's Canyon.

INSECTS	Zones: 27,000 - 18,000 cfs						18,000 - 12,000 cfs						12,000 - 7,700 cfs				7,700 - 5,000 cfs	
	72 hrs.		96 hrs.		120 hrs.		48 hrs.		72 hrs.		96 hrs.		24 hrs.		48 hrs.		24 hrs.	
	d	a	d	a	d	a	d	a	d	a	d	a	d	a	d	a	d	a
Ephemeroptera							8.7	4.0	2.66	-	16.0	-	14.7	-	13.4	-	6.7	1.3
Baetis sp.							8.7	3.3	1.33	-	14.7	-	12.0	-	10.7	-	6.7	1.3
Ephemerella spp.								0.7	1.33	-			2.7	-				
Rithrogena sp.											1.3	-			2.7			
Diptera	4.0	16.0	1.3	8.6	6.7	8.0	3.3	112.7	4.0	44.0	32.0	20.0	17.3	212.0	16.0	50.7	61.4	162.7
Chironomidae	4.0	14.7	1.3	5.3	6.7	8.0	3.3	112.7	4.0	44.0	30.7	20.0	17.3	212.0	16.0	50.7	30.7	162.7
Simulium sp.		1.3		3.3							1.3						30.7	
Trichoptera	0.7	2.7						24.0	4.0	9.3	13.3	-	2.7	360.0	6.7	128.0	6.7	221.3
Hydropsyche sp.	0.7	2.7						24.0	4.0	9.3	13.3	-	2.7	360.0	6.7	128.0	6.7	221.3
Lepidoptera								2.7	1.33	4.0	6.7	4.0	1.3	32.0	1.3	22.7	2.7	44.0
Paragyractus sp.								2.7	1.33	4.0	6.7	4.0	1.3	32.0	1.3	22.7	2.7	44.0

Table 5.3 High and Low Air Temperatures (°F), Wilson Ranch Site (Study Site II), Hell's Canyon, March 19-25, 1973.

DATE	HIGH	LOW
3/19/73	76	----
3/20/73	76	56
3/21/73	59	46
3/22/73	70	35
3/23/73	75	35
3/24/73	85	44
3/25/73	*	45

* Temperature recorder inoperative

Mayflies were most readily stranded. Numerous individuals were noted in small depressions of water behind rocks during dewatering. The depressions themselves soon became dewatered through percolation leaving the mayflies totally exposed.

There are considerable differences among insect species in exposure tolerance *(Table 5.2)*. As air temperature is undoubtedly an important variable, high and low temperatures were recorded at the site of study *(Table 5.3)*. Cool, spring temperatures provided favorable conditions for survival of many aquatic insects after dewatering. Mortality values in *Table 5.3* would be expected to be much higher during mid- and late summer when temperatures in Hell's Canyon often approach or exceed 100°F.

All dewatered zones did not receive the same intensity of post-dewatering sampling because of the restoration of lows to 27,000 cfs on March 25. However, obvious mortality differences among the aquatic insects are evident from the data. The chironomid dipterans demonstrated remarkable survival after 96 and 120 hours under the temperature and humidity conditions that prevailed; mortality after 24 hours was negligible. Trichoptera and Lepidoptera also showed high survival at 24 and 48-hour exposures. The 96-hour exposure period of March 24 (air temperature 85°F) brought about noticeable increases in mortality, approaching or exceeding 50% for the aforementioned insect orders. Mayflies were most sensitive to exposure with high mortality after 24-48 hours of exposure. Apparently, higher temperatures on March 24 contributed to this condition.

Observations indicated that the dense *Cladophora* mat served as both a survival and mortality factor to the insects residing in or on it. When the algal filaments were dewatered, insects residing near the mat-rock interface showed high survival because of prolonged moist conditions. Insects occurring at or near the outer surface of the mat often became entangled in the filaments and desiccated. The latter was particularly true for mayflies. Chironomids (Diptera) on the other hand were generally able to penetrate the filaments and locate more moist conditions. The *Hydropsyche* sp. (Trichoptera) and *Parargyractus* sp. (Lepidoptera) were noted in high numbers (often exceeding 30) under rocks where moisture and temperature conditions permitted survival.

In evaluating the above results, certain limitations must be recognized. The study was conducted over only a short interval of time with respect to the life cycle of the insects. While concerned principally with nymphs, larvae and pupae, it is probable the egg stage might be the most sensitive stage to out-of-water exposure. Field investigations involving present technology do not permit a critical analysis of this stage. Additionally, while mortality was less than expected during the initial exposure periods of 24 and 48 hours, the time of the study (March), by virtue of cool weather, was favorable for survival. A similar study during mid-summer would likely show increased mortality. It is presumed that stress placed on insects as a result of exposure would have different effects on different species as well as age groups.

The ecological principles of succession and stability are also inherently involved when interpreting water fluctuation phenomena in our waterways. It was evident from this study the algal zones and the nature of the flora on the bottom sediments are important variables influencing insect distribution and abundance in the Snake River. Extreme reductions or fluctuations of flow could have suppressing effects on algal development, thereby influencing insects, fish and other organisms dependent on the former for food.

SUMMARY AND CONCLUSIONS

Aquatic insects represent a large and important heterotrophic group of organisms in the middle reaches of the Snake River, far exceeding biomass values of smaller streams in northern Idaho containing less nutrients.

Drift by aquatic insects displayed a typical diel cycle with nighttime drift far exceeding daytime drift. Drift did not substantially increase during the period (4-5 p.m.) of decreasing flow suggesting that insects did not actively avoid stranding. Drift propensity generally increased during each reduced flow stage and substantially increased during the restoration of flows to 27,000 cfs. Numbers and biomass of drift insects are believed to be related to standing crop in the vicinity of the nets. The standing crop in turn is believed influenced by the stability and development of the algal and shoreline zonation.

Prolonged exposure of dewatered shorelines would probably cause a reduction in primary production and degradation of a detrital base, thereby causing a delay in insect recolonization of formerly inhabited areas.

Rapid reductions in flow caused considerable stranding of insects on gently sloping shores. Under cool daytime temperatures, survival was relatively high for the Ledpidoptera, Trichoptera and Diptera studied during exposure periods of 24 and 48 hours; Ephemeroptera were relatively intolerant to short term exposures out of water. Warmer temperatures would undoubtedly increase mortality as has been demonstrated by current laboratory simulation studies.

The present studies dealt with the nymph, larval and pupal stages. It is possible the egg stage is more seriously affected by dewatering; further, that different age classes within each feeding stage may be differentially affected.

Dense algal mats and presence of cobble and boulders increased survival of most stranded insects by providing places for escape from exposure and desiccation.

Because insect life is itimately associated with algal development in the Snake River, which in turn is related to numerous physical and chemical characteristics of the river, minimum flow recommendations with respect to a single organisimal group such as insects is necessarily multifaceted. In our judgement the question of minimum flow is of secondary importance to water fluctuation which causes ecological instability to the biota exposed during dewatering as well as deeper zones through disruption of normal photosynthesis and decomposition processes.

Constraint is recommended in liberal interpretation of results reported herein, in that the study was conducted for only a short period of time which in no way encompassed the life cycle of insects involved nor answered questions relating to possible latent or side effects to them. While the results were emperically derived and reflective of conditions at the time of the study, inference, speculation and application of findings to "seasonal" regulation of flows in the Snake River and other major waterways should be done with caution.

ACKNOWLEDGMENTS

Appreciation is extended to the following University of Idaho students and students' wives for their assistance in collecting and sorting field samples: Bill A. Fortis, Marvin Hanks, A.C. Jensen, Jim Stanton, Mrs. Loree Gilpin and Mrs. Claudia Nielson.

Funded in part by the Office of the Water Resources Research through Idaho Water Resources Research Institute of the University of Idaho, and by an operational studies contract with the Columbia River Fishery Development Program, National Marine Fisheries Service. Submitted with the approval of the Director of the Idaho Agricultural Experiment Station as Research Paper No. 7368, and Director of Idaho Forest, Wildlife, and Range Experiment Station.

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Editor's Note: It is anticipated that the authors will publish one or more papers, based on more detailed analysis of the data reported herein, in appropriate journals.

CHAPTER 6

CATCHABILITY AND FEEDING HABITS OF FISH

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INTRODUCTION

The objective of this study was to determine the effects of large and rapid changes in discharge on the catchability and feeding habits of fish at the Wilson Ranch in the Hell's Canyon reach of the Snake River, Oregon. This study was part of a program implemented in late March 1973 and involving many environmentally related agencies in the northwestern states. The study was developed to help establish criteria for instream flow requirements in rivers and in particular in the Hell's Canyon reach of the Snake River.

The original intent of this study was to utilize all manpower resources on a volunteer basis as a means of assessing fish catchability in the Hell's Canyon reach of the Snake River. Because of a general lack of fishing success perhaps related to the season of the year, and because of the time demands of numerous other duties of team members, little data from members other than the benthos team were taken. Therefore, with two exceptions which for consistency are not reported, all fish data were collected by a seven-man team.

PROCEDURES

Fishing was done on a volunteer basis and as time permitted from March 20 to 25, 1973. The total time fished was 54 man-hours. Fish were caught by angling with lures and bait.

The stomachs of most captured fish were preserved in formalin *(Plate 6.1)*. The contents of the stomachs were identified and enumerated in a laboratory. As the basic controlled-flow test procedure, discharge from Hell's Canyon Dam was altered at the end of consecutive 24-hour uniform flow periods as rapidly and as safely as possible. The discharge schedule and approximate time of arrival of the altered flow at the Wilson Ranch is shown on the next page.

Low water levels delayed the impact of altered discharge at Hell's Canyon Dam on discharge at the Wilson Ranch about one and three hours on March 24 and 25, respectively.

Photo by Franklin Jones, IWRB

Plate 6.1 Collection kits were prepared and used by study participants.

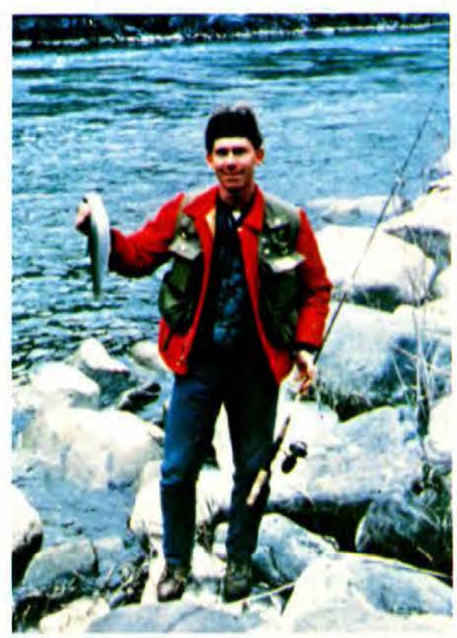

Photo by C. Koski, NMFS

Plate 6.2 Rainbow trout were caught at all flows observed.

The weather was cloudy with intermittent rain at the beginning and warm and sunny at the end of the study.

Date	Discharge, cfs[2]	Time of altered flow arrival
March 20 to 21	27,000	1600
March 21 to 22	18,000	1600
March 22 to 23	12,000	1600
March 23 to 24	7,700	1600
March 24 to 25	5,000	1700
March 25 to 26	27,000	1900

RESULTS

Catchability of Fish

During the 5-day study period anglers caught 12 rainbow trout, 1 Dolly Varden, 2 channel catfish, 6 northern squawfish, 2 carp, 12 largescale suckers, and 20 smallmouth bass. Carp, suckers and catfish bit earthworms whereas, trout, Dolly Varden, squawfish, and bass bit mainly lures and lures baited with earthworms. Rainbows, suckers, and bass were the most commonly caught fish. Except for three fish, suckers were obtained incidentally to angling for trout. Throughout the study period in slackwater area of pools, carp were observed skimming various organisms including filamentous algae from the water surface. No directed effort was made to catch carp or suckers.

There was no significant difference in number of trout *(Plate 6.2)* captured as water levels changed *(Table 6.1)*. More suckers and carp were captured at high flows and more squawfish and bass were captured at low flows than other species of fish. Fish success for bass at low flows, however, is attributed to an increase in water temperature rather than to reduction in discharge.

Fifty-four man-hours of fishing yielded 55 fish. The mean number of fish caught per hour was 1.0 and varied between 0.6 and 1.6 during the 5-day study period. Based on the number of man-hours of fishing pressure for all species, a chi-square analysis indicated that there was no significant difference in the daily number of captured fishes.

Food Habits of Fish

The stomach contents of 39 fish were analyzed *(Table 6.2)*. Relatively small numbers of insects were found in catfish, squawfish, and suckers. Squawfish stomachs contained fish and crayfish while sucker and catfish stomachs contained algae and insects.

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[2] At Hell's Canyon Dam, flows at Wilson Ranch may have been modified slightly by intervening inflows and by the channel-storage aspects of water-mass time of travel, as discussed in Chapter 2.

Table 6.1 Catch Per Hour and Composition of Fishes Captured by Angling During Five 24-Hour Periods of Sequentially Reduced Discharges of the Snake River, at the Wilson Ranch, Oregon (March 20-26, 1973).

Hell's Canyon Dam Discharge, cfs	Species captured	Number	Range in total length, inches	Man-hours of fishing	Fish per hour
	Rainbow trout	3	10 to 12		
27,000	Dolly Varden	1	13	8	0.6
	Carp	1	20		
	Rainbow trout	2	13		
18,000	Largescale sucker	12	16 to 24	15	1.0
	Carp	1			
	Rainbow trout	4	12 to 13		
12,000	Northern squawfish	4	14 to 15	5	1.6
7,700	Channel catfish	2	20 to 24	3	0.7
	Rainbow trout	3	13 to 17		
5,000	Northern squawfish	2	15 to 16	23	1.1
	Smallmouth bass	20	9 to 13		

One of four squawfish and five of 18 bass captured had empty stomachs. The other 13 bass stomachs contained 21 crayfish and 9 sculpins.

Rainbow trout were the only fish captured that fed consistently on insects; most of the insects were immature. Arranged in order from the most to the least numerous, the four most common insects found in trout stomachs were Baetis sp. (mayfly), *Hydropsyche* sp. (caddis fly), Chironomidae (midge) and *Simulium* sp. (black fly), *Table 6.3.*

Table 6.2 Stomach Contents and Sample Sizes of Seven Species of Fish Captured at the Wilson Ranch, Snake River, Oregon.

Species	Number	Stomach Content
Rainbow trout	10	Insects
Dolly Varden	1	Sculpin
Channel catfish	2	Algae and insects
Northern squawfish	4	Sculpins, crayfish, insects
Carp	1	Algae
Largescale sucker	3	Algae, clam shells, insects
Smallmouth bass	18	Crayfish and sculpins

Table 6.3 Mean Number of Insects in Rainbow Trout at the Wilson Ranch, Snake River, Tabulated According to Discharge.

Insecta	Discharge at Hell's Canyon Dam, cfs.			
	27,000 (2 fish)	18,000 (1 fish)	12,000 (4 fish)	5,000 (3 fish)
Emphemeroptera (mayflies) *Baetis* sp.	8	50	293	39
Trichoptera (caddisflies) *Hydropsyche* sp.	4	42	22	82
Lepidoptera (moths) Pyralididae	1	4	2	6
Diptera (flies) Blepharoceridae	0	1	2	0
Chironomidae	9	19	91	10
Simulium sp.	3	14	18	16
Total	25	130	428	153

On March 23 (12,000 cfs) one trout contained 1,097 *Baetis* sp.; another trout, 328 Chironomidae and on March 25 (5,000 cfs) two trout contained 92 and 112 *Hydropsyche* sp. Except for these four exceptions, less than 55 insects of any one species were found in any one stomach.

Because of the limited amount of data, no conclusions are derived from this study.

ACKNOWLEDGMENTS

The enthusiastic cooperation of Russell C. Biggam, Bill A. Fortis, Marvin Hanks, A.C. Jensen, and Jim Stanton, University of Idaho, in angling for fish and in analyzing data is sincerely appreciated. Our thanks go to Ken Witty, Oregon State Game Commission, for his faithful transportation of University personnel back and forth across the river.

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Submitted with the approval of the Director of the Forest Wildlife and Range Experiment Station.

CHAPTER 7

SALMONIDS

Ken Thompson
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INTRODUCTION

Hell's Canyon reach of Snake River is one of the world's truly unique stretches of free-flowing rivers. Not only does the canyon possess unparalleled scenic value, the river is equally impressive for its size and rate of descent. Among its many resource values are the anadromous and resident salmonids. More than 25,000 salmon and steelhead once migrated into and through Hell's Canyon each year to complete their reproductive cycle. After harnessing the vast hydroelectric potential of the lower Snake and Columbia Rivers, it is significant to note that the environmentally sensitive salmon and steelhead runs still exist in Hell's Canyon, although much reduced from former numbers. Their presence is no accident. Perpetuation of anadromous fish in the Middle Snake River system is the product of an enormous effort on the part of many who recognized the value of and obligation to preserve the public's fishery resources.

The Hell's Canyon Controlled Flow Study of instream flow requirements contained in part a continutation of this effort to manage wisely the salmonid resources of the Columbia River system. This chapter describes the procedures and findings of the team of biologists who examined flow requirements of salmon and trout in Middle Snake River, March 20-26, 1973. It is hopeful that this pioneering endeavor will serve as a model for similar studies on rivers throughout the nation.

Salmonid Resources

Fall chinook salmon, summer steelhead, rainbow trout, and Dolly Varden are the species of salmonids in Hell's Canyon. Summer steelhead, fall chinook salmon, and rainbow trout are the most important. Dolly Varden are found only in limited numbers. Spring and summer chinook salmon migrate through the Snake River into the Salmon River to spawn.

A significant sport fishery occurs on summer steelhead from September through April, with peak angling pressure occurring during October and November. Most steelhead are taken between Lewiston and the Imnaha River. A significant rainbow trout fishery has developed in Hell's Canyon since 1968. The rainbow fishery is most productive from June through September, but occurs to some degree year round. There is a minor fishery on fall chinook salmon in Hell's Canyon, but these runs contribute more to sport and commercial fisheries in the ocean and Columbia River.

Salmon and steelhead runs above Salmon River are much reduced from former numbers. Columbia and Snake River dams are believed to be most responsible for their decline, although other factors, such as watershed damage, are also responsible for the decline of Snake River anadromous fish. As many as 17,000 fall chinook salmon and 10,000 steelhead were recorded as once having migrated annually into and through the Hell's Canyon reach of Snake River. Several promising measures are being researched to relieve the stresses on anadromous fish caused by river development. Foremost are efforts to reduce embolisms caused by atmospheric gas supersaturations, and measures which protect fish from injury when passing dams. Success in these areas, combined with a strong hatchery program, could significantly increase the ultimate number of anadromous fish returning to Hell's Canyon. The hatchery program on summer steelhead returning to Hell's Canyon Dam has been encouraging. Continued development and propagation of stocks resistant to the stresses of Columbia and Snake River systems is a top-priority management objective.

Because anadromous fish runs are blocked from areas formerly used above Hell's Canyon Dam, more fish are forced to spawn in the Hell's Canyon reach below the dams. The need to provide good fish habitat in that reach is becoming increasingly important.

OBJECTIVES

This phase of the study was conducted to evaluate the relationship discharge has with availability and quality of salmonid habitat in Hell's Canyon. Biologists also examined the effects of discharge fluctuations on the aquatic environment.

The primary objective of this study was to determine the minimum and optimum flow requirements of salmonid fishes, consistent with established methodology used in Oregon.

Another objective of this pioneering endeavor in river flow study was to develop improved techniques which could be used to study instream flow requirements in other rivers throughout the nation *(Appendix 7.1)*. A summary of the procedures used to define instream flow needs of salmonids in Hell's Canyon follows.

METHODS

A detailed description of the methods employed by the salmonid team in the Hell's Canyon Controlled Flow Study is presented in *Appendix 7.1*. The salmonid team consisted of four crews which collected similar data at several sites located in four sections of the 107.7 mile study area. These four sections are referred to in this chapter as study areas.

Procedures used to evaluate flow requirements of salmonids were fashioned after those employed by the Oregon State Game Commission during the past decade. Although some modifications were necessary for Snake River application, the methods used were designed to evaluate environmental changes influencing the various biological activities of salmonids. Individual evaluations were conducted which related to flows needed for passage of adult fish, spawning, egg incubation, and rearing of juveniles.

Two separate techniques were available to determine flows required for passage of adult anadromous fish. Although not applied, study crews were prepared to obtain linear transect measurements of critical depths and velocities on shallow bars at the lowermost controlled flows. Because flows during the study did not create critical passage conditions, subjective observations were made at the various controlled flow levels to judge what flows are required for fish passage.

Methods employed to determine flows required for spawning involved linear transect measurements of water depths and velocities over gravel bars known to be used by salmonids, visual interpretation of flows required to meet minimum spawning flow criteria, relating discharge to dewatering of fish redds, analyses of intra-gravel dissolved oxygen at various surface flow depth, and relating discharge to the availability of spawning bars by utilizing aerial photos taken during the study.

The discharge required to successfully incubate salmonid eggs and accommodate sac fry emerging from the gravel, likewise, was determined by a combination of several interrelated evaluations. Spawning transect data were examined, because stream habitat for spawning and incubation are homologous. Locations of salmonid redds dewatered during the study were related to flow. Intra–gravel dissolved oxygen was evaluated by linear transect placement of plastic standpipes and use of the modified Winkler procedure for measuring dissolved oxygen. Eyed eggs of summer steelhead were buried in known spawning areas in small stainless steel baskets to evaluate egg survival after varying periods of dewatering. Aerial photos were examined to relate discharge to spawning habitat throughout the canyon.

The most complex relationship stream flow has to salmonid production is for what is described as rearing. Rearing flows must accommodate the need for food production, living space, shelter, and water quality. Linear transect measurements of width, depth, and velocity were examined to relate flow conditions to discharge. Dewatered beaches were systematically surveyed to assess stranding mortality and determine spatial distribution of juvenile salmonids (Chapter 10). Evaluations of travel time of stage wave and water mass (Chapter 2) may enable projections of river temperatures under various flow and atmospheric conditions. A team from the University of Idaho obtained extensive measurements on the effects of reduced flows on benthic organisms (Chapter 5), a basic food of salmonids. Bailey's work on periphyton (Chapter 4) provided insight into another important dimension of the ecosystem.

Recommendations concerning rate of flow change, particularly fluctuations caused by hydroelectric power peaking operations, are derived by egg dewatering and fish stranding mortality evaluations, fish redds and spawning gravel relationships with discharge, and monitoring rate of change of the river stage during the study. The recommendations are presented in Chapter 10.

RESULTS

Passage

Because the lowest controlled flow studied (5,000 cfs) did not present critical fish passage conditions, measurements could not be taken to project minimum flows required for fish passage. Observations by the salmonid team summarily concluded that slightly less than 5,000 cfs is the minimum required to safely pass migrating anadromous fish. Because the stimulating effect of high flows on anadromous fish migrations is not thoroughly understood, the need for larger attraction flows was not evaluated. Cross-sectional measurements of the river's velocity at 27,000 cfs did not reveal excessive velocities for fish migration. From observations made at the various study stations and from examination of aerial photographs of the 108-mile reach, all controlled flows during the study provided an adequate amount of river channel with flow depths and velocities suitable for fish migration.

Spawning

Some of the best data compiled in the salmonid phase of the Controlled Flow Study were those which reflect flow requirements for spawning.[1] Recommended spawning flows are presented in *Table 7.1.* Spawning flow recommendations are derived from 16 linear transects of flow depths and velocities over gravel bars. Supportive data were compiled from observations and estimates made of flows required to meet minimum spawning criteria, from the relationship existing fish redds had with river discharge, from analysis of intra-gravel dissolved oxygen relationships, and from examination of aerial photos taken during the study.

[1] Editor's Note: Basic data from the salmonid flow requirement investigation is voluminous and therefore omitted from this report. However, they will be published separately and be available from the Oregon Game Commission or the Pacific Northwest River Basins Commission.

Table 7.1 Recommended Flows for Salmonid Spawning, Released From Hell's Canyon Dam

Study Area	Optimum (cfs)	Minimum(cfs)
Anatone	18,700	13,400
Dug Bar	27,000	16,000
Pittsburg Landing	21,000	14,500
Saddle Creek	27,000	16,300
Hell's Canyon Reach (means)	23,425	15,050

Incubation

Surface flow conditions required to maintain suitable intra-gravel environment for incubation of fish eggs were related to transect data to determine discharge levels needed to cover preferred spawning areas. River discharge levels required to assure successful incubation of salmon and trout eggs were identified primarily at two study reaches in Hell's Canyon *(Table 7.2)*. The recommended flow for Hell's Canyon reach is the mean of flows determined at the two study sites. The distribution of gravel used by spawning fish, more than any other factor, influenced the surface flow recommended for incubation.

Table 7.2 Flows Required to Maintain Suitable Intra-gravel Dissolved Oxygen Levels for Salmonid Eggs and Fry, Hell's Canyon.

Study Area	Optimum[1] (cfs)	Minimum[1] (cfs)
Anatone	18,000	13,000
Saddle Creek	26,000	15,500
Hell's Canyon Reach (means)	22,000	14,250

[1] Flows required to maintain at least 5.0 ppm intra-gravel dissolved oxygen in gravel made available to spawning salmonids at 23,425 cfs and 15,050 cfs, optimum and minimum flows for spawning.

Flow levels adequate for egg incubation and fry emergence are primarily determined by the prevailing flows during the spawning period. For example, if the prevailing flow during the spawning period is more than the recommended 15,050 cfs an adequate flow for incubation, likewise, will be more than the recommended 14,250 cfs. If it were to become necessary to regulate the river flow upwards from an agreed flow regime during the period of fish spawning, fishery agencies should be consulted to determine subsequent flows adequate for incubation.

Rearing

Water required to successfully rear salmonids must accommodate their need for food, shelter,

Figure 7.1 Biological Activities of Salmonids by Species and Period of the Year, Hell's Canyon, and Recommended Optimum Flows.

Species	Activity	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Fall Chinook Salmon	Passage									4,000	4,000	4,000	
	Spawning											23,425	
	Incubation	22,000	22,000	22,000	22,000							22,000	22,000
	Rearing		12,000	12,000	12,000	12,000	12,000						
Summer Steelhead	Passage	3,000	3,000	3,000	3,000				3,000	3,000	3,000	3,000	3,000
	Spawning				23,425	23,425							
	Incubation				22,000	22,000	22,000	22,000					
	Rearing	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Rainbow Trout	Spawning				23,425	23,425	23,425						
	Incubation				22,000	22,000	22,000	22,000					
	Rearing	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Recommended Optimum Flows		22,000	22,000	22,000	23,425	23,425	23,425	22,000	12,000	12,000	12,000	23,425	22,000

Figure 7.2 Biological Activities of Salmonids by Species and Period of the Year, Hell's Canyon, and Recommended Minimum Flows.

Species	Activity	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Fall Chinook Salmon	Passage									4,000	4,000	4,000	
	Spawning											15,050	
	Incubation	14,250	14,250	14,250	14,250							14,250	14,250
	Rearing		12,000	12,000	12,000	12,000	12,000						
Summer Steelhead	Passage	3,000	3,000	3,000	3,000				3,000	3,000	3,000	3,000	3,000
	Spawning				15,050	15,050							
	Incubation				14,250	14,250	14,250	14,250					
	Rearing	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Rainbow Trout	Spawning				15,050	15,050	15,050						
	Incubation				14,250	14,250	14,250	14,250					
	Rearing	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Recommended Minimum Flows		14,250	14,250	14,250	15,050	15,050	15,050	14,250	12,000	12,000	12,000	15,050	14,250

Figure 7.3 Recommended Minimum and Optimum Flows for Salmonids, and Water Supply Records for Snake River at Hell's Canyon.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Minimum	14,250	14,250	14,250	15,050	15,050	15,050	14,250	12,000	12,000	12,000	15,050	14,250
Optimum	22,000	22,000	22,000	23,425	23,425	23,425	22,000	12,000	12,000	12,000	23,425	22,000
Supply[1]	15,860	19,566	18,490	25,650	22,720	20,030	10,780	10,320	11,880	14,030	14,770	14,770
Supply[2]	53%	85%	73%	80%	73%	70%	8%	8%	50%	72%	35%	55%

[1] USGS Water Supply Records for 1929-68. Mean monthly discharge at Hell's Canyon Dam. Flow regulated by extensive upstream storage. Upriver diversions for irrigation of about 3,000,000 acres.

[2] Percent of years the recommended minimum flows could be equalled or exceeded, by month, under 1970 levels of development and management (Idaho Water Resource Board).

space, and water quality.

Aquatic insects, the principal food items of salmonids, would be most available at flows which cover the most substrate suitable for their production. Data suggests a flow of 12,000 cfs would achieve the level of insect production required for salmonids.

Suitable rearing space and shelter, considering depths and velocities preferred by rearing salmon and trout, are most available at 12,000 cfs. Chapter 2 on Time of Travel and Chapter 10 on Fish Stranding provided data to support this conclusion.

Salmonids require water which does not exceed 65° F. for extended periods. Because of the extreme air temperatures and heat retention character of Hell's Canyon, stored water should be regulated for its maximum effect to control river temperatures during the summer. Snake River above Clarkston has been in excess of 75° F. in August when flows released from Hell's Canyon Dam ranged between 6,500 and 10,600 cfs. River temperatures have reached 70° F. and over at Clarkston in July when flows at Hell's Canyon Dam ranged between 10,000 and 16,000 cfs. Flow and temperature records for July, August, and September, indicate a minimum of 10,000 cfs may assure suitable water temperatures for salmonids.[2]

To make certain that the aquatic environment is suitable for rearing of salmonids at all times in Hell's Canyon, a minimum flow of 12,000 cfs is needed. The period of the year when rearing is the predominant biological activity of salmonids is illustrated in *Figure 7.1 and 7.2.*

CONCLUSIONS

To effect better management of the salmon and trout in Hell's Canyon, conclusions from this phase of the study are presented as recommended perennial flows which will accommodate all biological activities of salmonids *(Figure 7.3)*. Recommended minimum flows represent 9,713,298 acre-feet of water annually. A recent six-year average discharge of Snake River below Hell's Canyon Dam was 14,690,000 acre-feet per year (U.S.G.S., 1971). Recommended optimum flows for salmonids total 14,059,890 acre-feet annually.

ACKNOWLEDGMENTS

The following biologists participated on the salmonid team and obtained most of the data from which recommendations relating to salmonids were developed.

Allan Smith, Oregon State Game Commission
Duane West, Oregon State Game Commission
Mike Golden, Oregon State Game Commission
Ken Thompson, Oregon State Game Commission
Herb Pollard, Idaho Fish and Game Department
Will Reed, Idaho Fish and Game Department
Ron Lindland, Idaho Fish and Game Department
Dick Scully, Idaho Fish and Game Department
Wayne Burck, Fish Commission of Oregon
Bob Bishop, Washington Department of Ecology

Ken Witty, Oregon State Game Commission, and Terry Holubetz, Idaho Fish and Game Department, provided valuable boat and aerial reconnaissance data which document the effects of flow transitions on fish stranding mortality. The results of work on benthos, aquatic vegetation, and river times of travel conducted by other scientists were used in part to help define flow requirements of salmonids in Hell's Canyon.

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[2] National Marine Fisheries Service. 1971. Water Temperature Studies, January 1, 1960-December 31, 1970, Snake River System, Boise, Idaho, 155 pages.

APPENDIX 7.1

METHODOLOGY FOR DETERMINING INSTREAM FLOW REQUIREMENTS OF SALMONIDS IN HELL'S CANYON, SNAKE RIVER

The Hell's Canyon Controlled Flow Study employed a standard technique of determining flow recommendations for salmonids by evaluating flow requirements of their individual biological activities. Flow conditions required for upstream migration of adult fish, spawning,egg incubation, and rearing are activities for which hydrological criteria have been described through research.

Spawning

Spawning flows must provide adequate water for adult salmonids to spawn in their preferred stream areas. All important species of salmonids inhabiting the study stream or stream section should be considered while formulating a recommended flow.

Although several procedures were employed to derive recommended spawning flows for salmonids in Hell's Canyon, two basic procedures were used to evaluate flow requirements. These two procedures are the linear transect technique and observation procedure.

The transect technique involves the use of water depth and velocity measurements along a line intersecting prime spawning area of salmonids *(Plate 7.1)*. Transects normally are located at the head of riffles on cross-sectionally symmetrical gravel bars either in the main channel or side channel of the river *(Appendix Figures 7.1 and 7.2)*. Gravel bars were selected which approximated the size of those typically found in the study reach of Snake River and which were known to be used by salmonids for spawning.

Depths and velocities were measured at regular intervals along the transects. Measurements were taken frequently enough to insure proper identification of flow conditions suitable for spawning *(Appendix Figures 7.3 - 7.5)*. Average velocity measurements were taken at each station as described by USGS (Stream-Gaging Procedure, Geological Survey Water Supply Paper No. 888). Depth and velocity measurements were obtained at each of several flow stages *(Appendix Table 7.1)*. Transect widths usable for spawning plotted against discharge at several different flow stages provided curves from which recommended flows were derived *(Appendix Figure 7.5)*.

Gravel between ¼ inch and 6 inches in diameter, surface flow at least 0.8 foot deep, and velocities between 1.0 and 3.0 feet per second are standard criteria which were employed on Snake River to determine the suitability of a site and flow conditions for spawning of salmonids.

Equipment used in the Hell's Canyon Controlled Flow Study by the Salmonid Team is listed in *Appendix Table 7.2.*

A subjective observation technique was employed on gravel bars other than those used for transect analysis to more completely evaluate the flows required for spawning of salmonids in the study reach. At each of the controlled flow levels, estimates were made of the approximate flow required to accommodate spawning activities of salmonids. The flow which the various observed estimates seemed to indicate was used to reinforce the flow recommended for salmonid spawning.

Optimum spawning flow is that which covers the maximum amount of gravel with suitable depths and velocities. Minimum spawning flow is that which covers 80 percent of the gravel available

Appendix Table 7.1 Transect Measurements for Evaluating Spawning Flow Requirements (Hypothetical Data).

Cross-Section Width (measure at lowest flow)
(total width)

Feet of Usable Gravel – 44 feet

At Point	Water Depth	Velocity at .4'	Remarks	Usability (see criteria)
From right				
bank 0-20'	0	0		<0.8'
24'	0.3'	0.7	Gravel<¼"	
28'	0.8'	1.0	" "	
32'	0.9'	1.0	" "	
36'	0.9'	1.2	" "	
40'	1.0'	1.3		ok
44'	1.3'	1.8		ok
48'	1.2'	1.8		ok
52'	1.3'	1.8		ok
56'	1.5'	1.9		ok
60'	1.8'	2.1		ok
64'	2.0'	2.3		ok
68'	2.1'	2.6		ok
72'	2.3'	2.7		ok
76'	2.5'	2.8		ok
80'	2.9'	3.0		ok
84'	3.1'	3.3	Gravel>6"	
86'	3.2'	3.5	" "	
		3.0		

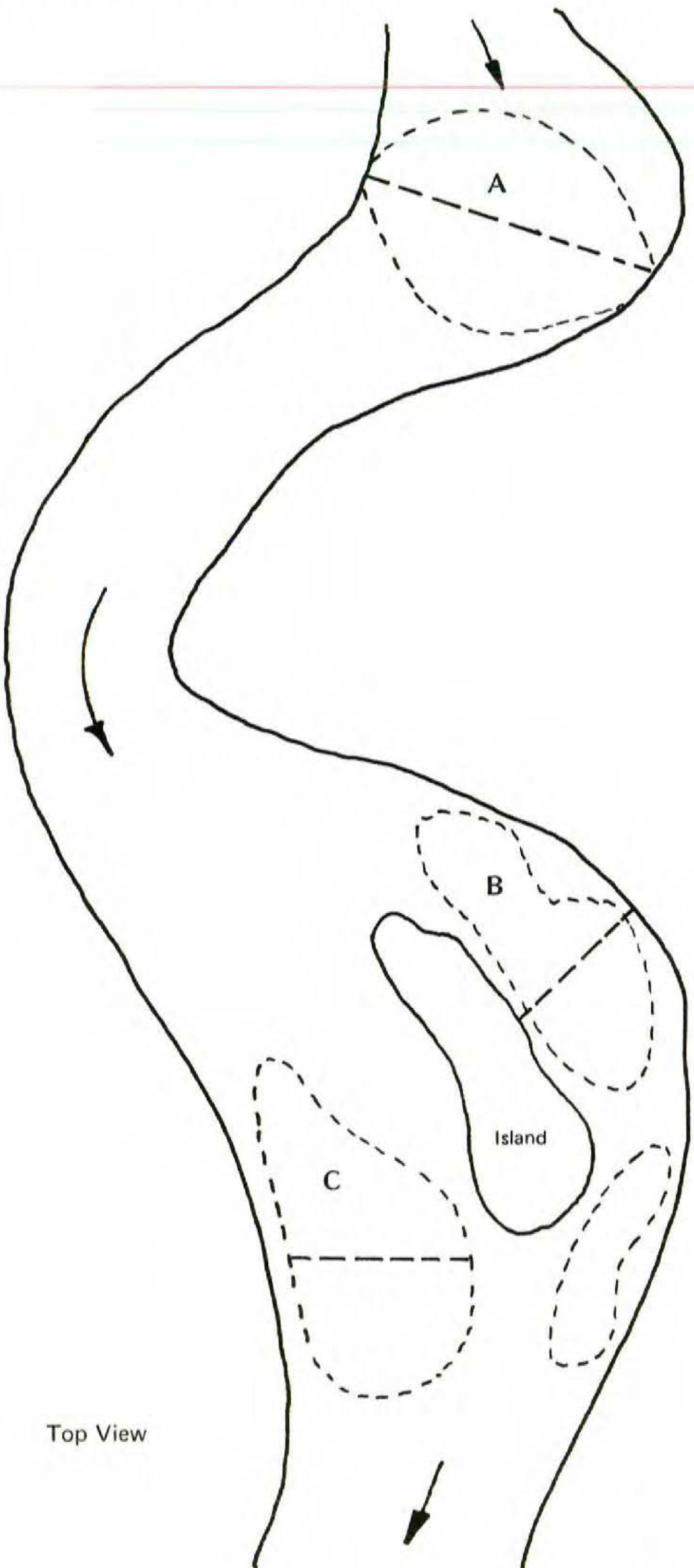
Approximately 80' in center of channel >3.0 fps and not wadable.

at an optimum spawning flow. This is approximately equivalent to the maximum efficient flow for providing suitable spawning area.

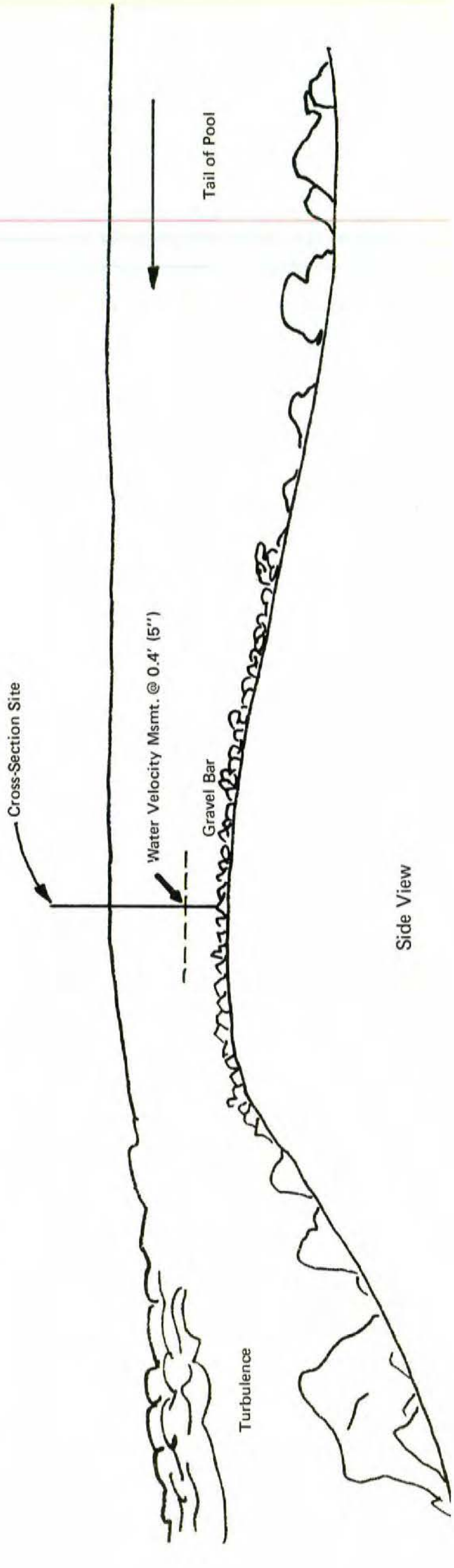
Appendix Table 7.2 Equipment Used to Evaluate Spawning Flow Requirements of Salmonids in Snake River.

Current Meter	Life Jackets
Velocity Conversion Tables	Data Forms
Tape Measure	Instruction Sheets
Wooden Stakes	Thermometers
Plastic Flagging	Cameras
Chest Waders	Previous Data

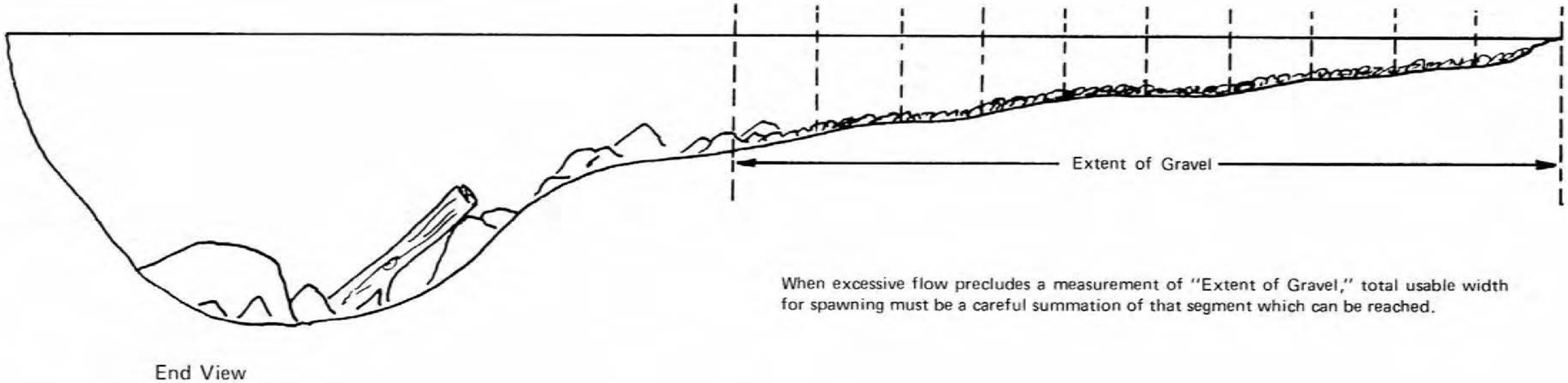
Appendix Figure 7.1 Location of Transects On Gravel Bars, Spawning Flow Requirement Evaluation



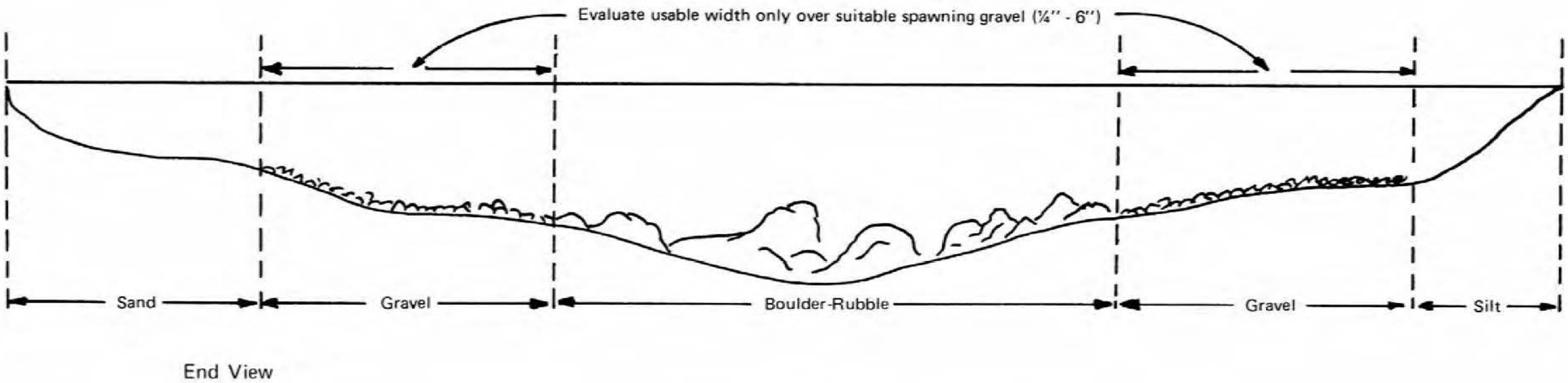
Appendix Figure 7.2 Location of Transect on Gravel Bar, Spawning Flow Requirement Evaluation



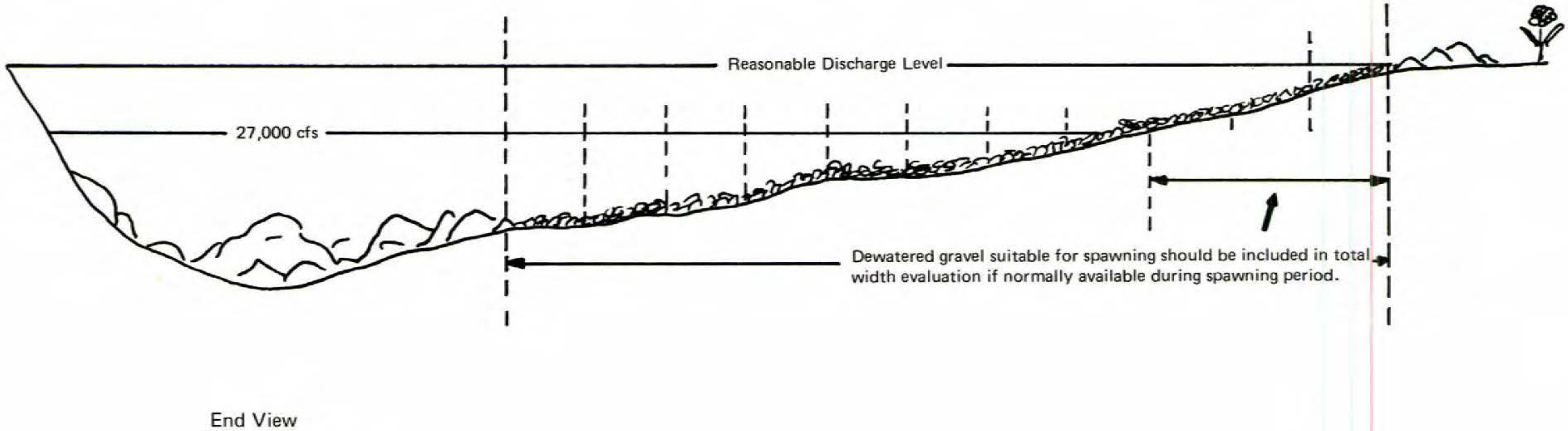
Appendix Figure 7.3a Spawning Flow Requirement Evaluation, Measurement of Total Transect Width Usable



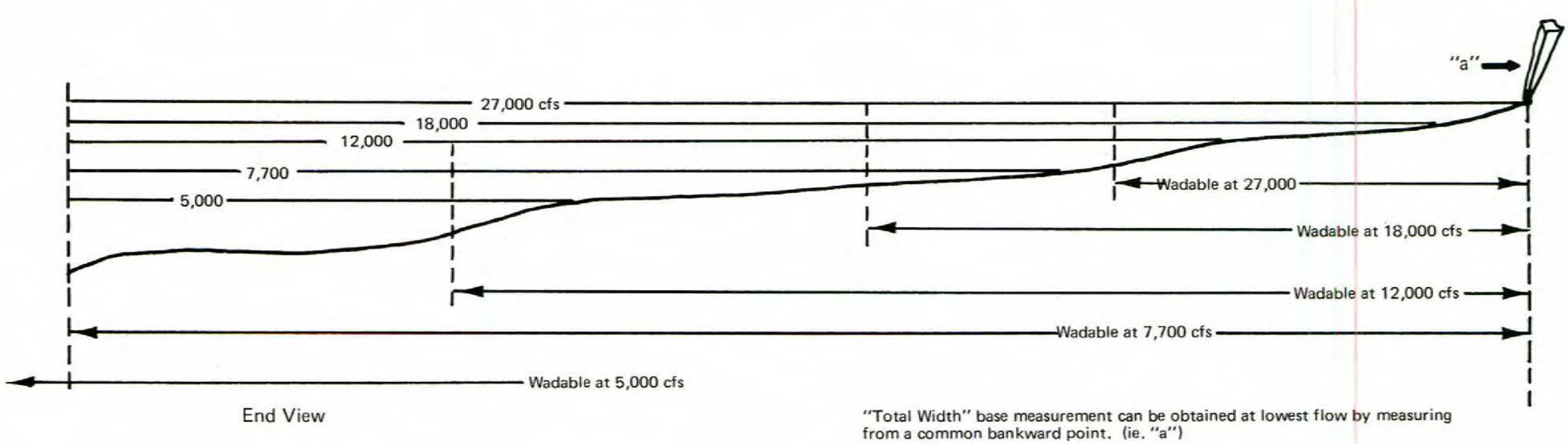
Appendix Figure 7.3b Spawning Flow Requirement Evaluation, Measurement of Total Transect Width Usable



Appendix Figure 7.3c Spawning Flow Requirement Evaluation, Measurement of Total Transect Width Usable



Appendix Figure 7.4 Spawning Flow Requirement Evaluation, Measurement of Total Transect Width



Appendix Figure 7.5 Graph of Transect Data for Determining Recommended Spawning Flow (Hypothetical Data)

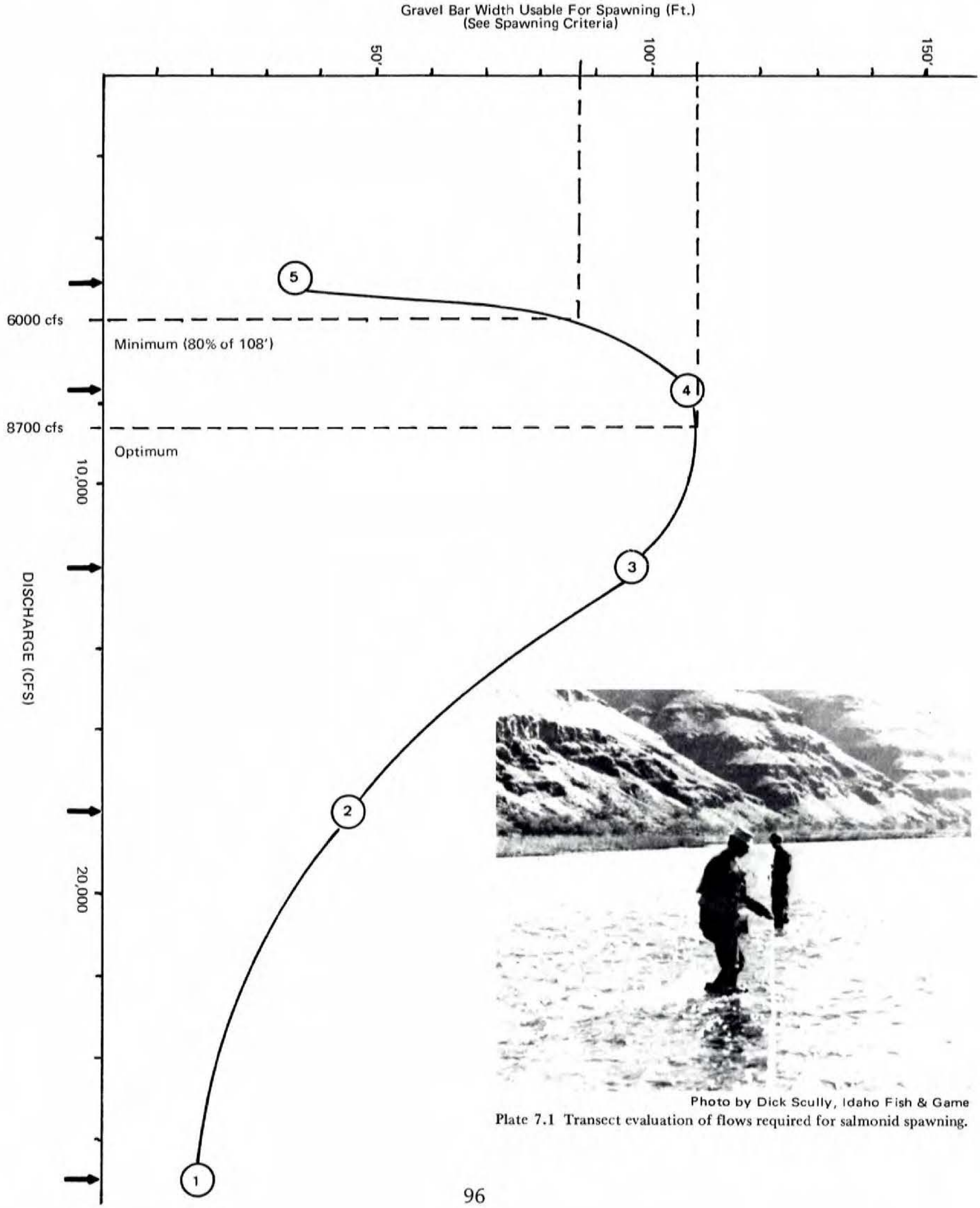


Photo by Dick Scully, Idaho Fish & Game

Plate 7.1 Transect evaluation of flows required for salmonid spawning.

Incubation

To assure successful egg incubation and fry emergence, adequate flows should be maintained over spawning areas for a period of 50 to 70 days following peak spawning activity. From the Hell's Canyon Controlled Flow Study, flows were recommended which will accommodate summer steelhead, fall chinook salmon, and rainbow trout.

Intra-gravel dissolved oxygen analyses and spawning transect information were the principal data used to recommend flows for incubation. Other information was used to reinforce these recommendations.

Intra-gravel dissolved oxygen was systematically sampled at each of the five controlled flows during the study. Sampling was accomplished by use of plastic standpipes driven into the gravel *(Appendix Plate 7.2)*. Standpipes were deployed along the same gravel transects used to evaluate spawning flow requirements *(Appendix Figure 7.6)*. The procedure used to determine the effects of reduced flows on intra-gravel dissolved oxygen is described in *Appendix Tables 7.3, 7.4 and 7.5.*

Data from other procedures were examined to provide additional insight into flows required for incubation, but are discussed in the sections of this appendix to which they are most appropriate.

Photo by Al Smith, Oregon Game Commission

Plate 7.2 Intra-gravel dissolved oxygen analysis.

Appendix Table 7.3 Procedure for Evaluating Intra-gravel Dissolved Oxygen, Hell's Canyon Controlled Flow Study

1. Try to establish standpipes in area so dissolved oxygen readings can be taken as late in the day as possible (to allow as much time as possible for intra-gravel environment to stabilize after each flow transition).
2. Drive standpipes into gravel just upstream from spawning transect. Add additional standpipes on each transect as soon as reduced flow stages permit. Metal reinforcing rods can serve to stabilize the standpipes in swift river currents.
3. Blow on top of standpipe to clear it of sediments. (Watch for bubbles around base of standpipe. Relocate standpipe in vicinity if it cannot be cleared).
4. Allow at least 6 hours for substrate and DO around base of pipe to stabilize. (Wait as long as possible after a flow stage has stabilized before sampling DO. Preferably, sampling should be done just prior to the subsequent flow stage or just prior to darkness. Each daily sampling should be done at the same time of day.)
5. With hand thermometer and string, take temperature of water in bottom of standpipe prior to testing DO.
6. Before extracting water sample, clear rubber sampling tubes of all excess water (this can be accomplished by grasping the cork end and twirling the rubber sampling tubes).
7. To obtain water sample from standpipe, insert longest rubber tube well into water column but do not allow it to touch bottom where it could pick up sediments. Place short rubber tube in mouth and carefully draw water sample, pinching tube with teeth or fingers between breaths to avoid letting water recede in sampling tube and air to become trapped in tube or sample bottle. Discard sample and repeat procedure if bubbles should appear.
8. When filling sample bottle, tilt bottle slightly to side to allow sample water to run down inside of bottle, thus avoiding aeration.
9. As soon as sample bottle is filled, gently remove stopper and raise ends of rubber tubing above bottle to allow excess water to overflow.

Appendix Table 7.4 Intragravel Dissolved Oxygen Analysis (Hypothetical Data)

Stream ______________________ Date ______________________

River Mile ______________________ Time ______________________

Discharge ______________________ Observers ______________________

10.5 ppm (surface DO)
48 (surface temperature)

Standpipe No.	DO	Water Temp. (F)	Surface Flow Depth (ft)	Surface Flow Velocity (fps)
a,1	5.5	52	0	0
a,2	8.0	49	0.5'	0.8
a,3	10.5	48	2.5'	3.6
b,1	3.0	54	0	0
b,2	9.0	49	2.1'	3.2

Remarks:

Appendix Table 7.5 Intra-gravel Dissolved Oxygen Analysis, Standpipe Location Key (Hypothetical Data)

Stream ______________________

River Mile ______________________

Observers ______________________

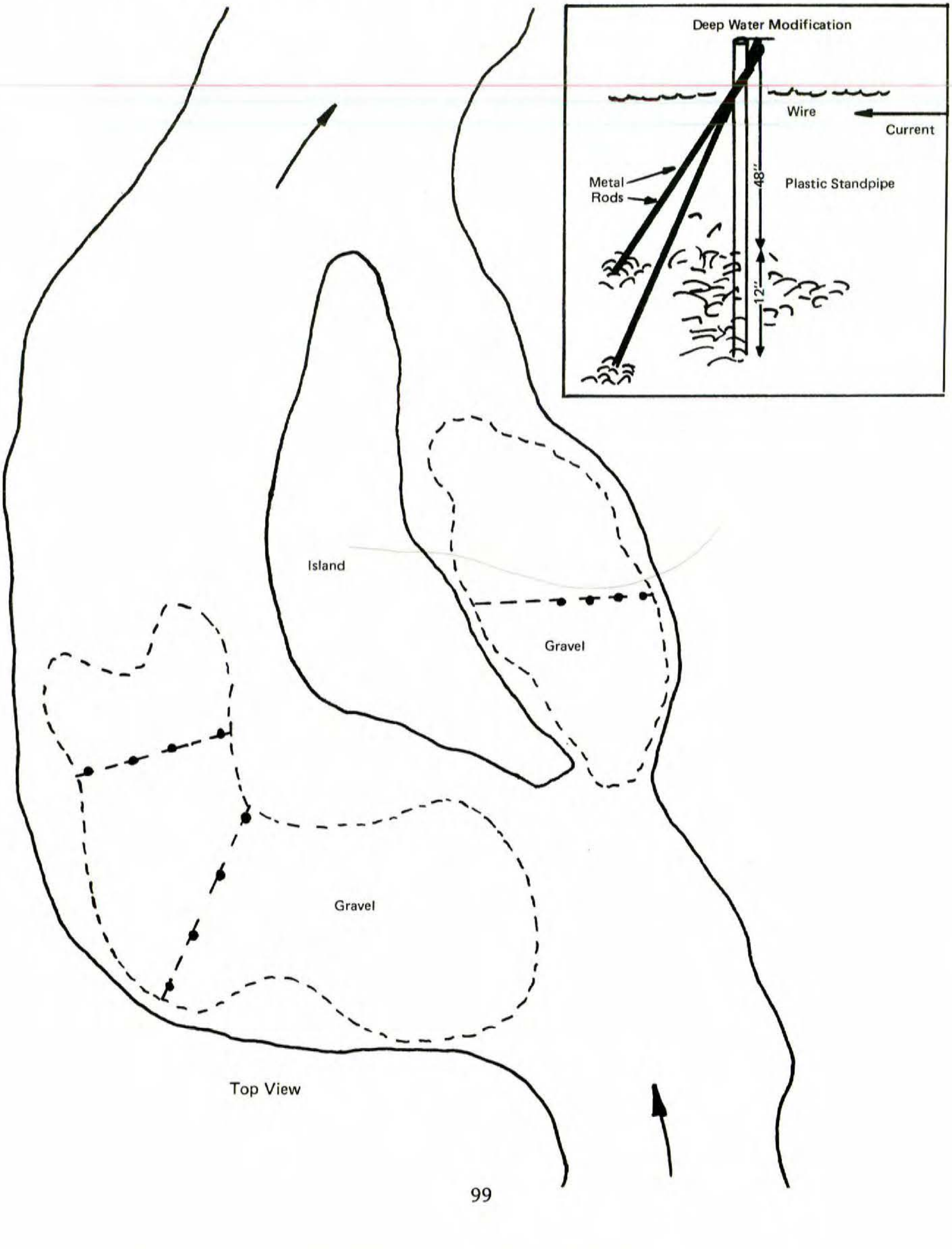
Standpipe No.	Location
a,1	10' from left edge of spawning transect - "A"
a,2	45' " " " " " "
a,3	
a,4	
a,5	
a,6	
a,7	
b,1	
b,2	25' from right bank of spawning transect - "B"
b,3	52' " " " " " "
b,4	
b,5	
b,6	

Appendix Table 7.6 Transect Measurements for Evaluating Passage Flow Requirements (Hypothetical Data)

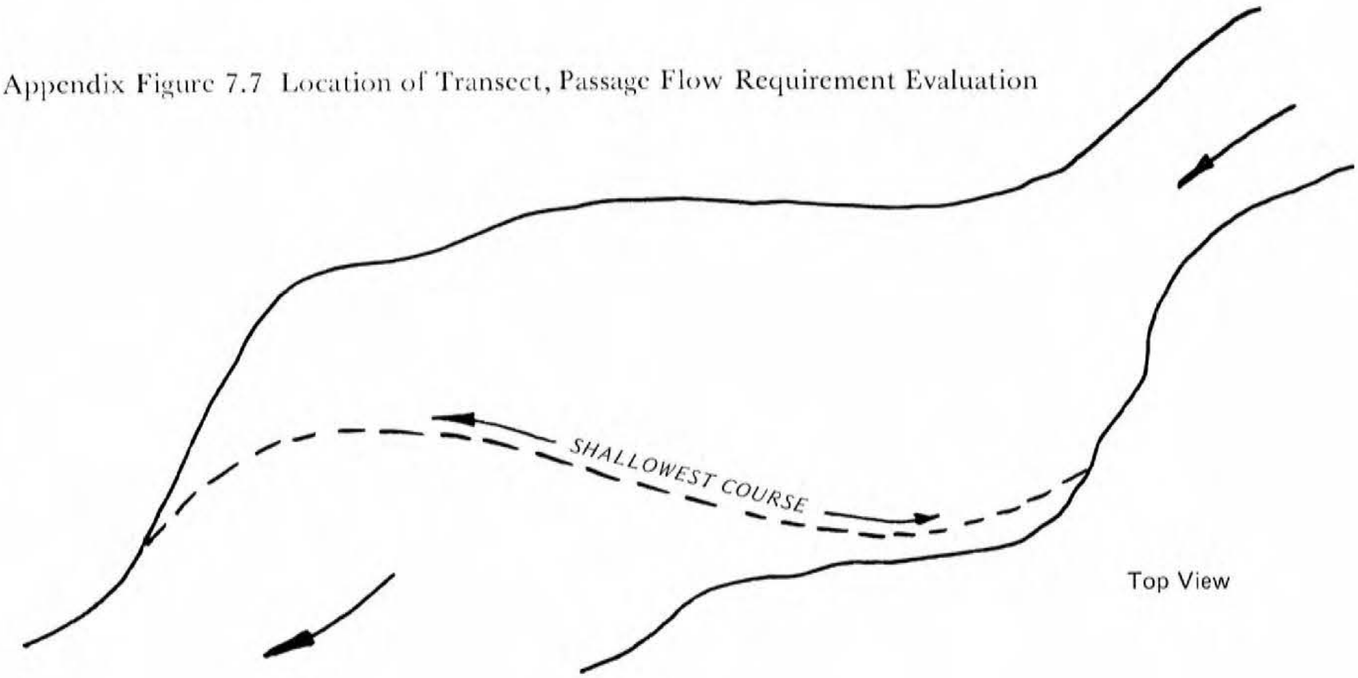
Cross-Section Width 410' (wetted width)
Percent Streambed Wetted 70 percent
Feet of Usable Gravel 240'

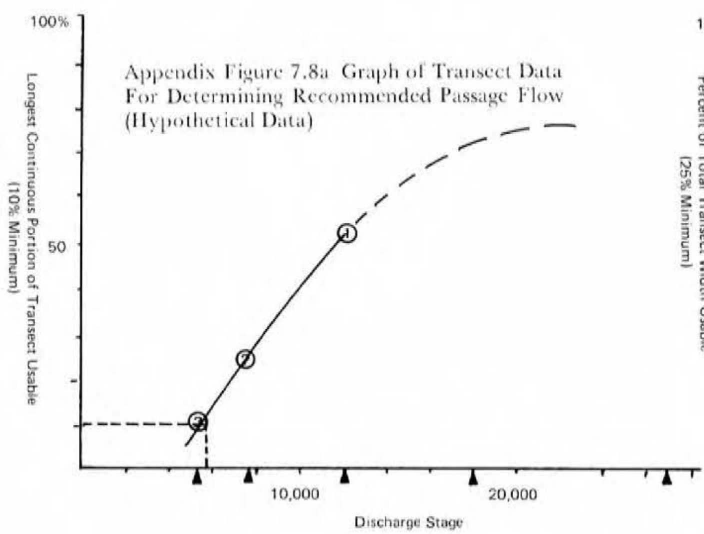
At Point		Water Depth	Velocity at .4'	Usability (See Criteria)	Remarks
From left bank	10'	0.1'	8 fps	0.8'	
	20'	0.2'	" "	"	
	30'	0.2'	"	"	
	40'	0.3'	"	"	
	50'	0.5'	"	"	
	60'	0.7'	"	"	
	70'	0.7'	"	"	
	80'	0.6'	"	"	
	90'	0.8'	"	ok	
	100'	0.9'	"	"	
	110'	0.8'	"	"	
	120'	0.7'	"	0.8'	
	130'	0.8'	"	ok	
	140'	1.0'	"	"	
	150'	1.4'	"	"	
	160'	1.3'	"	"	
	170'	1.5'	"	"	
	180'	1.6'	"	"	
	190'	1.8'	"	"	
	200'	1.9'	"	"	
	210'	1.8'	"	"	
	220'	1.7'	"	"	
	230'	1.8'	"	"	
	240'	1.6'	"	"	
	250'	1.6'	"	"	
	260'	1.4'	"	"	
	270'	1.6'	"	"	
	280'	1.5'	"	"	
	290'	1.3'	"	"	
	300'	1.3'	"	"	
	310'	1.3'	"	"	
	320'	0.9'	"	"	
	330'	0.9'	"	"	
	340'	0.7'	"	0.8'	
	350'	0.6'	"	"	
	360'	0.7'	"	"	
	370'	0.5'	"	"	
	380'	0.4'	"	"	
	390'	0.3'	"	"	
	400'	0.2'	"	"	
Right bank	410'	0.1'	"	"	

Appendix Figure 7.6 Location of Standpipe Transects on Gravel Bars, Intra-Gravel Dissolved Oxygen Analysis

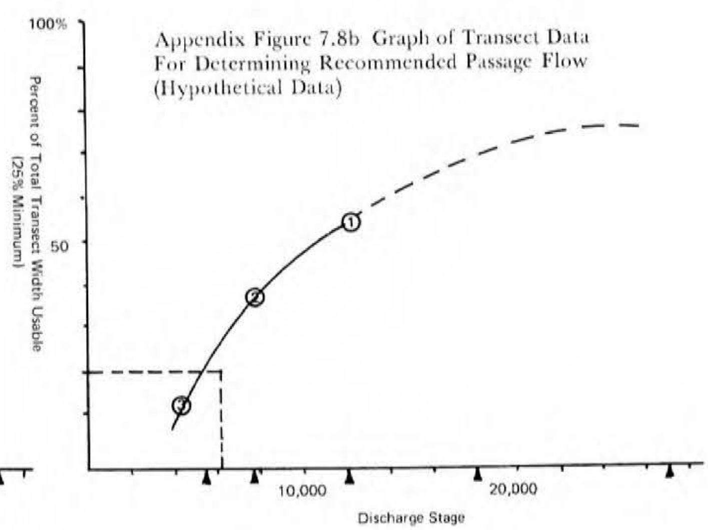


Appendix Figure 7.7 Location of Transect, Passage Flow Requirement Evaluation





Appendix Figure 7.8a Graph of Transect Data For Determining Recommended Passage Flow (Hypothetical Data)



Appendix Figure 7.8b Graph of Transect Data For Determining Recommended Passage Flow (Hypothetical Data)

10. Pour a small amount of water from sampling bottle to allow enough space for adding reagents.

11. Add $MnSO_4$ to water sample. Tap neck of sampling bottle with glass stopper to settle reagents from surface.

12. Add alkaline iodide-sodium azide. Replace glass stopper in water sample bottle with a quick twist. Tilt bottle slightly.

13. Shake sample bottle 5-10 seconds to dissolve chemicals.

14. Set bottle down to allow floc to settle halfway (if floc does not settle, allow 2 minutes to insure the process to reliably continue).

15. Add H_2SO_4 (after adding H_2SO_4, water sample is considered "fixed" and can be allowed to stand as long as desirable before titrating).

16. So that each drop PAO equals ½ part per million, place two cylinders full of water sample into titration container.

17. Add two drops of starch indicator to titration container with sample and mix.

18. Withdraw eye dropper filled with PAO and discard first drop.

19. Commence titrating with PAO, adding one drop at a time to water sample in titration container. Be sure to swirl water sample after each drop of PAO is added, especially near end point. End point is reached when water color returns to that of the water sample before any reagents were added.

20. Rinse all glassware in river water.

21. A subsequent water sample may be drawn from standpipe within 10-15 minutes.

22. Monitor each standpipe daily (at same time of day) as long as water sample can be drawn from standpipe. When water sample can no longer be drawn from standpipe, note the day, and pull the standpipe for use elsewhere to supplement subsequent measurements.

23. Reinforcing rods can be removed from standpipe after surface depth drops below 1.0'. This will enable the use of the bracing for standpipes subsequently established.

Passage

River flows to enable physical movement of adult salmonids through Hell's Canyon reach of Snake River are recommended as conclusions in this report. These flows will enable passage through the most critical reaches of river when anadromous fish are actively migrating in Hell's Canyon. Because the lowermost controlled flow of 5,000 cfs did not present critical passage flow conditions in the river, the two techniques prepared for the study were not employed.

The transect technique involves the analysis of stream width suitable for passage on a linear transect. Transect measurements of flow depth are taken along the shallowest course of a riffle extending from bank to bank *(Appendix Figure 7.7)*. From measurements obtained at several different flow levels, data can be graphed to project passage conditions at a range of flows *(Appendix Table 7.6, Appendix Figures 7.8a and 7.8b)*. A minimum flow recommended for passage has conventionally been one which creates a continuous portion of the transect representing 10 percent of its total width and which provides at least 25 percent of the total transect width suitable for passage of adult salmonids. To assure fish passage through all critical areas, the recommended passage flow is one which would provide passage through the most critical transects. The flow also is one which should provide passage over such obstructions as falls and cascades, which may require more water for fish to pass.

Flow criteria to have been employed on the Snake River were a minimum depth of 0.8 foot and maximum sustained velocity through a riffle of 8 feet per second.

A second technique readied for application during the Hell's Canyon Controlled Flow Study was a more subjective evaluation based on observations at different flow levels. As time and conditions permitted, biologists were instructed to note and estimate flows which would have provided passage conditions necessary to meet minimum passage criteria. A series of such observations at different flow levels, both above and below an adequate passage flow can substantially reveal the flow required to meet minimum flow conditions necessary for passage. By applying such observations at the lowermost controlled flow of 5,000 cfs, an appropriate passage flow was estimated.

Rearing

Several procedures were employed to evaluate flows required for salmonid rearing in Snake River. Data obtained from depth and velocity transects, systematic sampling of stranding mortality, time of travel studies conducted with fluorescent dye, and data obtained from the study of benthic organisms and the effects of reduced flows were all used to help formulate recommended flows for rearing. Flows required to provide adequate food, living space, shelter, and water quality for fish life were determined from these several allied studies. Chapters 2, 4, 5, 6, and 10 describe the phases of the Middle Snake River study which provided insight into flow requirements for salmonid rearing.

Effects of River Fluctuations

Hydroelectric power peaking in Hell's Canyon has some adverse effects on salmonids. Diurnal fluctuations of the river of one foot or more are not uncommon. Continued and increased fluctuation of river flows consititue a potential threat to aquatic life. Excessive fluctuations can dewater fish redds, strand fish, interrupt aquatic insect production on vast areas of the river bottom, displace rearing fish and interfere with their rearing requirements as they relate to territorialism, and promote irregularities in water quality which may be detrimental to fish life.

Several investigations were reviewed to evaluate the effects of flow fluctuations: egg dewatering and fish stranding mortality evaluations, fish redds (nests) and spawning gravel relationships with discharge, flow transition monitoring, and the studies on benthic insects and aquatic vegetation.

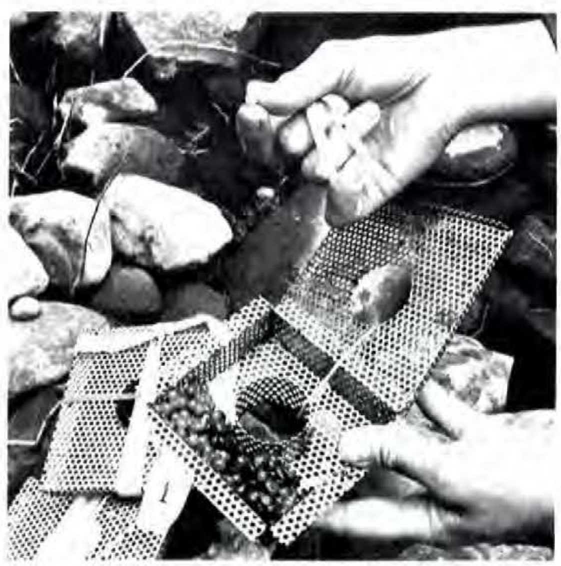


Photo by Tony Whyte, Vancouver *Columbian*

Plate 7.3 Salmonid egg dewatering evaluation.

Salmonid egg mortality data collected during the study are substantially inconclusive. Other fisheries research, however, has shown significant and immediate effects on salmonid egg viability when subjected to low dissolved oxygen levels. The procedure used during the Hell's Canyon Controlled Flow Study involved the use of eyed summer steelhead eggs acquired from a hatchery and stainless steel containers *(Appendix Plate 7.3)*. Twenty containers, each containing 100 steelhead eggs and pea-sized gravel, were buried at 2 separate locations in the 107.7 mile study reach. Five baskets each containing 100 eggs were deployed in a like manner in Asotin Creek, a tributary of Snake River at Asotin, Washington, as controls for the evaluation. Eggs were buried in the gravel at each study plot to simulate fish redd conditions. The experimental redds were dewatered after the first day. Two baskets were recovered each day thereafter to determine the accumulative mortality over the study period. Although difficulties were encountered in this particular evaluation, it was obvious that after a relatively brief period of dewatering, the summer steelhead eggs displayed significant mortality.

The systematic sampling of stranded fish following each stage of dewatering and the evaluation of flow transitions are explained in more detail in Chapter 10. The effects of flow fluctuations on and relationship of discharge to benthic insects and aquatic vegetation are discussed in Chapters 5 and 4 respectively.

CHAPTER 8

WARM WATER FISHES

Terry Holubetz
Idaho Fish and Game Department

The objective of this portion of the study is to determine the changes in the spiny-ray fish habitat of the Hell's Canyon controlled flow study area as the flow was varied from 27,000 cfs to 5,000 cfs. Because of the complexity of the habitat parameter, finite measurements were deemed infeasible. The findings of this chapter rely heavily on the ability of the author to interpret observations of the changing habitat.

Unlike most of the chapters in the report, this chapter is solely based on observations and interpretation of the observations by the author.

Methods

At each flow stage, the author made low-level aerial observations of Snake River from Hell's Canyon Dam to Asotin in a helicopter. Photographs of key spiny-ray fish habitat were obtained at all flow stages. Changes in the habitat were noted on a tape recorder at the end of each day.

The Corps of Engineers obtained complete sets of high-level aerial photographs of the Snake River at the 12,000 cfs, 7,700 cfs, and 5,000 cfs flow stages. Both high-level and low-level aerial photographs were studied thoroughly and habitat changes were noted *(Plate 8.1)*.

Photo by Milt Williams, Idaho Fish & Game Dept.
Plate 8.1 Experienced fishery biologist examines aerial photos for changes in warm water fish habitat.

Stranding of spiny-ray fish was studied by landing the helicopter and closely inspecting potential stranding sites.

Results and Discussion

The quality of spiny-ray fish habitat in the study reach generally improves as flows are reduced from 27,000 cfs to 5,000 cfs. A higher percentage of the river becomes suitable living space for spiny-ray fish as flows are reduced. This relationship is also true for undesirable species such as carp, squawfish, and suckers. Food production areas for all species of fish are reduced as flows decline from 27,000 cfs to 5,000 cfs. Competition for a limited supply of food between spiny-ray fish and other fishes intensifies as flows are reduced. In the present range, increased solar heating of waters at the lower flows would enhance the spiny-ray fish habitat.

The quantity of spiny-ray fish habitat increased as flows are reduced from 27,000 cfs to 12,000 cfs; as much of the river is changed from a high velocity area to a low velocity area. In this range of flows, the major portion of the areas dewatered are high velocity areas that are important as food production areas but do not provide living space for spiny-ray fish.

As flows are reduced from 12,000 cfs to 7,700 cfs, a higher percentage of the dewatered areas are spiny-ray habitat *(Plate 8.2 and 8.3).* Considerable stranding of spiny-ray species would occur with flow reductions in this range. The loss of habitat through dewatering appears to balance with the increase in habitat resulting from reduced velocities in the 7,700 cfs to 12,000 cfs range. The stream resource maintenance flow for spiny-ray fishes is believed to be in the 7,700 cfs to 12,000 cfs range.

As flows are reduced below 7,700 cfs, the amount of living space and food production area is reduced for spiny-ray fish. Stranding of these species would be severe with sudden flow reductions in this range of flows during the summer months.

Competition for a limited food supply and living space would tend to depress spiny-ray fisheries if flows were sustained at a stage below 7,700 cfs for an extended period of time (more than 30 days). A gradual reduction to flows below 7,700 cfs for a short period of time (less than 30 days) probably would not affect spiny-ray fish production if the reduction were not done during the spawning season. Any flow reduction during the spawning season of smallmouth bass affects the production of juveniles of this species. Angler success rates for spiny-ray fish increase as flows decrease.

Photo by Terry Holubetz, Idaho Fish & Game

Plate 8.2 Little Bar Rapids (RM 225.0) at 12,000 cfs.

The crappie fishery in the Snake River appears to be entirely dependent upon the amount of spill at the upstream projects. Crappie are not believed to be self-sustaining in the study reach. Fluctuating river stages in the Snake River benefit the spiny-ray fishery if the timing of the fluctuations are natural and not extreme. Unnatural fluctuations caused by daily and weekly peaking are believed to be far more damaging to the spiny-ray fishery than the present pattern of seasonal peaking.

Spiny-ray fish habitat does not appear to be the critical resource in the determination of a stream resource maintenance flow requirement for the study reach during a major portion of the year.

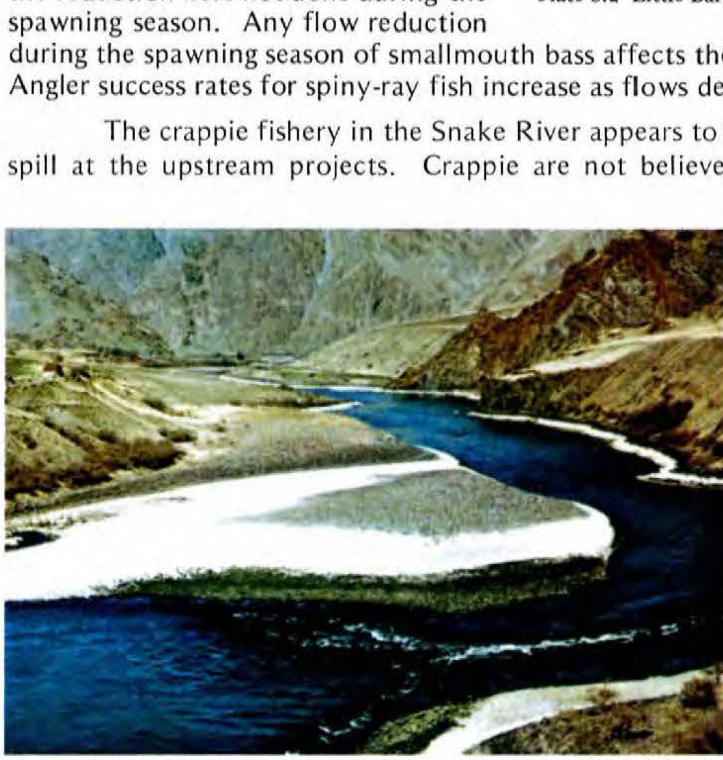


Photo by T. Holubetz, IF & G

Plate 8.3 Little Bar Rapids at 7,700 cfs.

CHAPTER 9

STURGEON FISHING

Rudy R. Ringe and John Coon

The University of Idaho is currently involved in a three year study (1972-1975) under the direction of Ted Bjornn, Cooperative Fishery Unit, College of Forestry, to determine effects of water development schemes on white sturgeon *(Acipenser transmontanus)*.

The objectives of this study are as follows:

1. Estimate abundance and age structure.
2. Assess mortality and growth rate.
3. Determine food habits.
4. Assess daily and seasonal movements.
5. Determine spawning habits.

Our objective for the Hell's Canyon Controlled Flow Study was to continue capturing and tagging sturgeon and supplying the information gained during this week to the Instream Flow Study. This chapter reports the results of our work with sturgeon during the Instream Flow Study.

Photo by T. Whyte, Columbian

Plate 9.1 Large hooks for large sturgeon.

Methods

A seven-man team, divided into 3 crews, fished three holes where sturgeon had previously been caught; the Oregon Hole (R M 238.1), Willow Creek Hole (RM 227.5), and the High Mountain Sheep Dam Site Hole (RM 188.9).

Two men with a six-man rubber raft equipped with a 9 h.p. outboard motor were transported to the Oregon Hole by Oregon Game Commission jet boat. They camped in tents and fished March 19-25 at this location. Three men with a 22 ft. jet boat fished the Willow Creek Hole and surrounding vicinity March 20-25 while using Sand Creek Camp as a base. Due to boat motor trouble, we relied on Dwight Kilgore with the Idaho Fish and Game jet boat to supply transportation from March 20 till March 26 from a camp at the mouth of the Salmon River.

Sturgeon were captured by sport fishing by rod and reel *(Plate 9.1)* and by the use of set lines *(Plate 9.2)*. The set lines were fished day and night and removed only long enough to record data on fish caught, rebait the line, and return it to the water. In some cases when no fish were caught in marginal holes some set lines were moved to another hole. The 5 set lines used were each approximately 100 feet in length (5/16-3/8 inch nylon rope) with from 10 to 16 dropper lines (500 lb. test parachute cord) attached to the main line at 6 foot intervals. The main line was weighted with 3-5 ounces of pencil lead at each dropper. Single hooks were used (size 12/0, 13/0, or 14/0) at the end of the dropper lines. The set line was weighted at the distal end with a rock (approximately 8-10 pounds), then stretched across the hole and weighted at the nearshore dropper with a second rock and then an appropriate length lead was tied from the set line to rocks or trees on shore. Rubber bumpers were placed on the main line at 3-hook intervals to absorb the shock and prevent damage to the fish. An inner tube was used as a shock absorber at the shore lead. Set lines were baited with smelt, lamprey and parts of dead fish caught during the study. Rod and reel bait included the same bait as set lines, but worms were the predominant bait.


Photo by T. Whyte, Columbian
Plate 9.2 Set lines being checked by sturgeon crew.

Captured fish were tagged with a plastic anchor tag *(Plate 9.4)* in the dorsal fin, measured for girth behind pectoral fins and in front of pelvic fins, measured for total length, and weighed with spring scales *(Plate 9.2)*. A section was clipped from the leading ray of the left pectoral fin to be used for growth and aging purposes. No attempt was made to ascertain food habits because no fish were killed during the study and a suitable method of stomach pumping has not yet been developed.


Photo by John Coon, University of Idaho
Plate 9.3 Sturgeon crew weighing giant white sturgeon captured on set line at Willow Creek Hole (RM 227.5).

It was intended to place a radio tag in a sturgeon in the Willow Creek area to monitor its movement during the flow reductions, but a suitable radio tag was not developed in time.

Scuba dives were made in the Willow Creek Hole and near the mouth of the Salmon River at 5,000 cfs, but visibility was so poor that no sturgeon were seen. The dye release contributed to excess turbidity at the Willow Creek Hole.

A net, 30 feet deep by 60 feet long, was pulled through Willow Creek Hole several times, but no sturgeon were captured. Lack of boat maneuverability while dragging the seine and insufficient length of net to give a good bag were believed to be the primary reasons why no fish were captured.

Results

The results of set line and rod and reel fishing are shown in *Tables 9.1 and 9.2* respectively. Age, length, and weight data analyzed to date are shown in *Table 9.3 and Figure 9.1*. A total of 9 fish were captured on set lines, one of which was previously tagged September 30, 1972. Sixty-eight fish were caught by rod and reel fishing with 3 recaptures. The size range from the set line fishing was from 24.2 inches to 98.1 inches. Only two of the 9 fish caught on set lines were under 78 inches long, while the largest fish caught by rod and reel was 34.8 inches *(Plate 9.5)*. The Willow Creek Hole produced the most fish, which is consistent with past records (continued samplings of this hole through the summer of 1973 has yielded a population estimate of 275 sturgeon between the lengths of 20 and

Table 9.1 Set Line Sturgeon Fishing Effort and Results During Instream Flow Study

Date (March, 1973)	Flow (cfs)	Time (MST)	Total Hours	Location	River Mile	Catch	Length Range (Inches)	No. Recaptures
20-22	27-18,000	1715-1015	40	Mouth of Salmon	188.2	0	-	-
20-21	27,000	1620-0930	17.20	H.M.S. Dam site	188.9	1	88.2	-
20-21	27,000	1900-1000	15	Willow Creek	227.5	0	-	-
20-21	27,000	1915-1015	15	Willow Creek	227.5	0	-	-
20-21	27,000	1800-0900	15	Oregon Hole	238.1	2	24.2 & 98	-
21-22	27-18,000	1000-0915	23.75	H.M.S. Dam site	188.9	0	-	-
21-22	27-18,000	1130-0930	22	Alum Range	226.5	0	-	-
21-22	18,000	1830-1000	15.5	Willow Creek	227.5	0	-	-
21-22	18,000	1800-0900	15	Oregon Hole	238.1	1	89.8	-
22-23	18-12,000	1045-1000	23.25	N.P. Dam site	186.2	1	26.0	-
22-23	18-12,000	1000-1000	24	H.M.S. Dam site	188.9	0	-	-
22-23	12,000	1830-1030	16	Willow Creek	227.5	0	-	-
22-23	12,000	1845-1100	16.25	Willow Creek	227.5	1	94.9	1 †
22-23	18-12,000	0900-1000	26	Sand Creek*	228.0	0	-	-
22-23	12,000	1800-0930	15.5	Oregon Hole	238.1	0	-	-
23-24	12- 7,000	1000-0930	23.5	N.P. Dam site	186.2	0	-	-
23-24	12- 7,000	1030-1000	23.5	H.M.S. Dam site	188.0	1	88.2	-
23-24	7,000	1930-0930	14.5	Willow Creek	227.5	0	-	-
23-24	7,000	1945-1000	14.25	Willow Creek	227.5	0	-	-
23-25	7-5-12,000	1830-1500	44.5	Oregon Hole	238.1	2	89.0	-
24-25	7-5,000	1030-1030	24.0	H.M.S. Dam site	188.9	0	-	-
24-25	7-5,000	0930-1630	31	N.P. Dam site	186.2	0	-	-
25	5,000	1100-1600	5	H.M.S. Dam Site	188.9			

* This was a 7-hook set line using 8/0 hooks.
† Recapture from September 30, 1972.

Table 9.2 Rod and Reel Sturgeon Fishing Efforts and Results During Instream Flow Study

Date (March, 1973)	Flow (cfs)	Time (MST)	Total Hours	Number Poles	Location	River Mile	Catch	Length Range (Inches)	No. Recaptures
20	27,000	1220-1240	0.3	2	Joseph Gage	192.3	0	-	-
20	27,000	1300-1330	0.5	4	HMS Dam S	188.9	0	-	-
20	27,000	1335-1350	.25	2	M of Salmon	188.2	0	-	-
20	27,000	1200-1845	6.75	3	Willow Cr.	227.5	12	21.3-28.1	-
21	27,000	1330-1430	1.0	3	M of Salmon	188.2	0	-	-
21	27,000	1445-1600	1.25	3	NP Dam S.	186.2	1	25	-
21	27,000	1730-1900	1.5	2	M of Salmon	188.2	0	-	-
21	27-18,000	1230-1900	6.5	3	Willow Cr.	227.5	16	21.5-34.3	-
22	18,000	0915-1030	1.25	3	HMS Dam S	188.9	0	-	-
22	18,000	1220-1310	0.8	4	Cottonwood	180.8	1	27.0	-
22	18,000	1415-1600	1.75	5	NP Dam S.	186.2	0	-	-
22	18-12,000	1800-0800	14.0	2	M of Salmon	188.2	0	-	-
22	18-12,000	1030-1900	8.5	3	Willow Cr.	227.5	16	22.0-28.7	-
23	12,000	1030-1230	2.0	4	NP Dam S.	186.2	0	-	-
23	12,000	1035-1225	1.8	1	M of Salmon	188.2	0	-	-
23	12,000	1430-1540	1.2	3	Divide Cr.	193.2	0	-	-
23	12,000	1740-1900	1.3	2	M of Salmon	188.2	2	21.3-26.0	-
23	12- 7,000	1100-1900	8.0	3	Willow Cr.	227.5	17	22.4-28.7	-
24	7,000	1300-1630	3.5	3	Divide Cr.	193.2	0	-	-
24	7,000	1700-1800	1.0	2	M of Salmon	188.2	0	-	-
24	7,000	1100-1215	1.25	3	Willow Cr.	227.5	0	-	-
24	7-5,000	1300-1500	2.0	2	Hat Creek	235.7	1	25.2	-
25	5,000	0930-1030	1.0	2	HMS Dam S	188.9	0	-	-

Table 9.3 Ages, Lengths and Weights of 39 Sturgeon (All Fin Rays Not Yet Processed).

Age (Years)	No. Fish	Length Ranges Inches	Average Length Inches	Weight Range Pounds	Average Weight Pounds
3	1		20.5		1.5
4	4	21.3-26.3	23.5	1.3-2.4	1.9
5	5	23.5-25.8	25.1	1.9-2.9	2.4
6	3	23.8-27.0	25.1	2.1-2.65	2.3
7	4	25.3-28.8	26.6	2.2-3.1	2.7
8	5	25.0-28.5	27.0	2.5-3.7	3.0
9	2	28.8-31.3	30.0	2.6-3.6	3.1
10	2	30.0-34.8	32.4	3.4-6.8	5.1
11	2	28.8-29.8	29.3	3.6-4.7	4.2
12	2	35.0-40.3	37.6	6.3-8.9	7.6
19	2	45.0-45.0	45.0	14.8-21.0	17.9
20	1	-	85.8	-	128.0
21	1	-	85.5	-	155.0
22	1	-	88.0	-	164.0
24	1	-	90.0	-	Unknown
25	1	-	88.5	-	149.0
28	1	-	91.0	-	164.0
31	1	-	94.0	-	184.0

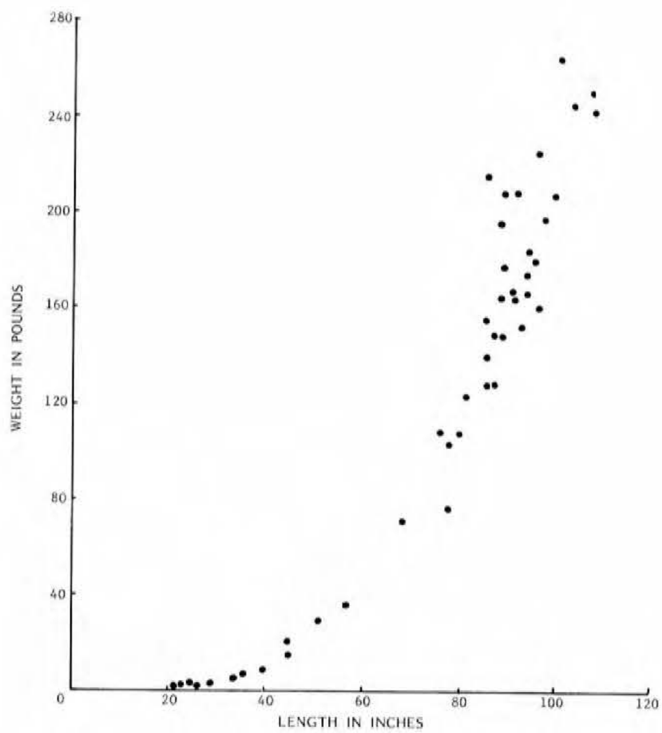


Figure 9.1 Lengths, and Weights of All Fish Caught to Date. Data Under 27 Inches Pooled.

90 inches). Day to day fishing effort was not always totally consistent because of transportation or other scheduling problems.

On the 23rd of March, the set line at Oregon Hole (RM 238.1) could not be pulled by the rubber raft and 9 h.p. motor. When finally pulled by the Oregon Game Commission jet boat on March 25, the line contained two 7½ foot long sturgeon and a sunken tree that was considerably longer! One set line recovered at Nez Perce Damsite (RM 186.2) had a 500 lb. strength dropper line pulled apart, presumably by a large sturgeon as the line was tangled, sometime during the night.

Photo by K. Bayha, BSF&W

Plate 9.4 Tags were placed in dorsal fin for future identification of recaptured fish.

There appeared to be no difference in fishing success at different flow levels. However, the number of fish caught was not sufficient to test significance of this relationship. No recaptured fish had moved from the hole of its first capture.

CONCLUSIONS

The main effect of flow changes in the Snake River on sturgeon is probably the influence on their food chain. Detrimental conditions for the growth and reproduction of such food items as clams, mussels, lamprey larvae, insects, crayfish, and sculpins could affect the sturgeon. (See Chapters 5, 6, and 10.)

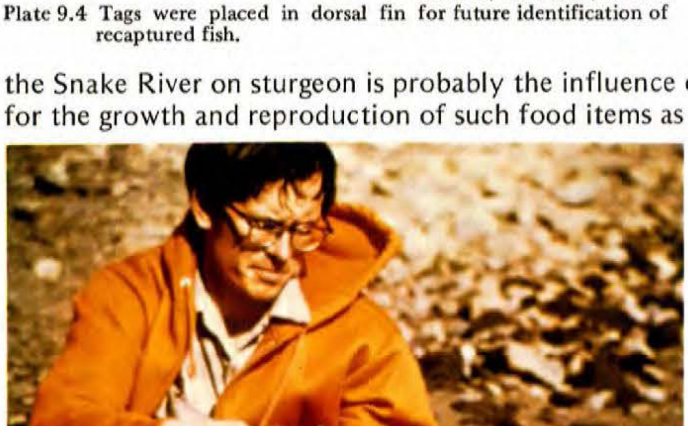


Photo by Don Pullum, U. S. Army

Plate 9.5 All sturgeon caught by rod and reel were less than 35 inches in length.

Many of the areas were harder to fish at higher flows because the lines were swept out of the holes and set lines were tangled by back eddies and high velocities. However, fishing success did not seem to be altered by level or change of river flow. Another influence of changes in river flow would be access to the river by sturgeon fishermen which is covered in Chapter 14-Navigation.

The age and growth data for white sturgeon in the Middle Snake *(Table 9.3 and Figure 9.1)*, appear to be similar to that found for white sturgeon in the San Pablo Bay of California (Pycha, 1956) and the Fraser River of British Columbia (Semakula and Larkin, 1968). As might be expected in the case of such long living fish, all three populations show a great deal of variability among individuals. An exact and valid comparison of these three sturgeon populations will require a considerable refinement and/or amplification of the existing data for all three. To help evaluate environmental effects on sturgeon growth, it is hoped to obtain such a comparison as part of the presently continuing sturgeon study.

ACKNOWLEDGMENTS

The authors acknowledge the assistance of the following University of Idaho graduate students who participated in the field effort: Geoff Hogander, Tom Hallbuck, Dave Hanson, Jim Athearn, and Rick Stowell. Dwight Kilgore, Idaho Fish and Game Department, provided boat support for the crew based at the Salmon River Camp.

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CHAPTER 10

FISH STRANDING SURVEYS

Ken Witty and Ken Thompson
Oregon State Game Commission

OBJECTIVE

The purpose of conducting fish stranding surveys during the Hell's Canyon Controlled Flow Study was to evaluate occurrence of fish stranding and redd dewatering during periods of rapid water flow decrease in the Snake River below Hell's Canyon Dam.

Since construction of three dams in the Middle Snake River, fish of all species have been observed stranded on gravel bars and in isolated pools by biologists, boaters and anglers during periods of rapidly declining water flows. Decreased flows also have occurred in periods following fish spawning. Consequently, fish redds are dewatered for varying periods of time.

Fish stranding and redd dewatering is caused by water manipulations at Hell's Canyon Dam. Within provisions of the Federal Power Commission license for Idaho Power Company to operate three dams on the Middle Snake River, Article 43 states in part: "The minimum plant operation will be 5,000 cfs at Johnson's Bar, at which point the maximum variation in river stage will not exceed one foot per hour." Prior to dam construction on the Middle Snake River, minimum flows of 5,000 cfs and water fluctuations of one foot per hour were not common.

The Hell's Canyon Controlled Flow Study gave fish biologists an opportunity to evaluate fish stranding during periods of rapid flow decrease below Hell's Canyon Dam. Fall chinook redds were examined, and tests were conducted with steelhead eggs to evaluate impacts of dewatering. This chapter reports on fish stranding surveys and fall chinook redd examinations. Impact of dewatering fish eggs in the gravel is discussed in Chapter 7.

Photo by C. Koski, NMFS

Plate 10.1 Johnson Bar Gage, 18 miles downstream from Hell's Canyon, is monitoring point for rate of flow change.

METHODS

As part of the designed controlled flow study, the water flow at Hell's Canyon Dam was reduced as quickly as physically possible at 12:00 noon M.S.T. on March 21, 22, 23, and 24 from 27,000 to 18,000; 12,000; 7,700; and 5,000 cfs, respectively.

Staff gage readings, for the purpose of this chapter, were made at Saddle Creek and at Johnson Bar. The Saddle Creek gage was a temporary gage installed for the purpose of the study and was readjusted each day for each flow transition[1]. The Johnson Bar gage is a permanent U.S. Geological

[1] Flow transition and stage wave: A phenomenon of pressure changes resulting from an increase or decrease in discharge which results in a translatory wave which moves through water at a greater velocity than that of the water particles.

Survey gaging station *(Plate 10.1)*.

Fish biologists working on the salmonid study recorded the occurrence of fish stranding and examined exposed salmon redds at Saddle Creek (RM 236.0), near Pittsburg Landing (RM 219.9 and 213.8), and above Lewiston (RM 149.5). The total area surveyed at each flow transition was 1,780 linear yards.

RESULTS

Figure 10.1 depicts the gage readings at Saddle Creek, and *Figure 10.2* depicts readings at the Johnson Bar gaging station during each water flow transition period. Note in the figures that the water flow transition period extends over a greater period of time as the flows decrease.

At Saddle Creek, the flow transition exceeded one foot per hour, but the mean flow transition during the study was a drop in water level of 0.85 feet per hour. The maximum flow transition at Johnson Bar was 0.90 feet per hour which occurred during the first hour of fluctuation at the water flow transition of 27,000 to 18,000 cfs. Neither the water flow transition nor the minimum flow requirement stipulated by Federal Power Commission license was violated during the study. Consequently, fish stranding and redd dewatering observed during the study could have occurred within the quidelines of the Federal Power Commission license.

Figure 10.3A depicts the total number (N) of fish that were observed stranded during the various flow changes. *Figures 10.3B, 10.3C and 10.3D* show, by fish classification, numbers of fish stranded during the four stage-wave discharge periods. These data show that while the reduction from 12,000 to 7,700 cfs most severely affected warm water game fish and non-game fish, the salmonids were initially impacted during the 18,000 to 12,000 cfs reduction. *Plates 10.2 and 10.3* show examples of stranding which occurred during the reduction from 12,000 to 7,700 cfs.

Eight chinook redds were examined, all of which were exposed between flows of 18,000 cfs and 7,700 cfs with most the exposure occurring between the 12,000 and 7,700 cfs flows. *Plate 10.4* shows fall chinook redds being exposed at 7,700 cfs. All redds examined contained fall chinook sac fry *(Plate 10.5)*. This is not to say that all chinook fry perished. *Plate 10.6* shows other redds still wetted at 5,000 cfs.

CONCLUSIONS

Fish stranding and redd exposure does occur in the Snake River and stranding and exposure occurs when water fluctuations and flows are maintained within requirements outlined in the Federal Power Commission license to operate dams on the Middle Snake River.

The Hell's Canyon Controlled Flow Study showed that fish stranding in the Snake River is not directly proportional to flow transitions. Fish stranding appears to be more directly related to dewatering of those zones fish are most accustomed to occupying. General observations indicated that a fish had a territory, and was reluctant to leave this location resulting in it being stranded.

Stranding losses of fish were most significant in side pool areas and on gravel bars. *Plate 10.7* shows the general type of area where fish stranding occurred. Fish stranding losses were not significant in areas where the river bank gradient was steep.

Water flows less than 18,000 cfs expose fall chinook redds. To a degree, exposure of fall chinook redds is a product of flows during spawning periods. The minimum daily flows for October

Photo by Al Smith, OGC

Plate 10.2

Photo by C. Koski, NMFS

Plate 10.3

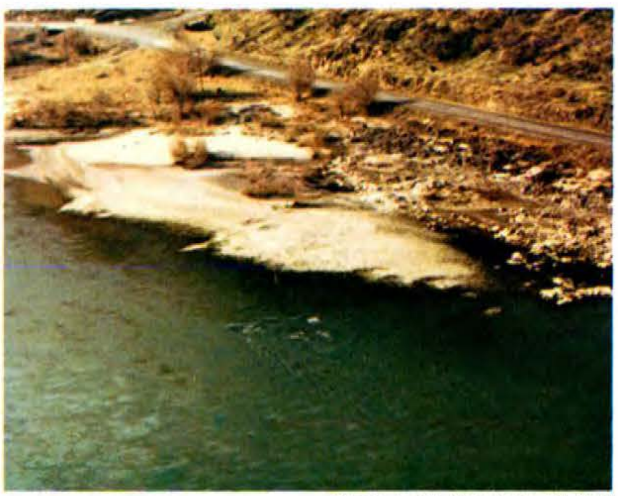


Photo by T. Holubetz, IF & G

Plate 10.4

Photo by Ken Thompson, Oregon Game Commission

Plate 10.5

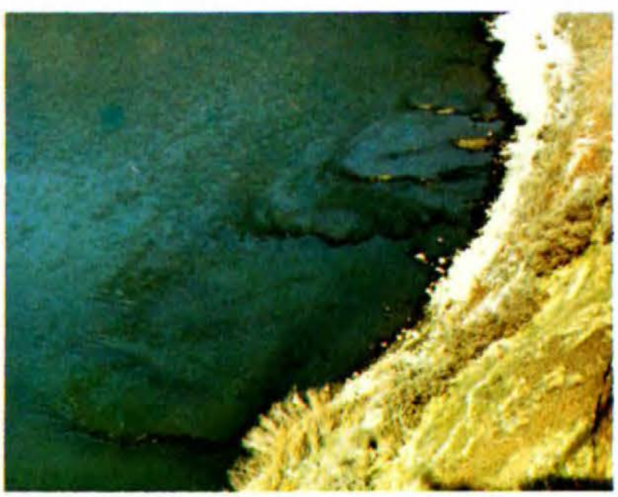


Photo by T. Holubetz, IF & G

Plate 10.6

Plate 10.2 Small mouth bass fingerlings and other small fish stranded at 7,700 cfs. (RM 149.9).

Plate 10.3 Sculpin eggs exposed by low flow conditions at 7,700 cfs (RM 228.0).

Plate 10.4 Exposed fall chinook redds at lower end of gravel bar near mouth of Couse Creek (RM 157.6).

Plate 10.5 Fall chinook sac fry stranded in exposed redd (RM 157.7).

Plate 10.6 Fall chinook redds still wetted at 5,000 cfs (RM 152.3).

Figure 10-1

Snake River Flow Transitions

Saddle Creek

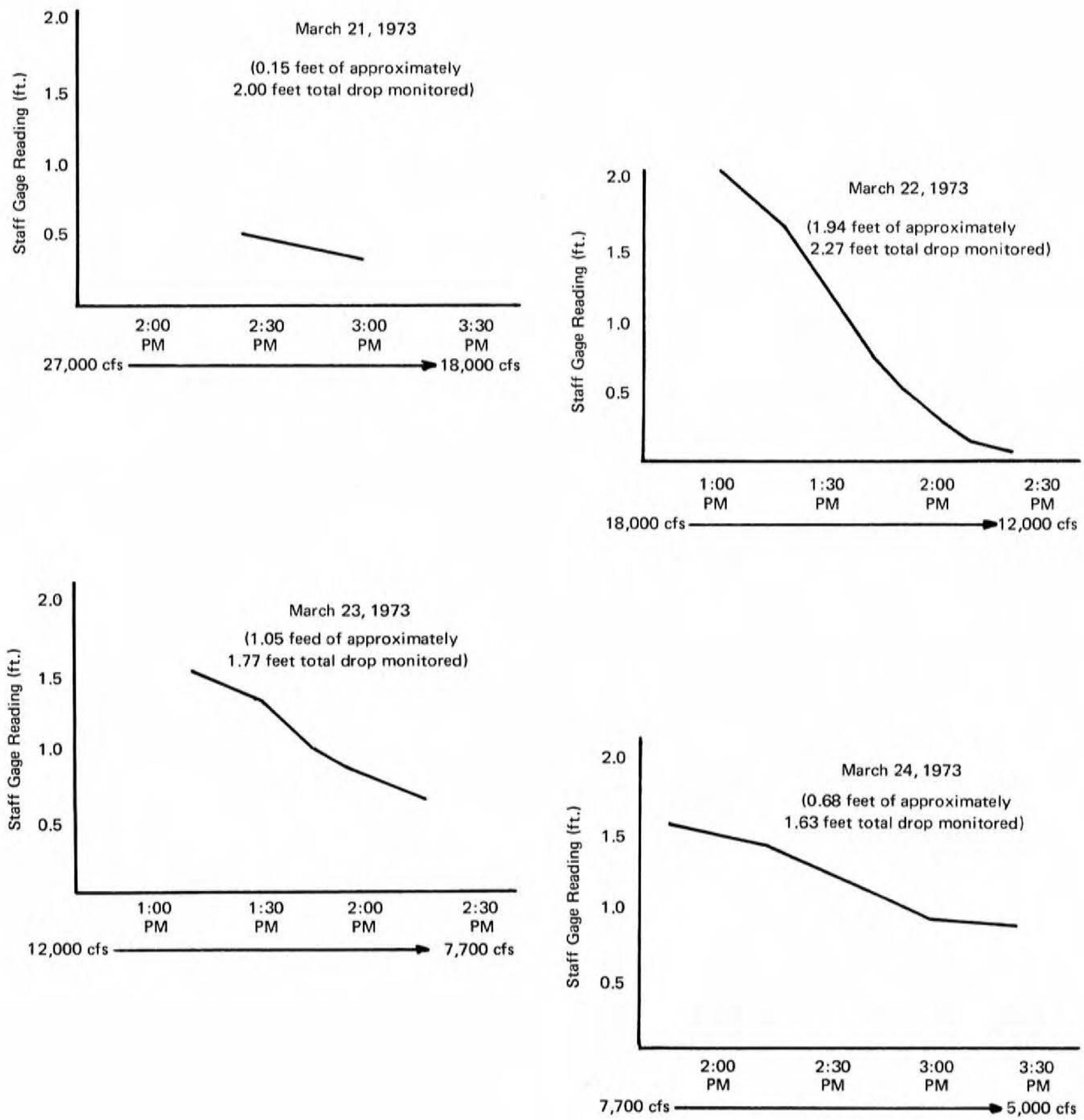


Figure 10-2

Snake River Flow Transitions

Johnson Bar

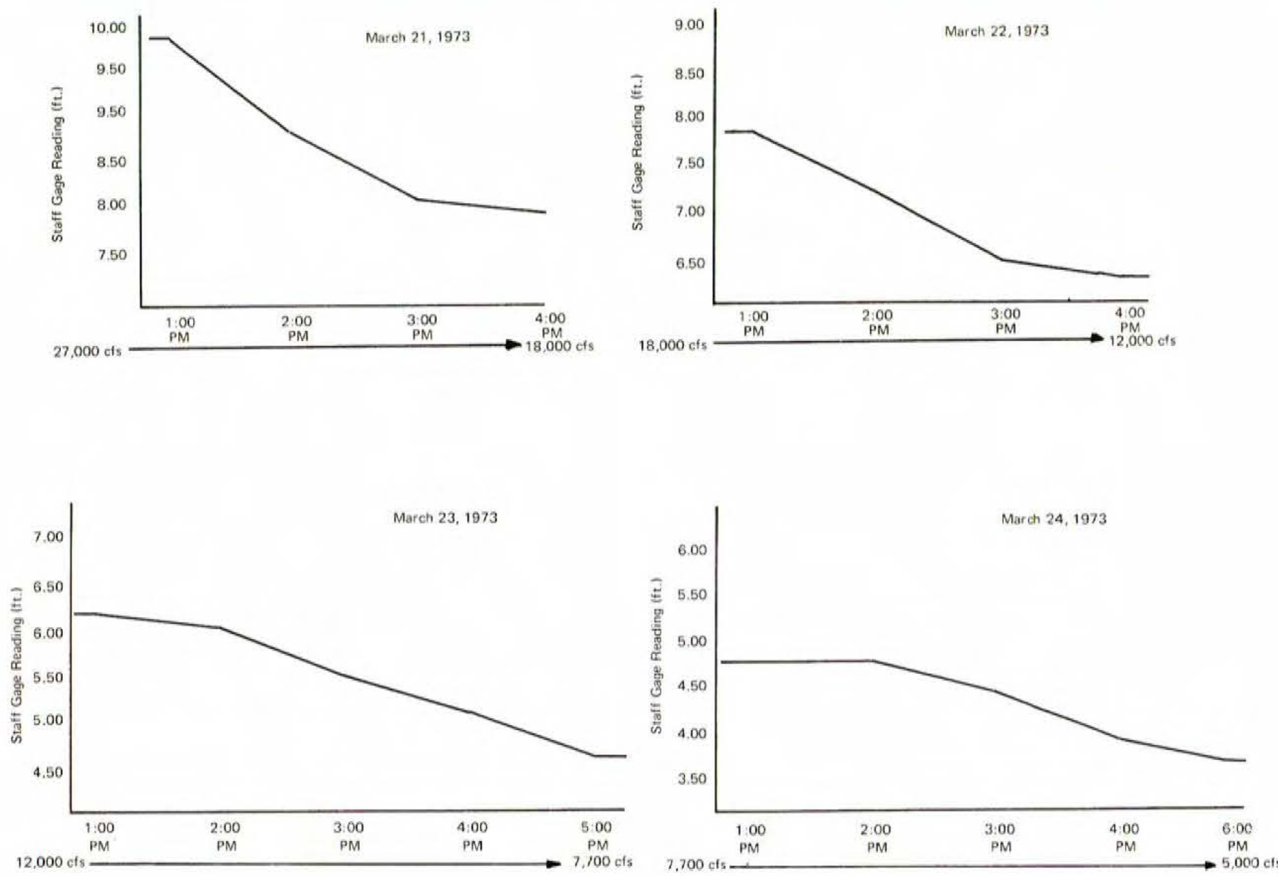
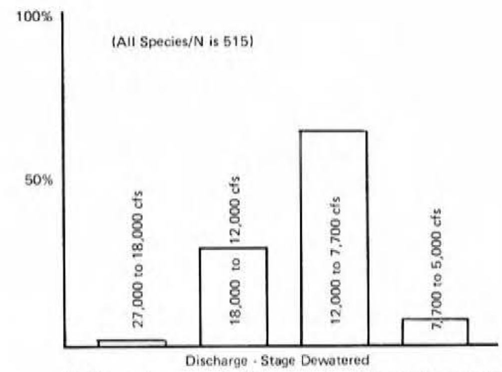
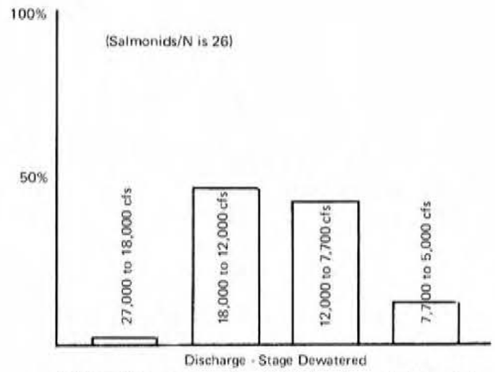


Figure 10-3
Fish Stranding

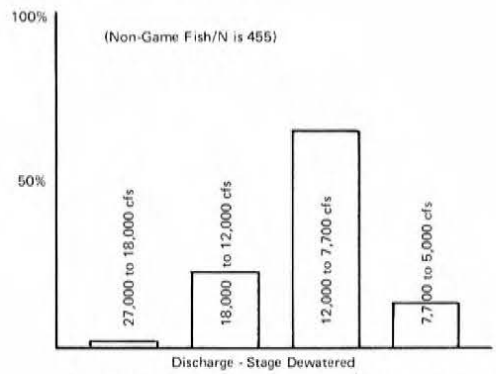
Fish Stranded - Percent of Sample



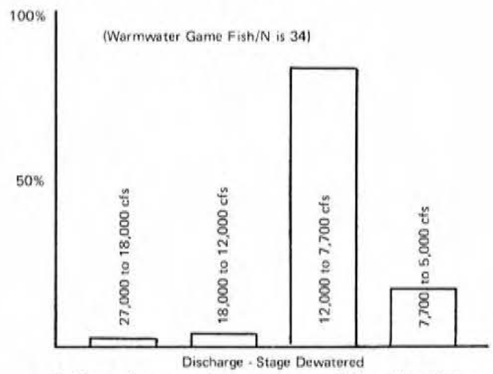
A Percent frequency of all fish species found stranded on an index unit survey for four transition flows during the Hell's Canyon Controlled Flow Study.



B Percent frequency of salmonid fish found stranded on an index unit survey for four transition flows during the Hell's Canyon Controlled Flow Study.



C Percent frequency of non-game fish found stranded on an index unit survey for four transition flows during the Hell's Canyon Controlled Flow Study.



D Percent frequency of warmwater game fish found stranded on an index unit survey for four transition flows during the Hell's Canyon Controlled Flow Study.

Table 10.1 Discharge in Cubic Feet Per Second of Snake River at Hell's Canyon Dam

Year	Level	January	February	March	April	May	June	July	August	September	October	November	December
1967	Mean	18,370	18,730	15,570	13,480	15,520	22,080	13,130	10,180	13,180	13,480	14,010	15,290
	Max.	25,800	25,100	20,800	19,300	22,100	34,600	23,100	13,400	16,100	16,500	16,600	19,900
	Min.	11,300	12,600	8,920	7,570	8,980	10,000	8,870	6,550	9,880	10,300	10,200	11,000
1968	Mean	20,240	22,290	13,760	15,120	8,077	13,490	9,837	14,140	12,570	13,590	15,500	17,990
	Max.	27,700	34,500	33,000	35,200	11,300	24,200	12,800	23,300	15,200	25,000	17,700	22,100
	Min.	18,200	15,200	9,420	10,100	4,950	6,360	7,750	9,140	9,710	7,580	10,700	13,700
1969	Mean	27,510	33,420	38,420	44,440	28,420	19,560	11,470	11,610	14,020	15,610	14,900	16,390
	Max.	36,500	46,400	50,700	54,600	43,100	31,100	17,700	14,800	17,800	19,200	17,500	19,800
	Min.	16,400	26,600	26,800	28,500	13,800	12,400	9,950	9,570	9,800	11,700	13,600	11,300
1970	Mean	26,190	31,850	20,470	21,890	30,150	34,530	17,000	11,220	15,960	15,610	14,900	16,390
	Max.	49,700	49,400	24,100	29,700	45,200	42,300	45,200	13,100	21,000	19,200	17,500	19,800
	Min.	15,900	21,100	14,900	12,500	14,800	22,200	9,600	9,960	10,700	11,700	13,600	11,300
1971	Mean	34,680	44,680	41,920	61,440	50,410	39,100	22,590	11,170	15,450	16,870	19,700	24,980
	Max.	57,800	50,100	58,300	73,700	65,400	53,000	50,400	12,800	18,000	22,300	25,700	30,300
	Min.	16,300	39,200	23,600	32,200	38,800	32,900	10,900	9,090	13,500	11,200	12,400	19,100
1972	Mean	31,250	38,940	64,110	49,840	33,960	26,370	13,040	12,730	15,510			
	Max.	45,400	46,000	73,100	65,300	48,000	45,100	21,400	16,300	18,600	27,000	28,000	28,100
	Min.	25,100	24,800	45,300	31,200	21,700	16,000	10,200	10,300	11,300	17,500	19,700	19,700

U.S.G.S. Stream Gaging Records

and November, 1972, were 17,500 and 19,700 cfs, respectively. If the minimum flows during the spawning period had been, for example, 15,000 cfs, one could conceivably expect by projecting the study findings, to find the majority of redds becoming dewatered at approximately 13,700 cfs.

Photo by T. Holubetz, IF & G

Plate 10.7 General type of area where fish stranding occurs.

However, the concept presented is valid only to a degree. Chapter 7 states optimum and minimum flows needed for fall chinook spawning are 23,425 and 15,050 cfs, respectively. Water flows less than the recommended flows will reduce the available spawning area. Also, the normal mean water flow of the Snake River would not generally result in exposing redds *(Table 10.1)*. However, minimum flows since 1967 have exposed fall chinook redds during incubation periods.

During the flow study, stranding loss of all chinook sac fry and fry was greater than anticipated. Fisheries personnel assumed that fall chinook fry had emerged from the gravel and had migrated to sea by the third week of March, but this was not the case.

In recommending water flows to avoid fish stranding in the Middle Snake River below Hell's Canyon Dam, water flow transitions below 18,000 cfs should be discouraged, and flow transitions below 12,000 cfs should be avoided at any time of year; especially during fish spawning, egg incubation, and fry emergence periods. Power peaking should be restricted to flows in excess of 18,000 cfs and preferably conducted only at the same range of flows.

Snake River flows below 18,000 cfs, and especially below 12,000 cfs, expose fall chinook redds and spawning gravels of other salmonids. Chapter 7 discusses the water flows needed for salmonid spawning, incubation and rearing. Chapter 7 also discusses the impact of dewatering of gravels on egg and fry development.

CHAPTER 11

WILDLIFE

Keith Bayha

Bureau of Sport Fisheries and Wildlife

Because the amount of streamflow does not directly affect most forms of wildlife in Hell's Canyon, there were no substantive data collected during the study. Many forms of wildlife are, however, indirectly affected by streamflow as it affects the lower trophic levels comprising the food chain. The otter, bald eagle, osprey, mergansers and goldeneyes depend on the river's productivity of fish life. Therefore, flow requirements for fish and the organisms in lower trophic levels comprising food supply would be flow requirements for these wildlife species.

Canada geese nest along the Snake River. Unlike goose populations of other river reaches, this population does not depend on island nesting sites, but utilizes secure sites along the shore. This is probably due to the fact that high flows during spring runoff scour the islands of soil and vegetation.

During the prestudy reconnaissance trip and during the course of the study, an attempt was made to survey the breeding pair population, from the air and boat. Helicopters were less effective as many times birds would not take to the air ahead of the chopper as they would the boat. *Table 11.1* lists the river mile and name of location where geese were observed, and the date of the observation. These observations are presented here simply because no previous assessment of the Canada goose breeding population has been recorded within the study reach.

Table 11.1 Goose Observations During the Hell's Canyon Controlled Flow Study.

Location	Date	Number of Birds
River mile 162.5, Taplin Ferry	2-20-73	2
River mile 169.5, above Rogersburg	2-20-73	3
River mile 172.9, Wild Goose Range	2-20-73	2
River mile 202.2, Five Pine Range	2-20-73	3
River mile 203.7, Roland Bar	2-20-73	3
River mile 214.7, Pittsburg-Wilson Ranch	2-20-73	2
River mile 215.6, Pittsburg Landing	2-20-73	10
River mile 221.5, Half Moon Bar	2-20-73	2
.... above Granite Creek	3-21-73	4
.... above Johnson Bar	3-21-73	1
.... above Johnson Bar	3-21-73	2

From these observations, it would appear the total resident goose population from Hell's Canyon Dam to Lewiston in March 1973 could have been between 30 and 40 birds, with a breeding population of about 10 pairs.

The duck population consisted primarily of American Goldeneye, American Merganser, Mallards, and a few American Widgeon.

Maintenance of riparian vegetation can be affected by river flow and stage, since the succulence and productivity of this vegetation is dependent upon the abundant water supply available to the plant roots supplied by the river. This vegetation is important to chukar partridge, mule deer, beaver, raccoon, porcupine, and other forms of terrestrial wildlife as food and cover to varying degrees at certain times of the year. However, a definite flow volume is not as important as the frequency of flow fluctuation, so long as some water is in the river.

In summary, it is felt that flows required for other life forms would be sufficient for wildlife.

(Editors Note: Information on the wildlife resource in the study reach can be found in the Fish and Wildlife Service report contained within the U.S. Department of Interior's Resource Study of the Middle Snake, April 1968.)

CHAPTER 12

RECREATION

Northwest Region
Bureau of Outdoor Recreation

INTRODUCTION

This chapter deals with the effect of different river flows on various outdoor recreation activities. Excluded from recreation activities discussed are sport fishing and whitewater boating, covered in other chapters.

The various river flows (27,000 cfs, 18,000 cfs, 12,000 cfs, 7,700 cfs, 5,000 cfs) referred to in this chapter are not the flows at any of the observation sites. The figures indicate the discharges from Hell's Canyon Dam while the actual flows at downstream study sites are greater, due to inflow from tributaries between the dam and observation sites (see Chapter 2).

OBJECTIVES

The objective of the recreation element of this study was to gather information to enable us to judge the relative effect of various flows on recreational opportunities.

No attempt was made to determine the optimum or the minimum flows for recreation. The limitations encountered in gathering data did not allow for the comprehensive results upon which to make such determinations. These limitations included the almost total reliance upon subjective evaluations by the recreation study participants, the lack of well-developed and tested methods of evaluating instream flows for recreation, and the lack of data on recreation use within the specific study area.

Photo by Jim Morris, Bureau of Outdoor Recreation

Plate 12.1 Water line was staked by recreation specialists to assist in evaluating beach profiles.

Photo by Jim Scott, Washington Department of Ecology

Plate 12.2 Beach slopes and current velocities were measured at each flow to determine suitability for water contact sports.

METHODS

Six individuals were stationed at several locations along the river. Each individual observed at least one site repeatedly at each flow. To permanently record the effects of the various flows, pictures were taken from fixed photo points (see photo appendix). The high-water line of each stabilized flow was marked with stakes driven into the beach *(Plate 12.1)*. Where equipment was available, beach slope and current velocities were measured at each flow in the pool areas *(Plate 12.2)*. Where equipment was not available, estimates were made.

Sites were selected which hopefully were representative of the stretch of river being studied.

Ideally each site also would have been a desirable recreation area. However, because of the need to ease the logistical problems of the study, some of the sites observed were not good recreation sites.

Observations of each flow's effect on pool and riffle areas, on exposed beach, on channel width, on visual and sound quality, and on navigation conditions were recorded. Based upon these observations, each planner evaluated the relative adequacy of the flows for recreation.

In order to categorize these evaluations, a modified application of the Kanawha River Basin Method developed by the Northeast Region of the Bureau of Outdoor Recreation was used.[1] These evaluations were largely subjective, specific to the study sites, and based on personal judgment. The evaluations are presented in the river rating displays contained in this chapter. It should be emphasized that the ratings expressed in the following "Kanawha" charts are not meant to be absolute expressions of the optimum, maximum, or minimum flows. The ratings represent, instead, a relative comparison of each flow's adequacy for general recreation. The individual categories and guidelines, as modified for this sutdy, for selecting each are given below:

Minimum Acceptable. The minimum acceptable flow is that flow which provides only for the most limited recreational use of the stream. Compatible streamside recreation opportunities include picnicking, camping, and sightseeing activities, and compatible instream activities include nature study and possible swimming in the pool areas.

Low Satisfactory. Low satisfactory flow is compatible with a range of both instream and streambank recreation pursuits, including camping, picnicking, and sightseeing. The most probably problem area at this flow rate would be the lack of sufficient water depth to adequately float a boat over stream riffle areas at some locations.

Optimum. Optimum flow is that flow which will maintain the unique characteristics of the stream area and will provide for an optimum combination of uses. Generally, this flow will accommodate swimming, boating, sailing, canoeing, studying nature, and streambank activities such as picnicking, camping, hiking, and sightseeing. This flow produces a visual and audible enhancement of the stream resource which is generally pleasing to the recreationist and notably adds to the quality of the recreation experience.

High Satisfactory. At the high satisfactory flow, many instream activities would be curtailed substantially, particularly swimming. All streambank recreation activities such as camping, picnicking, and sightseeing can still occur.

Maximum Acceptable. Maximum acceptable flow is assumed to be the highest rate of flow usable by the recreationist. This flow represents an upper limit beyond which further beneficial uses of the stream for recreation are severely restricted. Recreation uses of streamside lands include picnicking, camping, and sightseeing. At this flow, instream activities such as swimming, studying nature, sailing, and leisure boating are no longer acceptable. The only instream activity that may possibly occur if this flow rate is approached is whitewater boating.

It should be noted that "optimum" flow is that flow which provides for an "optimum combination of uses." The optimum combination could be defined in a number of ways. It might be the

[1] Bureau of Outdoor Recreation, Northeast Region office, "Draft Report of Kanawha River Basin Comprehensive Study." Appendix H - Outdoor Recreation, Philadelphia, Pa., May 1970, 87 pp. (unpublished).

largest variety of activities, or one or two activities which involve the largest number of recreationists, or it could be those uses or activities which are considered by the general public and/or the resource managers to be the most desirable. For the purposes of this exercise, we considered optimum flow to be that flow which allowed for the largest variety of recreation activities.

One weakness of this system is that each individual planner may have a different opinion of the same flow condition. What one individual may consider an "optimum" flow, another may consider "low satisfactory." Hopefully, this problem was minimized through discussion among the participants.

RESULTS

The results are discussed for each site separately. Each discussion represents the total observations of a single individual. Those for China Bar and the site immediately below the confluence with the Salmon River were by the same individual. The material is organized and presented in the following order:

1. Location of site
2. Description of site
3. Discussion of effect of flows on recreation activities
4. Shoreline profile
5. River Rating Chart

Due to the short period of time each flow was stabilized, it was not possible to assess the effect of decreasing flows on water temperature. The slight increase in water temperature recorded during the study was probably due to warming air temperature. Water temperature is an important consideration for water-contact recreation. Further study would be necessary to determine how flow fluctuation affects water temperature (see Chapters 2 and 3 for more information).

Photo by K. Bayha, BSF & W

Plate 12.3 Aerial view of first recreational evaluation site below mouth of the Grande Ronde (RM 168.4).

Observation Area No. 1

Location: Below confluence with Grande Ronde River on the Washington side of the Snake River (RM 168.4 to 160.3).

Description of Site: Three specific sites within close proximity were observed. The first was near the Washington Dept. of Game boat launch located immediately below the confluence with the Grande Ronde River *(Plate 12.3)*. The site consists of an access road, parking lot, and the double-lane boat launch. The beach is gravel. The second site is about eight miles downstream just above Buffalo Eddy *(Plate 12.4)*. A short spur provides access from the road. The beach is sandy, except for rocky portions at the upper and lower ends. There is a deep hole in the river channel just off the central portion of the beach. The third site, about one mile below the previous site, is the site of historic Indian petroglyphs on the rocks beside the river *(Plate 12.5)*. A pool area is created by rock outcroppings on the upstream and downstream sides of a sandy beach.

Recreational Potential of Site: Much of the shoreline along this stretch of river consists of sandy beaches which receive fairly extensive recreation use. Good access is provided along the Washington side of the river by a road running parallel to the river up to the confluence with the Grande Ronde River. Some problems are encountered with private ownership of lands adjacent to the river. Additional problems are created by inadequate off-road parking provisions. Public access to the Idaho side is almost totally dependent upon boats, but considerable use is made of the beaches.

Effect of Flows on Recreation Activities:

Power Boating

Although all of the flows observed were suitable for power boating, the higher flows were more desirable. Clearance over some of the gravel bars and other aspects of navigation became more of a problem at each successively lower flow. The boat ramp became difficult at 5,000 cfs.

Swimming, Wading, and Water Play

Generally, the conditions were best at the lower flows. Higher flows covered the sand beach at the first site. Without a sandy beach, the site was not well suited to these activities. At the second and third sites, conditions improve with the lower flows and were best at the 7,700 cfs to 12,000 cfs flows. At the lower flows, exposed beach area increased. However, also at the lower flows, the pool areas decreased in size and the slope of the beaches increased. *Figures 12.1, 12.2, and 12.3* are shoreline profiles of the three locations comprising observation area 1.

Picnicking and Camping

The different flows caused no appreciable effect on these activities.

Photo by J. Scott, Wash. Dept. of Ecology

Plate 12.4 Beach above Buffalo Eddy; second recreational evaluation site (RM 160.6).

Photo by J. Scott, Wash. Dept. of Ecology

Plate 12.5 Third recreational evaluation site at RM 160.3 near Indian petroglyphs.

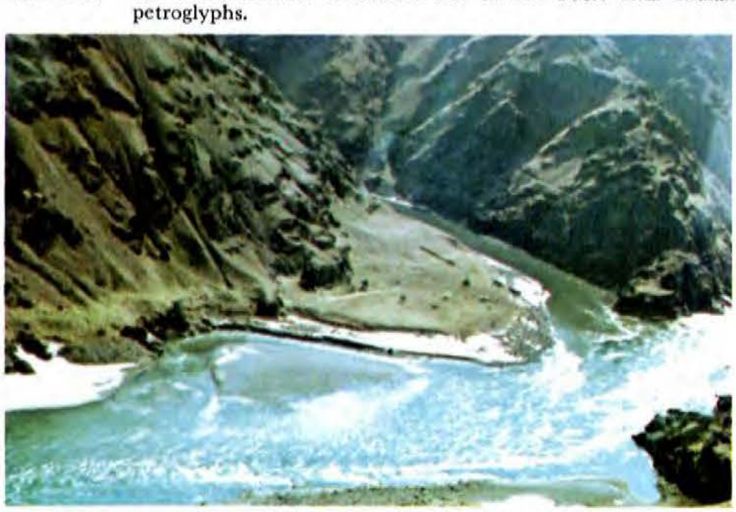


Photo by K. Bayha, BSF&W

Plate 12.6 Observation area 2 near confluence of Salmon and Snake Rivers.

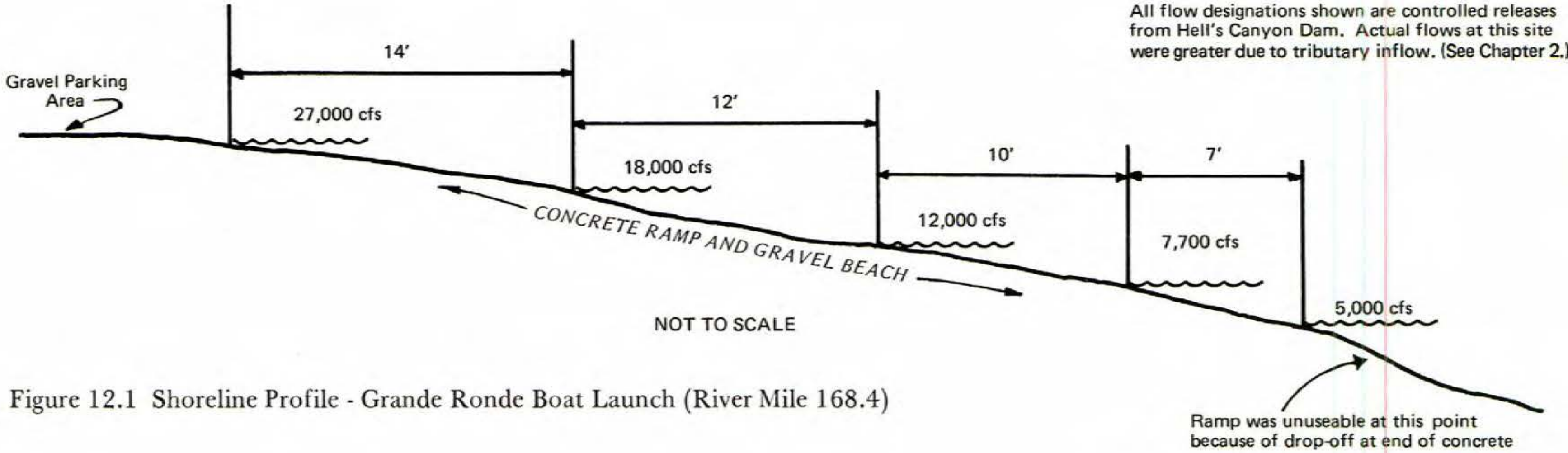


Figure 12.1 Shoreline Profile - Grande Ronde Boat Launch (River Mile 168.4)

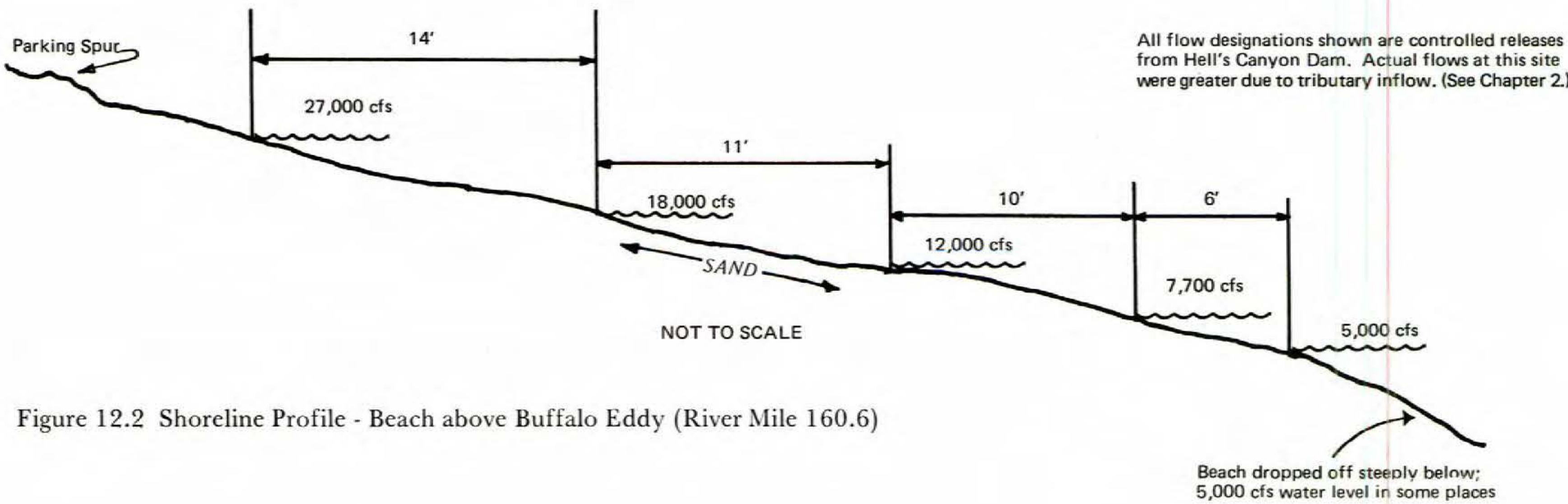


Figure 12.2 Shoreline Profile - Beach above Buffalo Eddy (River Mile 160.6)

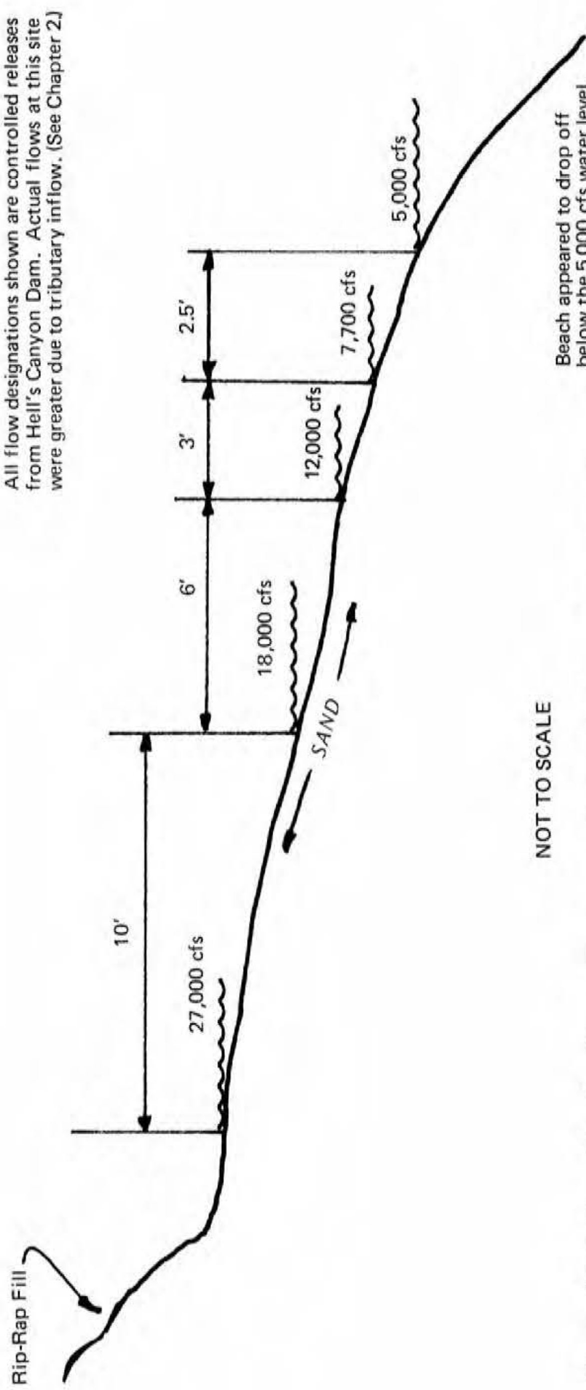


Figure 12.3 Shoreline Profile - Indian petroglyphs site (River Mile 160.3)

Flow* (cfs)	Minimum Acceptable	Low Satisfactory	** Optimum	High Satisfactory	Maximum Acceptable
27,000				X	
18,000				X	
12,000			X		
7,700		X			
5,000		X			

Table 12.1 River Rating Chart (Modified Kanawha Method) for the Snake River segment from River Mile 168.4 to 160.3

* All flow designations were controlled releases from Hell's Canyon Dam. Actual flows in this reach were greater due to tributary inflow (See Chapter 2).

** The actual optimum was considered to range somewhere between 7,700 cfs and 18,000 cfs.

Aesthetics

No appreciable effect was observed.

Table 12.1 shows the overall recreation rating for the river reach from the mouth of Grande Ronde River downstream about 10 miles, according to the modified Kanawha Method.

Observation Area No. 2

Location: Approximately ¼ river mile below the confluence with the Salmon River on the Idaho side of the Snake River (RM 188.0).

Description of Site: The site consists primarily of a gently sloping sandy beach *(Plate 12.6).* The upstream portion is gravelly and connects with a large gravel bar which is exposed at lower flows. The pool area is not well protected from the main current and thus is not suitable for swimming. Behind the beach, the brush and boulder-covered ground slopes steeply upwards to join the steep canyon walls. The site is reached easily on foot from the relatively large, flat area at the confluence of the Snake and Salmon Rivers. Access to the confluence of the two rivers is by boat only.

Recreational Potential of Site: The site has high potential as a future boat access camping area. The large flat area above the river offers considerable potential. Good boat-landing sites and beach areas exist on both the Snake and Salmon Rivers. The scenic location is quite favorable as a jumping-off point for a variety of activities, including boating up-river, hiking, fishing, hunting, etc.

Effect of Flows on Recreation Activities:

Power Boating

The conditions deteriorated as the flows decreased. At 27,000 cfs, the less powerful boats would probably encounter difficulty in passing upstream through the rapids. As the flows decreased, more rocks were exposed, creating hazards to boaters. At 5,000 cfs, extremely hazardous boating conditions were created even for the jet boats. At all flows, good boat-landing conditions existed at this site.

Swimming, Wading, and Water Play

The pool area beside the main current was not suitable for swimming. At the highest flow, the currents created hazardous conditions. At the lower flows, the pool decreased in size with the upstream portion eliminated and the main current passing closer to the shoreline. Also the water surface of the pool became choppy. The most desirable conditions for wading and water play were at the middle of the flow range. *(Figure 12.4* shows the shoreline profile at Observation Site 2.)

Picnicking and Camping

The different flows caused no appreciable effect on these activities except for the limitations on navigation. An important consideration is that this is a boat-access-only site, and some boats may not be able to reach it at certain flows.

Aesthetics

The most obvious effect was the exposure of green algae on the rocks and shoreline at the lower flows. Most people would consider this exposed algae condition as unpleasing. There was also a decrease in the turbulence of the flowing water as the flows decreased.

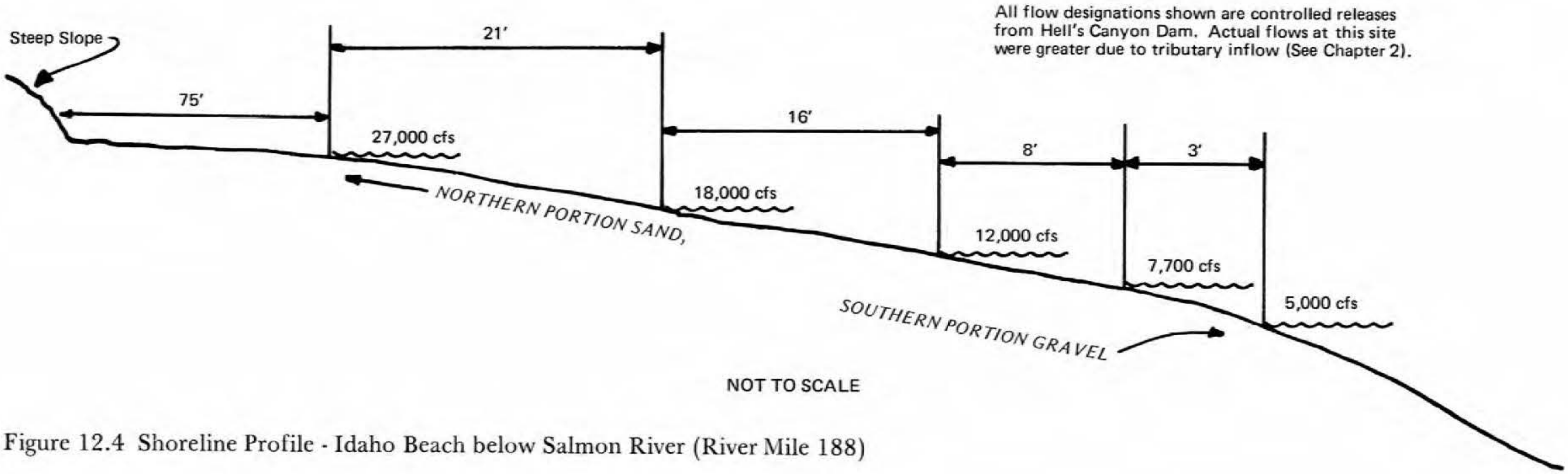


Figure 12.4 Shoreline Profile - Idaho Beach below Salmon River (River Mile 188)

Flow* (cfs)	Minimum Acceptable	Low Satisfactory	Optimum	High Satisfactory	Maximum Acceptable
27,000				X	
18,000			X		
12,000			X		
7,700		X			
5,000		X			

Table 12.2 River Rating Chart (Modified Kanawha Method) for the Snake River immediately below the confluence with the Salmon River.

* All flow designations are controlled releases from Hell's Canyon Dam. Actual flows at this site were greater due to tributary inflow (See Chapter 2).

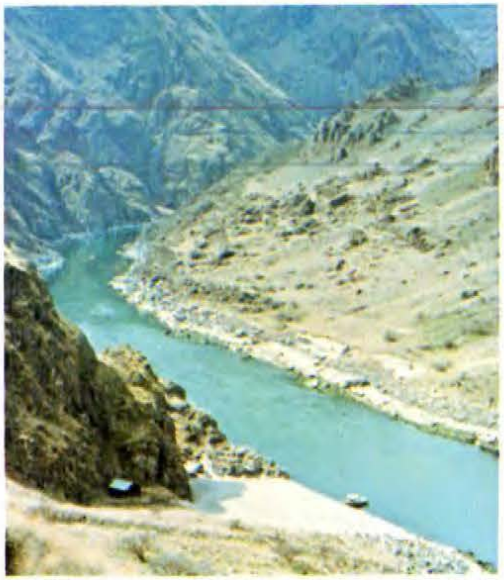


Photo by John Dooley, Bureau of Reclamation

Plate 12.7 Overview of observation area 3 at China Bar (Joseph Gauge RM 192.3).

Table 12.2 shows the overall recreation rating at the mouth of the Salmon according to the modified Kanawha Method.

Observation Area No. 3

Location: China Bar (Joseph Gauge) above the confluence with the Imnaha River on the Oregon side of the Snake River (RM 192.3).

Description of Site: The pool at this site is protected from the main river current by outcroppings of rock on both the upstream and downstream sides *(Plate 12.7)*. About 16,000 square feet of sandy beach are exposed at the 27,000-cfs flow. Beyond the beach above the high-water mark there is a grass, bush, and rock-covered slope leading up to the canyon wall. Access to the site is possible via boat as well as by foot trail down the canyon from a road on the canyon rim.

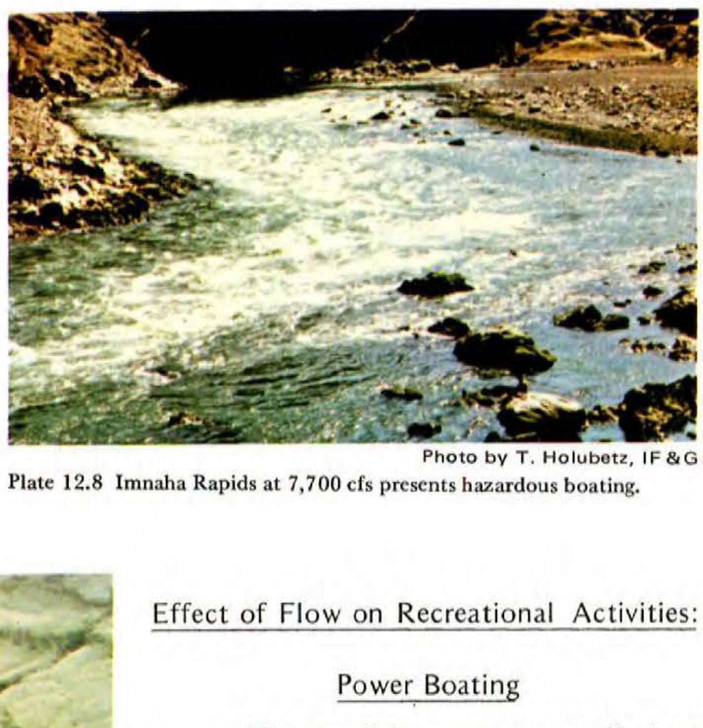


Photo by T. Holubetz, IF & G

Plate 12.8 Imnaha Rapids at 7,700 cfs presents hazardous boating.

Recreational Potential of Site: This site is presently receiving considerable use from hikers and motorbikers as well as boaters. Boating use of the site will probably never be extensive because of competition with non-boating use. The attraction of the site for visitors includes space to camp, the sandy beach, and the old copper mine tunnels.

Photo by K. Bayha, BSF & W

Plate 12.9 Observation site 4 at Dug Bar, site of Chief Joseph's historic crossing.

Effect of Flow on Recreational Activities:

Power Boating

The conditions were generally best at the higher flows. However, the Imnaha Rapids downstream became increasingly difficult to navigate as the flows decreased. More rocks became exposed, the navigable channel narrowed, and the swells increased in height *(Plate 12.8)*. At 7,000 cfs, these rapids became quite hazardous to boaters. Boat-landing conditions at this site remained good at all flows.

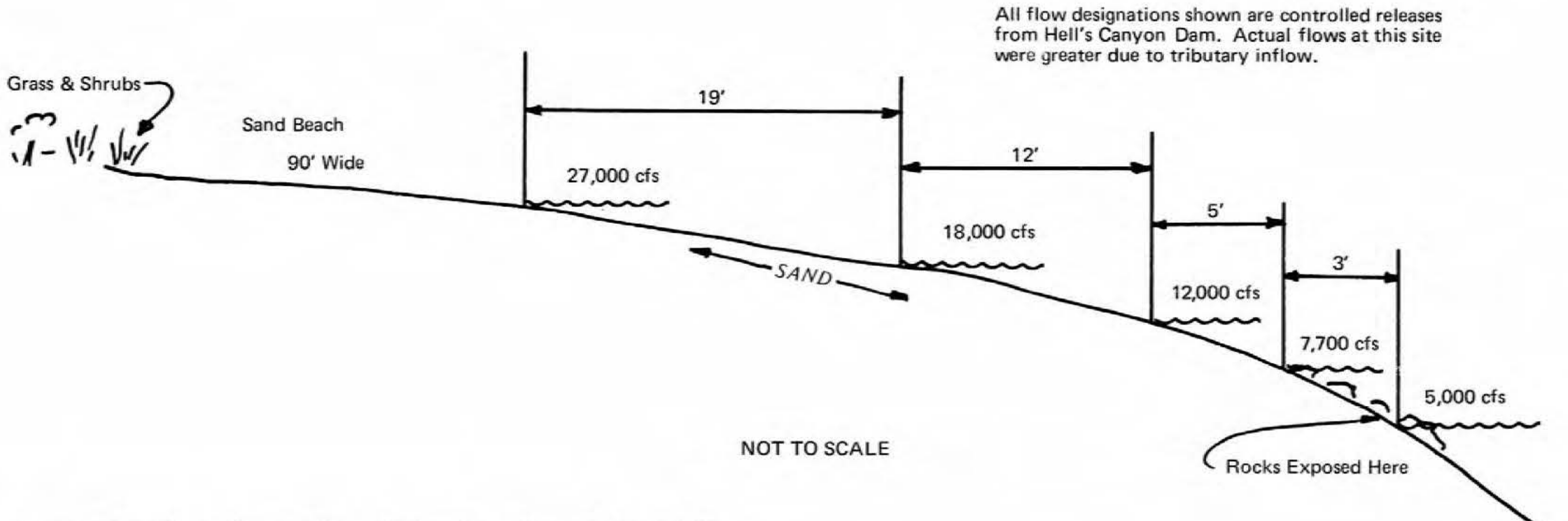


Figure 12.5 Shoreline Profile - China Bar (River Mile 192.3)

Flow* (cfs)	Minimum Acceptable	Low Satisfactory	Optimum	High Satisfactory	Maximum Acceptable
27,000				X	
18,000			X		
12,000			X		
7,700		X			
5,000		X			

Table 12.3 River Rating Chart (Modified Kanawha Method) for the China Bar Site.

* Discharge from Hell's Canyon Dam

Swimming, Wading, and Water Play

This site is not well suited for swimming due to the limited surface area of the pool. The discharges for wading were best in the range between 18,000 and 12,000 cfs. At lower flows the beach near the water's edge was very steeply sloped. Also, the lower flows decreased the size of the pool area, bringing the main river current closer to the shore. *Figure 12.5* shows the shoreline profile of Observation Site 3.

Picnicking and Camping

The different flows had no effect on these activities except for limiting access for some boaters because of navigation constraints.

Aesthetics

The most obvious effect was the exposure of green algae on the rocks and shoreline at the lower flow levels. Most people would consider this exposed algae condition as unpleasing. There was also a decrease in the turbulence of the river as the flows decreased. *Table 12.3* presents overall rating for Observation Site 3.

Observation Area No. 4

Location: Dug Bar – about four miles above the confluence with the Imnaha River on the Oregon side of the Snake River (RM 196.7).

Description of Site: This is a long, flat area of about 100 acres *(Plate 12.9).* It is presently used as a cattle ranch. The shoreline is gravelly and not well suited for water-contact activities. There is a gravel-surfaced, single-lane boat ramp and limited provision for camping. Access to the site is via boat or via an unimproved road. The site is historically significant as the site where the Nez Perce Indians led by Chief Joseph crossed the Snake River during its flood stage in June 1876 while being pursued by the U.S. Cavalry.

Recreational Potential of Site: Recreational use of the site is marginal now due to difficult overland access and private ownership of the land. However, with properly designed development, the site could support a lot of use. The access road would have to be improved. Improvements would also need to be made in camping, sanitary, and boat-docking facilities in order to accommodate large numbers of people. Attractions of the area include the scenery, the fishing, the camping and boating opportunities, and the historical significance.

Effect of Flows

On Recreational Activities:

Power Boating

The best conditions were at 18,000 cfs. Conditions continued to deteriorate as the flows lowered. At 7,700 cfs and particularly at 5,000 cfs, hazardous conditions were created for navigation.

Photo by F. Jones, IWRB

Plate 12.10 Lower Pittsburg Landing is used primarily as a boat launching site.

Swimming, Wading, and Water Play

Due to the steepness and rockiness of the shoreline, the conditions were not suitable at any flow for these activities *(Figure 12.6)*.

Picnicking and Camping

The different flows had no effect on these activities except for limiting access for those users dependent upon boat access.

Aesthetics

At flows of 12,000 cfs and lower, green algae was exposed on the rocks and shorelines. Most people would consider this condition as unpleasing.

Table 12.4 shows the overall recreation rating for Observation Site No. 4.

Observation Area No. 5

Location: Pittsburg Landing, Idaho side of river.

Description of Site: Two specific sites were observed. Lower Pittsburg Landing (RM 214.9) consists primarily of a county-operated boat-launching ramp *(Plate 12.10)*. The site is not suitable for any water-dependent recreational activities except boating. There is no sandy beach. The shoreline is covered with large, slippery rocks. A pool area is protected from the main river current by a large rock outcrop. Upper Pittsburg Landing (RM 216.2) is suited to general recreation activities *(Plate 12.11)*. There is a sandy beach which extends out into the water. The pool area is suitable for swimming, wading, and other water recreation activities. Both sites are accessible via boat or an unimproved road. Usage of the road is largely dependent upon the weather. Above the river, there is a large, flat area which could be developed for

Photo by K. Bayha, BSF&W

Plate 12.11 Downstream view of Snake River near Pittsburg Landing; recreation evaluation site is on right in distance.

Photo by Jake Szramek, Oregon Water Resources Board

Plate 12.12 View of Sand Creek recreation evaluation area.

Photo by C. Koski, NMFS

Plate 12.13 Recreation evaluation area 7 at the mouth of Steep Creek (RM 229.0).

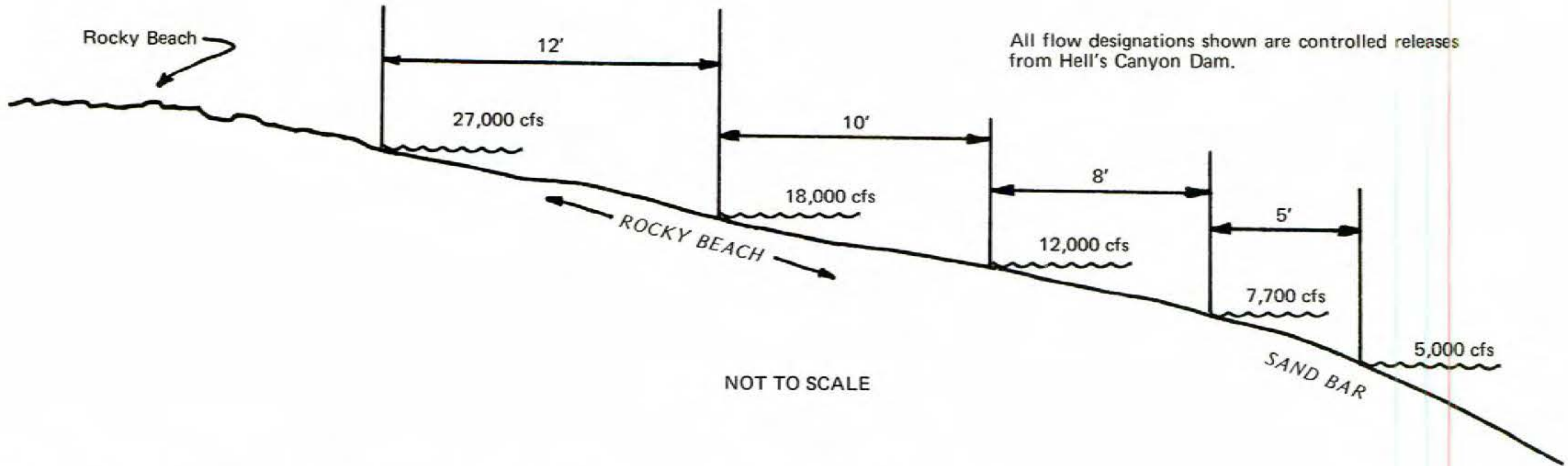


Figure 12.6 Shoreline Profile - Dug Bar - Nez Perce Crossing Site (River Mile 196.7)

Flow* (cfs)	Minimum Acceptable	Low Satisfactory	Optimum	High Satisfactory	Maximum Acceptable
5,000		X			
7,700		X			
12,000			X		
18,000			X		
27,000				X	

Table 12.4 River Rating Chart (Modified Kanawha Method) for the Dug Bar Site.

* Discharge from Hell's Canyon Dam

recreation sites, including picnicking and camping. Upper Pittsburg Landing is a better camping site and also has been used as a fueling station by boaters.

Recreational Potential of Site: The location and the large amount of open, developable ground make this a highly desirable, potential recreational site. The Federal Government is in the process of acquiring the private land at Pittsburg Landing through condemnation proceedings. Plans for future use will be developed by the U.S. Forest Service. In addition, bills currently before Congress propose National designation of the canyon (S.657 and H.R. 2624 – Hell's Canyon National Forest Parklands and S.2233 – Hell's Canyon National Recreation Area). If the land were developed for recreation, the access road would have to be improved to accommodate expected increases in use. Improvements would also need to be made in boat-docking and launching facilities.

Effect of Flows on Recreation Activities:

Power Boating

Above 18,000 cfs or below 12,000 cfs, conditions for tying up boats become less favorable because of moving water and/or exposure of large rocks. *Figures 12.7 and Figures 12.8,* illustrate the conditions at each flow for the lower and upper landings, respectively.

Swimming, Wading, and Water Play

These activities are only desirable at the Upper Landing. There was little change affecting these activities as flows decreased from 27,000 cfs to 12,000 cfs, except for additional sandy beach being exposed. At 7,700, some rocks appeared near the surface of the pool area which would cause problems for swimmers. *Figures 12.9 and 12.10* show a plan and profile view of the lower and upper landings, respectively.

Picnicking and Camping

The different flows had no effect on these activities except for limiting access for those users dependent upon boat access.

Aesthetics

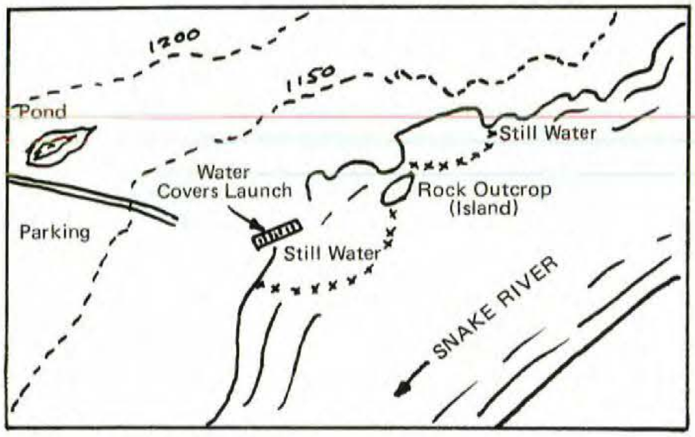
The most obvious effect was the exposure of green algae on the rocks and shoreline at the lower flow levels. Most people would consider this condition as unpleasing.

Table 12.5 shows the overall recreation rating for the two observation sites at Pittsburg Landing according to the modified Kanawha Method.

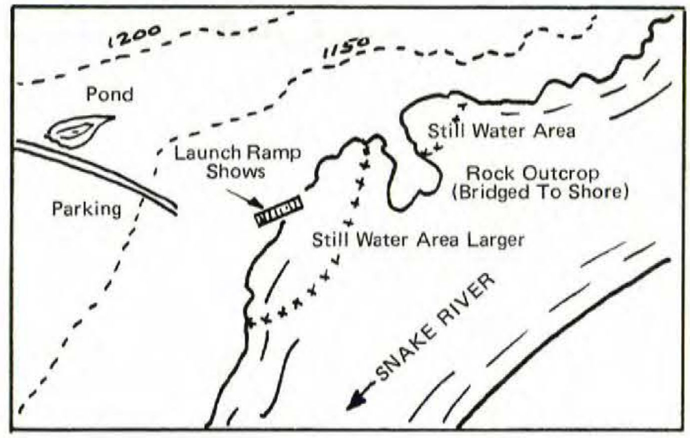
Observation Area No. 6

Location: Sand Creek – below Johnson Bar on the Oregon side of the river (site of Oregon Game Commission's administrative cabin). (RM 228.0)

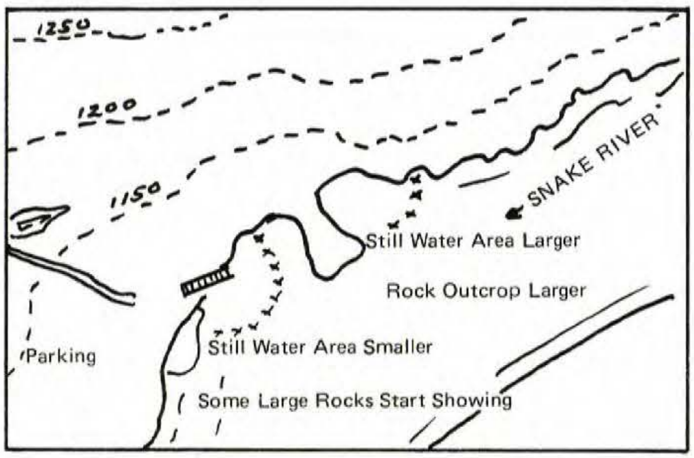
Description of Site: This is an extremely limited site for water-dependent recreation. Adjacent to the water, the beach is very rocky and almost devoid of sand *(Plate 12.12).* The area above the high-water mark is fairly steeply sloped up to a level bench. The entire site is about ten acres in size. The site is not protected enough from the main river current to provide any substantial pool. Primary access to the site is probably by boat, but trail access is also available parallel to the river.



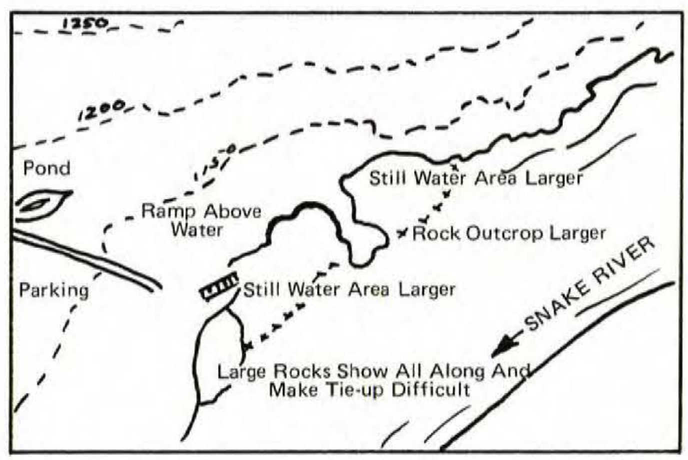
A. 27,000 cfs



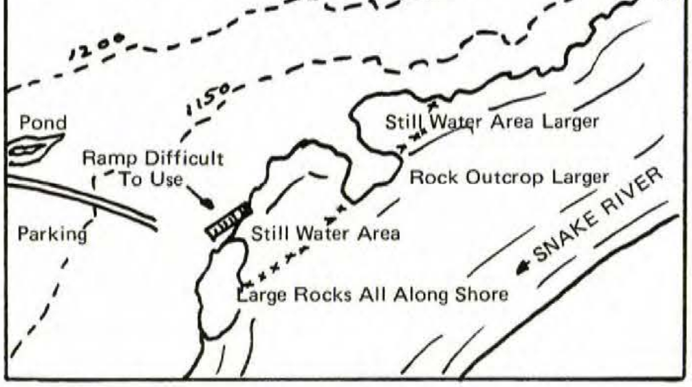
B. 18,000 cfs



C. 12,000 cfs

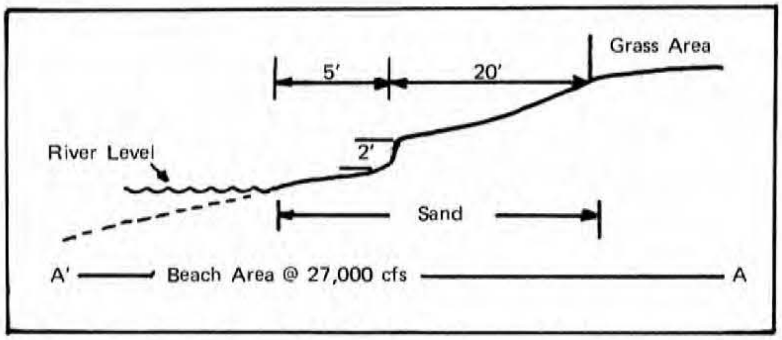


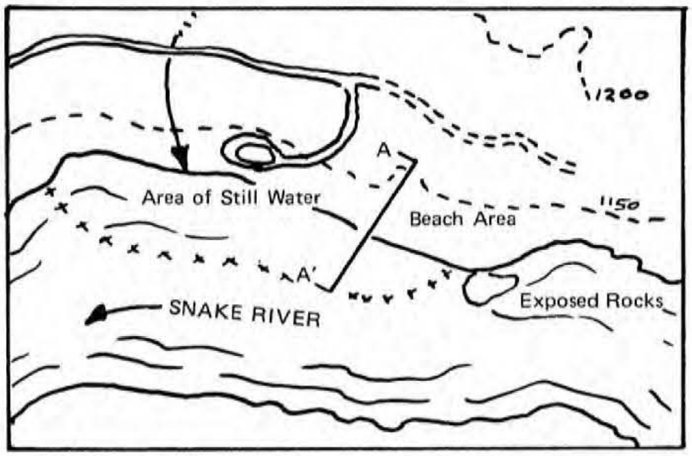
D. 7,700 cfs



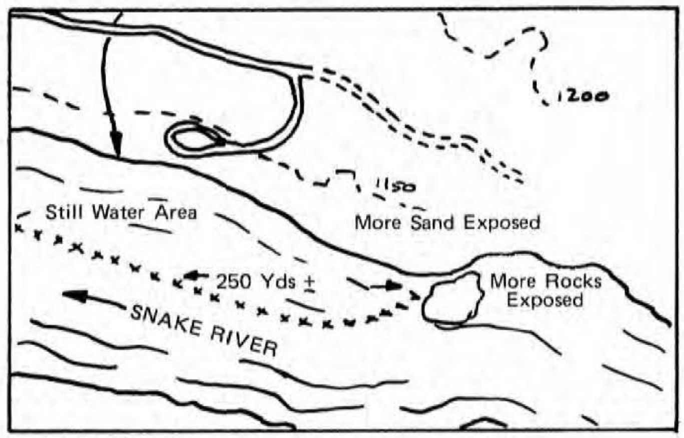
E. 5,000 cfs

Figure 12.7 Illustrations of Changing Conditions at Lower Pittsburg Landing for the Five Flows Observed. (River Mile 214.9)

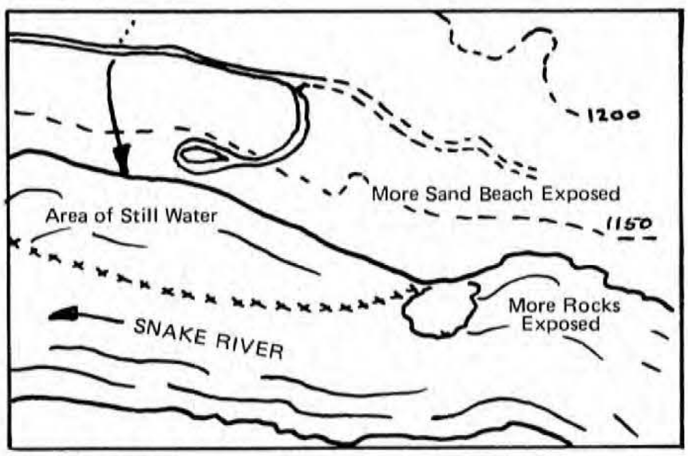




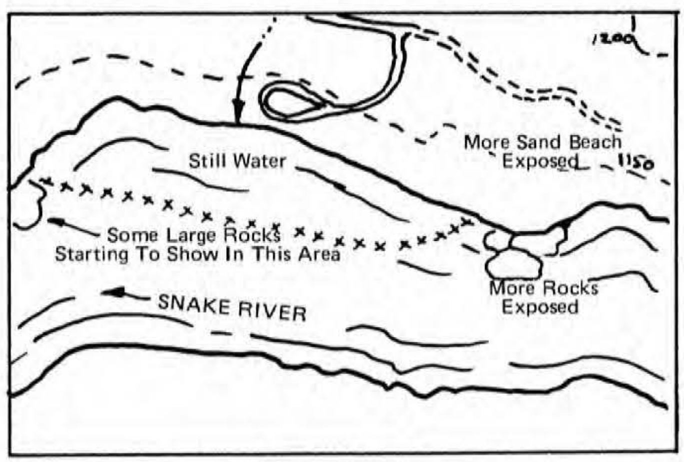
A. 27,000 cfs



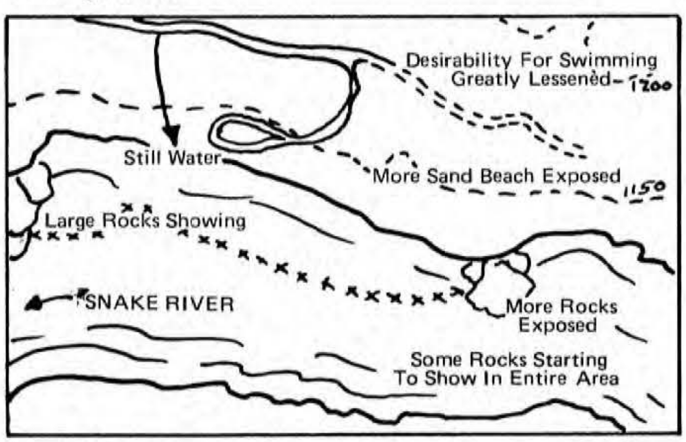
B. 18,000 cfs



C. 12,000 cfs



D. 7,700 cfs



E. 5,000 cfs

Figure 12.8 Illustrations of Changing Conditions at Upper Pittsburg Landing for the Five Flows Observed. (River Mile 216.2)

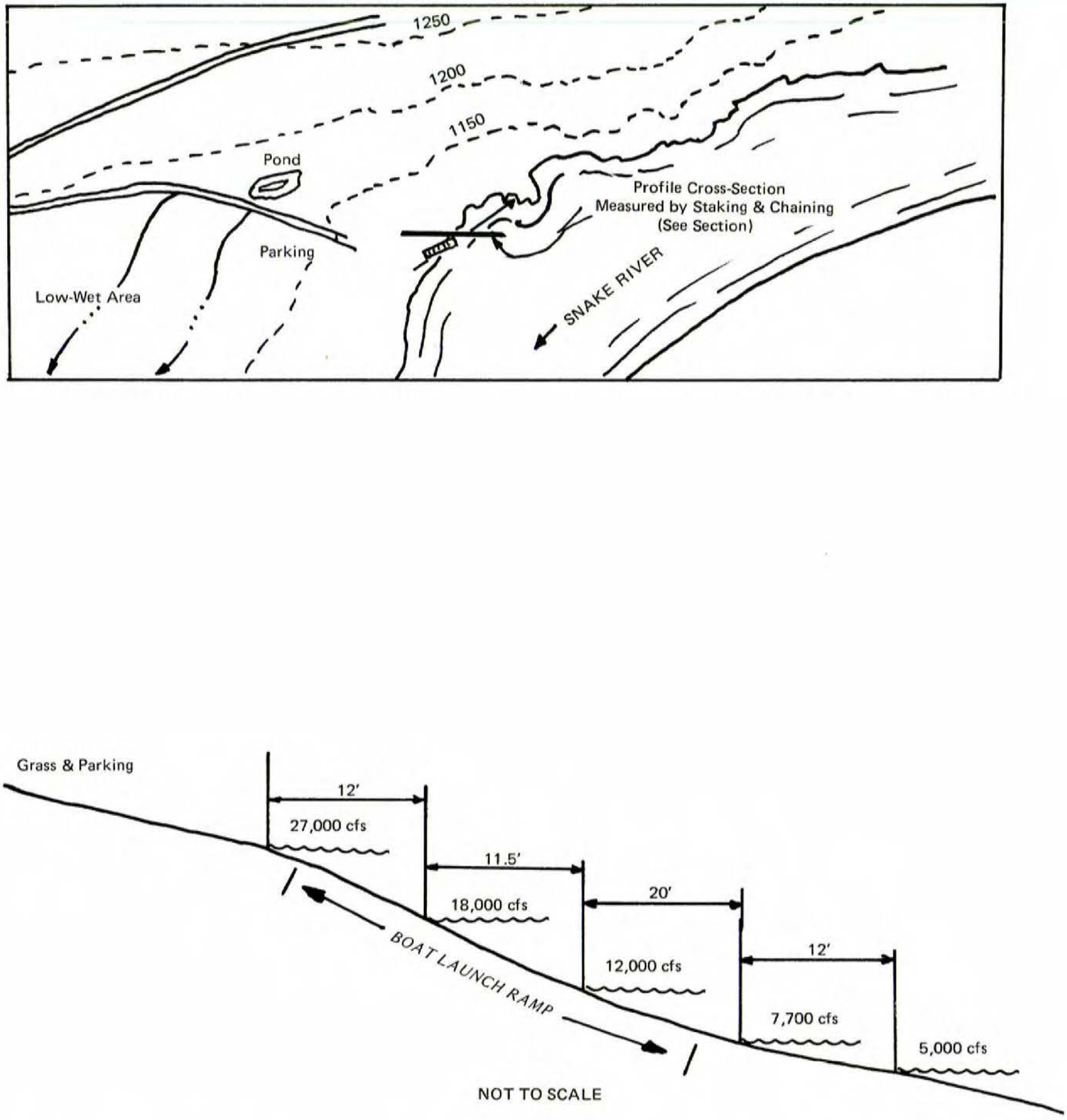


Figure 12.9 Shoreline Profile - Lower Pittsburg Landing (River Mile 214.9)

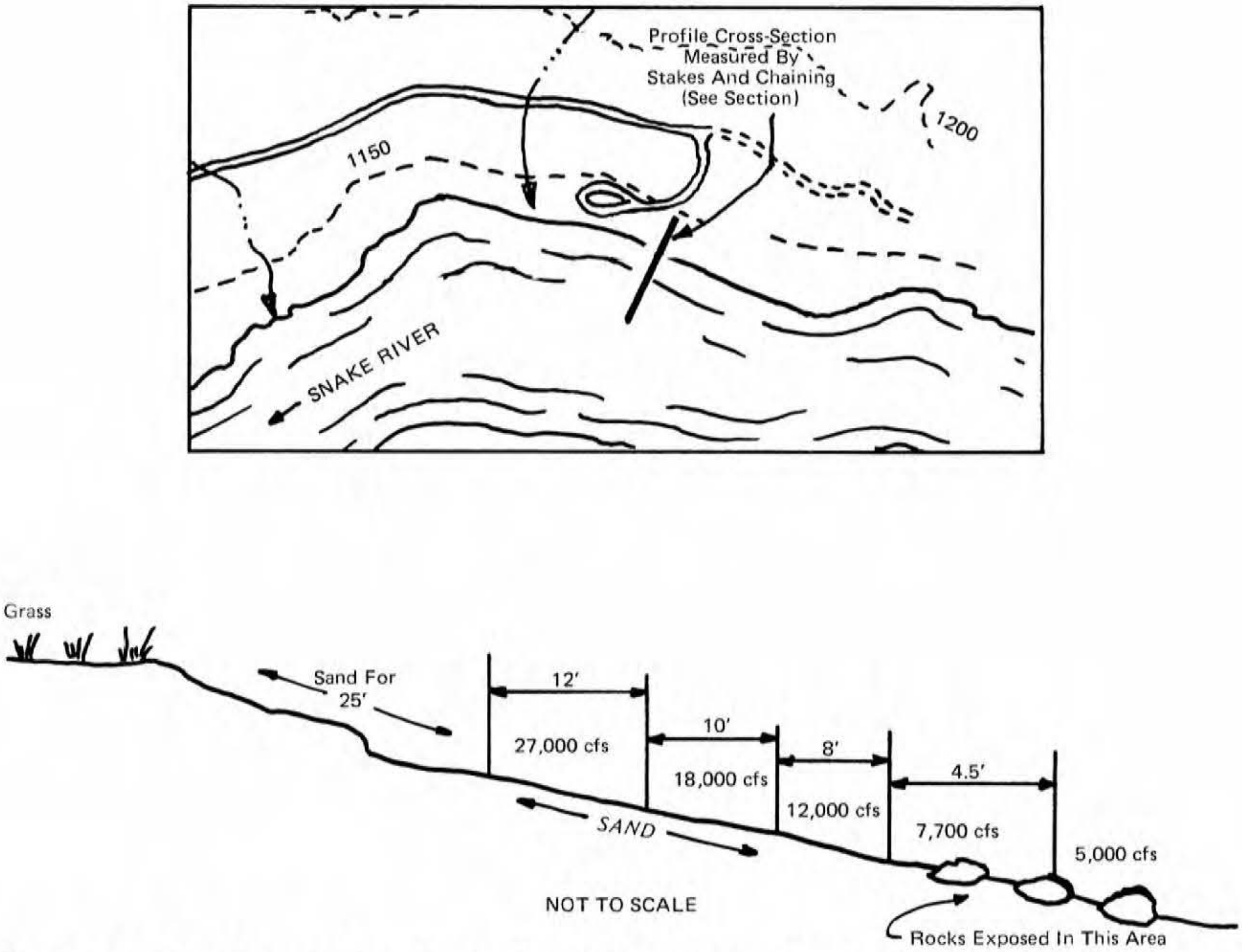


Figure 12.10 Plan View and Shoreline Profile of Upper Pittsburg Landing (River Mile 216.2)

Flow* (cfs)	Minimum Acceptable	Low Satisfactory	Optimum	High Satisfactory	Maximum Acceptable
27,000				X	
18,000			X		
12,000			X		
7,700		X			
5,000		X			

Table 12.5 River Rating Chart (Modified Kanawha Method) for the Pittsburg Landing Site.

* Discharge from Hell's Canyon

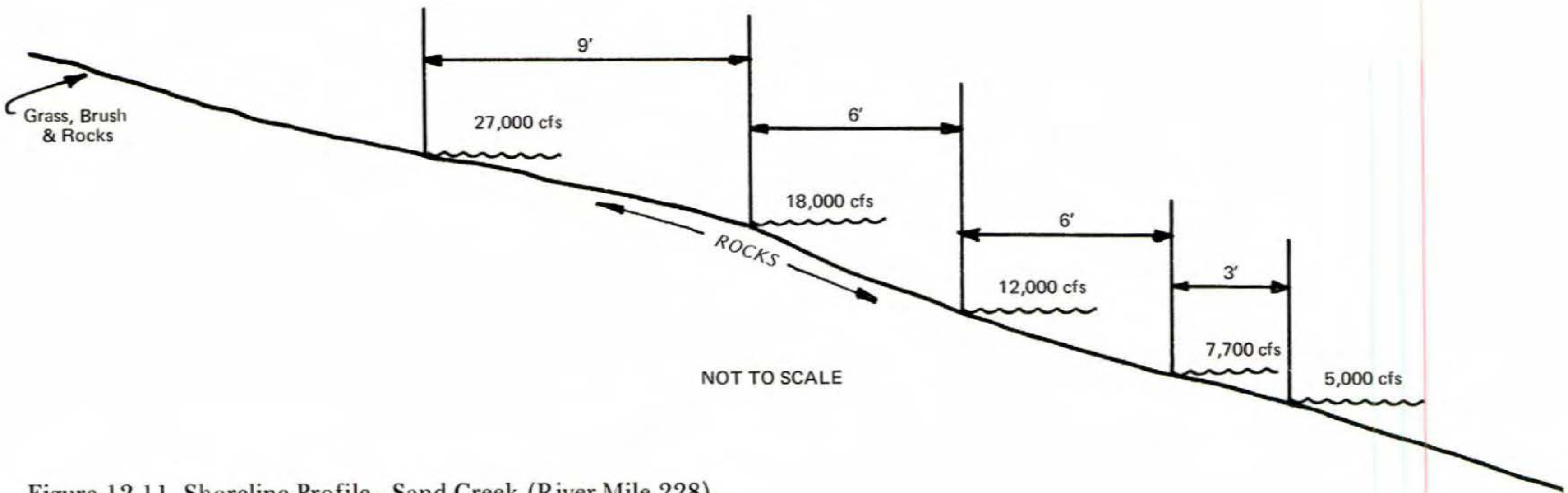


Figure 12.11 Shoreline Profile - Sand Creek (River Mile 228).

Flow* (cfs)	Minimum Acceptable	Low Satisfactory	Optimum	High Satisfactory	Maximum Acceptable
27,000				X	
18,000				X	
12,000			X		
7,700		X			
5,000		X			

Table 12.6 River Rating Chart (Modified Kanawha Method) for the Sand Creek Site.

* Discharge from Hell's Canyon Dam

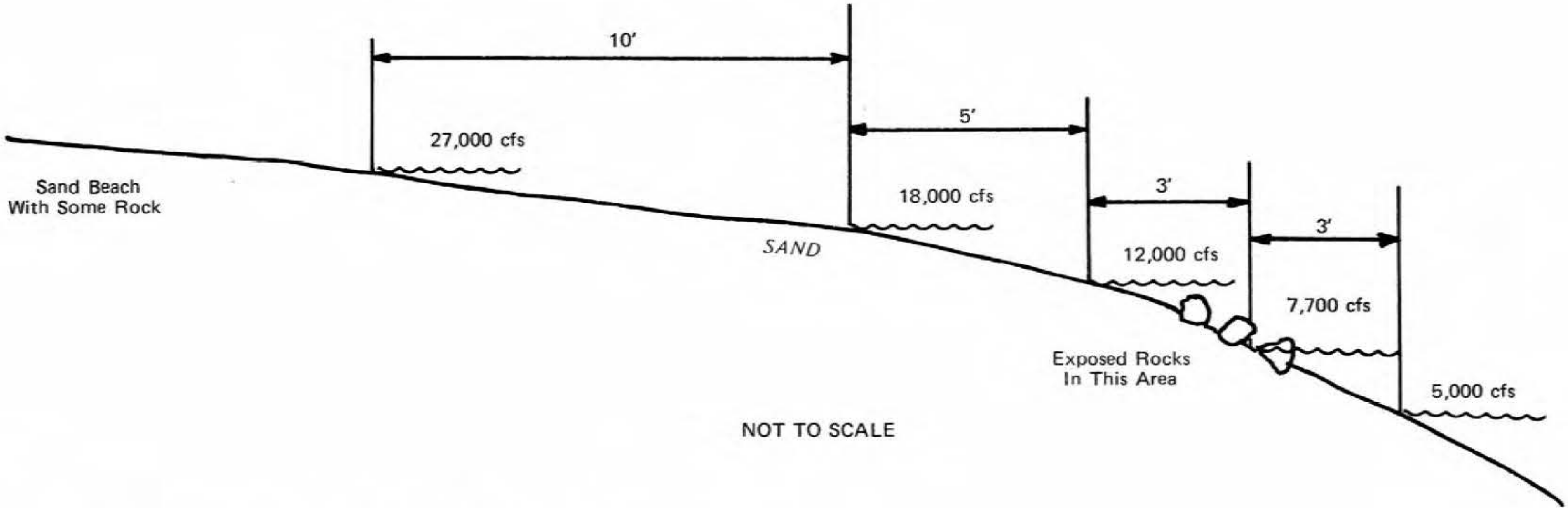


Figure 12.12 Shoreline Profile - Steep Creek (River Mile 229).

Flow* (cfs)	Minimum Acceptable	Low Satisfactory	Optimum	High Satisfactory	Maximum Acceptable
27,000				X	
18,000				X	
12,000			X		
7,700		X			
5,000		X			

Table 12.7 River Rating Chart (Modified Kanawha Method) for the Steep Creek Site.

* Discharge from Hell's Canyon Dam

Recreational Potential of Site: This site will not be able to accommodate a high-capacity type of recreation use. With limited development, it should be able to serve as an overnight campsite for small boating and hiking parties. The major attraction for the recreationist would be the availability of drinking water from a small creek, the flat area for camping, and the striking scenery observable from the site.

Effect of Flows on Recreation Activities:

Power Boating

The conditions were generally best at the higher flows. There were no rapids or other navigational restraints at the site itself. At 7,700 and 5,000 cfs, there were some navigational hazards upstream and downstream from the site. Boat-landing conditions at the site remained good at each flow.

Swimming, Wading, and Water Play

This site was not desirable for these activities. Without a protected pool area, recreationists would be exposed to the main river current and eddies. At 5,000 cfs, the current was slow enough to allow wading. However, the shoreline was rocky and slippery at all flows. *Figure 12.11* gives the slope profile of this site.

Picnicking and Camping

Even though the beach conditions are not good, the attractiveness of the surroundings makes this a favorable site. The different flows had no effect on these activities except for limiting access for some boaters because of navigation constraints.

Aesthetics

The different flows had no major impact on aesthetics. The rapids and white water diminished considerably at the lowest flows, leaving an almost tranquil stream in this section. There would be considerable differences of opinion as to the relative desirability of this condition from an aesthetical point of view. *Table 12.6* presents the overall evaluation for Observation Site 6.

Observation Area No. 7

Location: Steep Creek – about one mile below Johnson Bar on the Idaho side of the river (site of Idaho Department of Fish and Game's cabin). (RM 229.0)

Description of Site: The pool at this site is protected from the main river current by outcroppings of rock on both the upstream and downstream sides *(Plate 12.13)*. The beach and the pool area are sandy but limited in size. The site is enclosed by steep brush and rock-covered ground. Access is possible by boat as well as by a foot and horse trail which parallels the river.

Recreational Potential of Site: This site is only suitable for small parties of recreationists because of the limited area. Use would probably be limited to overnight camping by small boat and trail parties. Since it is located near what is considered to be the upstream end of the navigable portion of the river for power boats, it could possibly become an important boater's campsite.

Effect of Flows on Recreation Activities:

Power Boating – No Data.

Swimming, Wading, and Water Play

As the flows lowered, the size of the pool area decreased. At 7,700 and 5,000 cfs, the slope of the beach into the water increased sharply *(Figure 12.12)*. Also at these flows, the river current was only about fifteen feet beyond the shore, creating a hazardous condition for water play and swimming.

Picnicking and Camping

The different flows had no effect on these activities except for limiting access for those users dependent upon boat access.

Aesthetics

There were no obvious impacts of different flows on aesthetics.

Table 12.7 gives the overall recreation rating for Site No. 7 according to the modified Kanawha Method.

CONCLUSIONS

Application of the Kanawha Method, modified for this study, was not entirely successful. The participants agreed that its application would be more appropriate for rivers of less magnitude than for the Snake. Also, the method might have been more appropriate if there had not been one dominant water recreation activity which greatly affected the other activities. Within the canyon, boats are the primary practicable method of travel. Therefore, the decision on an adequate flow of water for recreation largely hinges on an adequate flow for boating. The Kanawha Method does not address itself to the importance of one single activity over all others. The method needs to be further modified to include a way of weighing an activity such as boating to increase its relative importance in the overall evaluation. More discussion on the relation of flows to boating can be found in Chapter 14.

A critical problem for recreational boaters not directly identified elsewhere in this chapter is the repetitive stranding and floating of boats caused by the daily fluctuation of river flows. Even though the study did not specifically collect data related to this problem, its importance to the recreational use of the river should not be overlooked.

In general, all of the discharges (27,000 cfs, 18,000 cfs, 12,000 cfs, 7,700 cfs, and 5,000 cfs) observed were considered by the observers to be acceptable for the array of recreation activities being considered.

Conditions for specific activities were better at some flows than at others. Conditions for power boating generally were better at the higher flows (27,000-18,000 cfs). The specific site made a difference in which flows were most desirable for a particular activity. At some sites, the lowest flow observed was best for water-contact activities, while at other sites, the middle ranges of flows, (18,000-12,000 cfs) were best.

During the field study period, it was apparent that neither the minimum nor maximum acceptable flow for most recreation activities was witnessed. The "minimum acceptable" flow, that flow which no longer supports any substantial instream recreation activities, is apparently less than 5,000 cfs. The "maximum acceptable" flow, that flow at which further use of the river for general recreation is substantially restricted, is apparently beyond the upper limit of flows observed during the study period. Reference to these limits on acceptability is based upon a set of standards (Kanawha Method) developed for rivers in general. It is not intended to imply that some flow less than 5,000 cfs is the actual minimum acceptable flow for recreation purposes in the Hell's Canyon portion of the Snake River. To determine the acceptable flow, one must first decide which recreation activity is the most crucial and is to be used as a measure. For the Snake River, the crucial activity may be power boating, in which case the minimum acceptable flow is more than 5,000 cfs. The same reasoning applies to determining an optimum flow.

There were definitely some weaknesses encountered in the gathering of data for the recreation element of the study. The number of sites observed was not sufficient to obtain a complete picture of the recreation condition along the river at each flow. Some of the sites were not desirable recreation sites. In addition, the amount of time a flow remained stabilized at one level was not sufficient for a parameter such as slope of the beach to stabilize.

At the sites with a good, sandy beach, it was observed that the shoreline dropped off rather steeply into the water at the lower flows. This creates an undesirable or even hazardous condition for general recreation activities on the beach. However, it should not be concluded that this condition is permanently characteristic of these low flows.

The profile of these beaches was formed by transportation and deposition of sand and gravel through the actions of another range of river flows. This range seldom, or perhaps never, included discharges as low as 7,700 and 5,000 cfs from Hell's Canyon Dam. If such a low flow were included in the normal range of flows through the canyon, the beaches might eventually adjust and develop a slope profile similar to that now observed at the higher flow levels.

Another effect of flow is the loss of sandy beaches along the Snake River over the past ten to fifteen years since the Brownlee, Oxbow, and Hell's Canyon Dams were built. The sand bars along the river are gradually being eroded away as a result of flow fluctuations and the trapping of sediments in the reservoirs upstream *(Plates 12.14 and 12.15)*. The loss of these sand bars may adversely affect recreation activity by reducing the number and quality of desirable recreation sites.

Photo by Hollis Oaks, Asotin, Washington

Plate 12.14 Sizeable sandbar near High Mountain Sheep campsite is shown in this 1964 photograph.

The same adjustment to flow range would occur with the green algae observed on the rocks and shoreline at the lower flows. Most of the observers found the sight and sometimes the smell of this algae displeasing. However, if regularly exposed for long periods of time, this vegetation would eventually disappear from above the low-water line.

It should also be noted that observations are only reliable for conditions found during the study period, and that summer-time conditions may differ considerably and might result in different conclusions. For example, the lower flows containing returned irrigation water might result in stagnated water conditions in pools adjacent to some of the desirable beaches.

Photo by H. Oaks, Asotin, Washington

Plate 12.15 View of same sand bar six years later.

By consolidating the observations of the recreation study participants, some brief comments on the effects of each discharge on recreation activities can be made:

<u>27,000 cfs</u> — Good conditions existed for navigating over the shallow gravel bars and through the critical rapids. Due to the fast water, the conditions for water-contact activities (swimming, wading, and water play) were not good. However, the eddies and white water created by the fast current added to the aesthetics of the river.

<u>18,000 cfs</u> — Good conditions still exist for power boats. With the slower river current, conditions for water-contact activities improved within the pool areas. Except for the rapids, there

was less turbulence in the river.

12,000 cfs – This flow did not present a serious navigation problem for power boats. However, more hazards existed from additional rock exposure and narrower navigable channels. Conditions within the protected pools for water-contact activities were best at this flow for many of the sites. The green algae along the rocks and shoreline began to be exposed.

7,700 cfs – Power-boat navigation became hazardous through some of the critical rapids. Due to the physical differences of the various sites, the effect of the flows on pool and beach conditions varied greatly. Conditions for water-contact activities were much improved at some sites while becoming worse at others. Additional algae was exposed along the rocks and shoreline.

5,000 cfs – Navigation through many of the rapids was extremely hazardous for all power boats and impossible for some. Conditions for water-contact activities varied from the best observed at some sites to the worst observed at other sites. The aesthetics of the river were noticeably affected by the additional exposure of algae along the shoreline and the almost tranquil condition of the flow along some reaches of the river.

RECOMMENDATION

The objective of the recreation element of the study was to judge the relative effect of various controlled flows on recreational opportunities. This objective was largely fulfilled for all activities except boating. More work is needed on refining an acceptable methodology before an attempt can be made to establish the optimum and minimum flow requirements for recreation. When the methodology has been tested and a team instructed in its application, then perhaps we can go back to the Snake River and make firm recommendations on optimum and minimum flows. The experience gained from this study should be of great benefit to any future efforts. In the interim, the comments made in this chapter in regard to the relative adequacy of flows for recreation can be used as guidelines, if necessary, by decision-making bodies. However, it is important that any reference to the data or conclusions contained in this chapter be tempered by the limitations described in this chapter.

ACKNOWLEDGMENTS

Representatives from a number of Federal and State agencies participated in the field work and in the compilation of the information included in this chapter. Individuals, and their respective agencies, involved in the recreation element of the study include:

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Merle Mews	Idaho State Parks and Recreation Department
James Scott	Washington State Department of Ecology
James Morris	Bureau of Outdoor Recreation
Joseph Szramek	Oregon State Water Resources Board

CHAPTER 13

WHITEWATER BOATING

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Idaho Department of Fish and Game
and
Dee Crouch, M.D.

OBJECTIVES

The whitewater boating portion of the controlled flow study was unique in that we were there primarily to enjoy ourselves and then evaluate the experience at each flow encountered. In an attempt to relate to the reader some of the excitement and humor we enjoyed during the floats, the first person, diary style of writing is used. The report that follows is drawn largely from Welsh's personal diary.

METHODS

Between March 21 and March 24, two kayakers and I in a six-man raft participated in the Hell's Canyon Controlled Flow studies. The kayakers were Jim Leonard from Salmon, Idaho, and Dr. Dee Crouch from Yakima, Washington. According to the "International System of Paddler Classification" (Urban, 1965),[1] Dr. Crouch would be a Class V (Senior Leader) and Jim Leonard would be Class III (Intermediate). I have wide experience in large and small rubber rafts and wooden drift boats, but none in canoes or kayaks.

Photo by Jim Winner, Idaho Dept. of Water Admn.

Plate 13.1 The whitewater team relied on a CH-47 helicopter to airlift team and float craft upstream for each day's run.

At 27,000 cfs, we ran from Granite Creek Rapids to Sheep Creek, and at 12,000, 7,700, and 5,000 cfs, we ran from below Hell's Canyon Dam to Sheep Creek *(Figure 13.1)*. We depended upon the CH-47 (Chinook) helicopter *(Plate 13.1)* to airlift our team and float craft upstream to start the run each day. On the second day, our aircraft was too late to catch the 18,000 cfs flow, which was dropped to 12,000 cfs at noon.

The whitewater team evaluated each day's run according to the "International System" of rating the degree of difficulty of running rivers (Urban, 1965). The definitions of the six grades of difficulty are as follows:

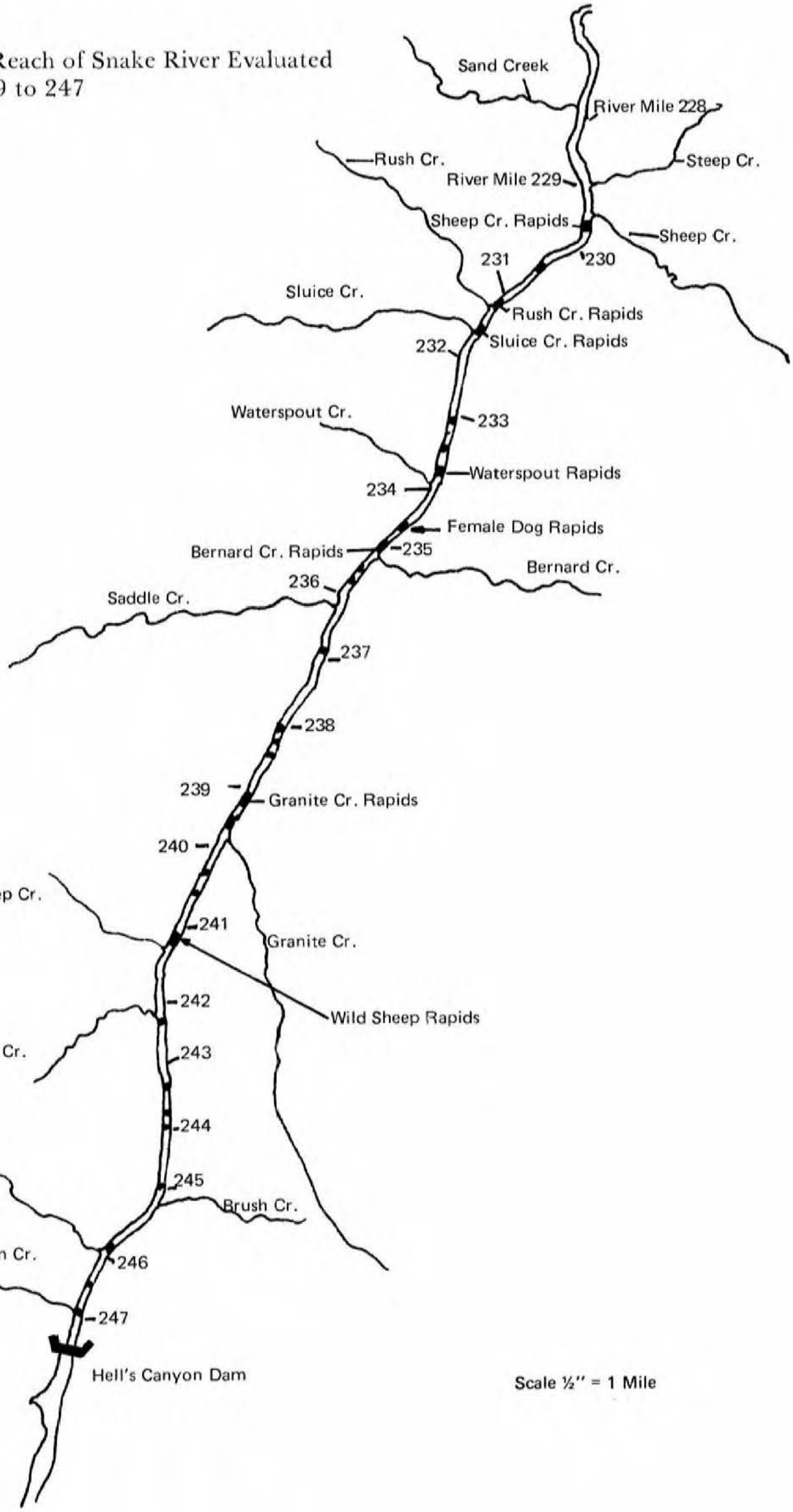
Grade I: Very easy, waves small, regular. Passages clear. Sandbanks, artificial difficulties like bridge piers, riffles.

Grade II: Easy. Rapids of medium difficulty, with passages clear and wide. Low ledges.

Grade III: Medium. Waves numerous, high irregular. Rocks, eddies. Rapids with

[1] Urban, John T., 1965. *A Whitewater Hand Book for Canoe and Kayak.* Appalachian Mountain Club; 5 Joy Street; Boston, Mass.

Figure 13.1 White Water Reach of Snake River Evaluated
River Mile 229 to 247



passages that are clear though narrow, requiring expertise in maneuver. Inspection usually needed.

Grade IV: Difficult. Long rapids. Waves powerful, irregular. Dangerous rocks. Boiling eddies. Passages difficult to reconnoiter. Inspection mandatory first time. Powerful and precise maneuvering required.

Grade V: Very difficult. Extremely difficult, long, and very violent rapids, following each other almost without interruption. River bed extremely obstructed. Big drops, violent current, very steep gradients. Reconnoitering essential but difficult.

Grade VI: Extraordinarily difficult. Difficulties of Grade V carried to extremes of navigability. Nearly impossible and very dangerous. For teams of experts only, at favorable water levels and after close study with all precautions.

RESULTS

In general, the kayaks, being much more maneuverable, can run most of the rapids by several different routes. The six-man raft (Avon Redshank) is usually limited to one line in most of the better rapids, especially at moderate and low flows.

March 21, 1973 – Flow 27,000 cfs

Due to helicopter transportation difficulties, we made arrangements with Ken Witty of the Oregon Game Commission to transport ourselves and our boat upstream to Granite Creek Rapids. We carried the raft and two kayaks to above Granite Rapids and prepared to float. The kayaks ran the middle of the rapids with very little difficulty *(Plate 13.2)*. I elected to run the rapids on the Oregon side and attempt to hit the center of the V-trough. I made the first few oar strokes of the study, hit the slot slightly off center, flipped, and began to swim *(Plate 13.3)*. I made it to the Oregon side and the kayakers retrieved my raft. While dog paddling toward shore, the thought went through my mind that it was going to be a long week *(Plate 13.4)*. The remainder of the float was uneventful with "sneaks" available alongside all the better known rapids downstream to Sheep Creek camp. "Sneaks" can be defined as relatively calm water chutes usually along the shores. Travel time from Granite to Sheep Creek was three hours.

Photo by Royce Williams, Idaho Daily Statesman

Plate 13.2 Kayakers ran through the middle of Granite Creek Rapids at 27,000 cfs with little difficulty.

Photo by Dr. Dee Crouch, Yakima, Wash.
Plate 13.3 Team Leader Tom Welsh's first encounter with the "big water" of Granite Creek Rapids.

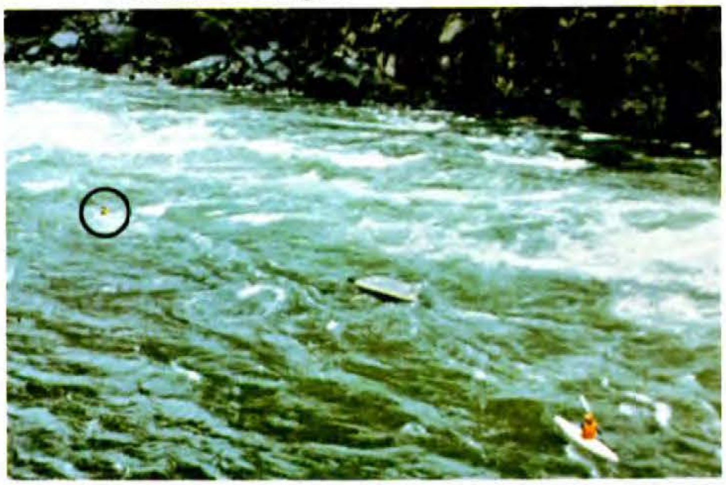


Photo by K. Bayha, BSF&W
Plate 13.4 Welsh beginning a "long week!"

Photo by C. Koski, NMFS
Plate 13.5 At 12,000 cfs, kayakers ran Wild Sheep Rapids near the Idaho shore (top center).

March 22, 1973—Flow 12,000 cfs

The Chinook helicopter flew us from Sheep Creek to Hell's Canyon Dam. On this day we were joined by two other kayakers, Alex Lane and Al Beam from Ketchum, Idaho. We started floating at 1:00 PM, after the flow reduction to 12,000 cfs at noon. We arrived at Sheep Creek at 5:45 PM (elapsed time-4 3/4 hours).

The kayakers all chose to run Wild Sheep Rapids on the Idaho side *(Plate 13.5)*. All had difficulty and flipped in a particularly obtrusive hole about halfway through the rapids. All righted themselves and had no further difficulty. I took the raft along the Oregon side of Wild Sheep and switched over to the center of the V-trough. It was a very thrilling ride during which I took on about 50 gallons of water.

The kayakers took Granite Rapids right down the middle and all did a good job. I ran Granite quite easily on the Oregon side between two small boulders situated near the end of the rapids *(Plate 13.6)*.

The remainder of the float was enjoyable for both the kayakers and myself. I took on about 50 gallons of water in Bernard Rapids. Waterspout Rapids was good on the Oregon side, while Sluice Creek and Rush Creek Rapids were enjoyable on the Idaho side.

March 23, 1973—Flow 7,700 cfs

The Chinook picked us up at Sheep Creek at 11:00 AM and flew us to Hell's Canyon Dam. The two kayakers from Ketchum discontinued at this point due to previous commitments. We began floating at 1:00 PM into a strong upriver wind. Coupled with the lack of current between rapids, it was necessary to paddle almost continuously in order to reach camp before dark (7:00 PM).

Jim and Dee attempted to run Wild Sheep Rapids on the Oregon side but the Chinook, with photographer aboard, was hovering above the rapids and blew them over before they got to the good stuff. They were undecided as to the degree of difficulty of Wild Sheep at 7,700 cfs, since they ran most of it upside down.

During my assessment of Wild Sheep, I could see no way of running it except the same line I had used yesterday. However, the V-slot formed by two eight-foot curling waves was very narrow and it would take perfect positioning in order to keep from rolling up. I borrowed a helmet and noseplugs from one of the kayakers, which proved to be an unnecessary precaution as I somehow hit the slot perfectly and took on only a few gallons of water. Wild Sheep Rapids at 7,700 cfs *(Plate 13.7)* is practically impossible for small rafters unless the oarsmen are either extremely lucky or exceptionally good.

I ran Waterspout Rapids beginning on the Oregon side and switching to the middle about half-way through *(Plate 13.8)*. Bernard Rapids had to be run down the middle, while Sluice Creek Rapids was still runable on the Idaho side. The sneak on the Idaho side of Rush Creek Rapids was gone so I tried it down the middle and attempted to get over to the Idaho side. On the way across, I fell into a huge hole which put me over on my back. I crawled on top of the raft and righted it with no problems. An unnamed, at least unkown to us, rapids just above Waterspout was a "female dog." (RM 234.8)[2]

March 24, 1973 – Flow 5,000 cfs

Today I took Doug Erdman of the Idaho State Parks and Recreation Department with me in my raft. Since

Photo by T. Holubetz, IF & G

Plate 13.6 Granite Creek Rapids at 12,000 cfs provided near ideal whitewater conditions.

Photo by T. Holubetz, IF & G

Plate 13.7 Wild Sheep Rapids is practically impossible for small rafters at 7,700 cfs.

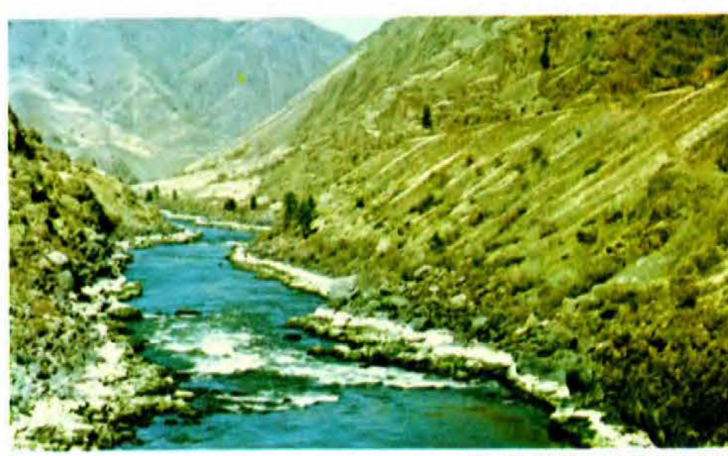


Photo by T. Holubetz, IF & G

Plate 13.8 Water Spout Rapids demanded tricky maneuvering at 7,700 cfs.

[2] Editor's Note: Subsequently identified as "No-Name Rapids" by the Corps of Engineers.

we lacked an extra wet suit for Doug, we dressed him in waterproof pants and top with the forearms from my wetsuit and an extra pair of wetsuit boots I had brought along. The kayakers ran Wild Sheep (boulder-strewn) more or less down the middle, picking their way between the boulders. We took the raft down the Idaho side and switched over to the middle about one-third of the way through. I missed my line slightly at the bottom of the rapids, but we remained upright.

The kayakers ran Granite on the Idaho side and switched over to the middle just below the big rock in the middle (slightly exposed at 5,000 cfs). We tried the same line, but were swept into a huge hole on the Idaho side near the bottom of the rapids. The raft turned sideways and started to crawl out of the hole but slowly slipped back in, and over she went. The force of the current sucked Doug's booties off and drove his water-proof pants to his knees, which slightly hampered his swimming. Fortunately he still had a hold of the bowline, so pulled himself to the raft and we both crawled on and paddled to shore.

Bernard and "Female Dog Rapids" were technically difficult. Waterspout was still sneakable along the Oregon shore. A sneak was also discovered along the Idaho side of Rush Creek Rapids.

Generally, the rapids at 5,000 cfs are sharp and short, creating longer distances between whitewater.

DISCUSSION AND CONCLUSIONS

Jim Leonard, Dee Crouch, and I agreed that the best flow encountered for high-quality whitewater boating was 12,000 cfs. At 27,000 cfs, most of the rapids smooth out with the exceptions of Granite and Wild Sheep which became almost unrunable. At 5,000 cfs, the rapids are short and sharp with long slack-water sections between them. The low flows also necessitate considerable paddling between rapids. The intermediate flows provide kayakers with numerous eddies in which they practice their "eddy" turns. In this type of maneuver, they swing behind a rock, slowly move the bow of the kayak into the current while simultaneously dipping their paddle and leaning into the turn. The kayak (when the turn is properly executed) swings effortlessly into a 180-degree turn. It is a very graceful maneuver to observe.

For high quality whitewater boating, the best section of the Snake River in the study area is between Hell's Canyon Dam and Johnson Bar. Below Johnson Bar, the good rapids are few and far between. Float parties nearly all depart from below Hell's Canyon Dam with some floating all the way to Lewiston. Those going to Lewiston usually have outboard motors to propel them through the long pools on the lower river. Float parties also can take out at the other roads intersecting the river including Pittsburg Landing, Dug Bar, and Graves Creek.

The whitewater boating crew agreed that the section of Hell's Canyon from Hell's Canyon Dam to Sheep Creek is big, exciting water, rivaling the Grand Canyon of the Colorado as a whitewater boating experience. Wild Sheep and Granite Creek Rapids are by far the most dangerous and exciting rapids in the study area.

Following are the grade of difficulty of the different flows encountered using the "International System."

Water	Snake River
Stream Segment	Hell's Canyon Dam to Sheep Creek
Dates	March 21 - 24, 1973
Type and Size of Crafts	Kayaks and 6-Man Rubber Raft
Experience of Participants	Class III and V

Flow (CFS)	27,000	18,000	12,000	7,700	5,000
Rating	V*	**	V	IV	IV

* Two Kayakers and raft ran only from and including Granite Creek Rapids to Sheep Creek. Another two kayakers ran from Hell's Canyon Dam to just above Granite Creek Rapids. According to the latter two kayakers' description of Wild Sheep Rapids at 27,000 cfs, this section should be classified as Grade VI.

** Unable to run at 18,000 due to helicopters being late and flows changing at noon.

CHAPTER 14

NAVIGATION

Don Mathews
Corps of Engineers, Walla Walla District

INTRODUCTION

This chapter deals with the experience and problems of power-boat navigation in Hell's Canyon during various known sustained flows. Its purpose is to evaluate the impact of the controlled flows on navigation in the canyon, and to determine what flow is necessary to sustain navigation of the type prevalent on the Middle Snake River.

METHODS

Two methods were used to collect information for evaluation.

a. A navigation evaluation form was distributed to all powerboat operators observed on this reach of Snake River during the test period. Information requested included boat data, purpose of trips, river stage, navigation data, and damages sustained, if any. A sample form is shown at the end of the chapter.

b. A boat with operators was chartered from a Lewiston, Idaho, guide service to run the Snake River between the mouth of the Grande Ronde River (RM 168.7) and the foot of Granite Creek Rapids (RM 239.1). These cruises were made daily from Thursday, 22 March, through Sunday, 25 March, during periods of sustained flows of 18,000, 12,000, 7,700, and 5,000 cfs. It was not considered necessary to evaluate flows higher than 18,000 cfs.

By leaving the launch area at the mouth of the Grande Ronde River at 8:00 AM (MST), there was ample time to reach Granite Creek Rapids[1] by 12:30 PM (MST), before the effect of the 12:00 PM (MST) daily flow reduction at Hell's Canyon Dam was felt at that point. After a brief rest stop, the trip downstream could be made on the same sustained flow. Several members of the Corps' staff participated in these cruises as observers and recorders. Cameras and tape recorders were used to record pertinent information.

Photo by Don Mathews, Corps of Engineers

Plate 14.1 The navigation evaluation team traversing Rush Creek rapids in a 24' aluminum jet boat, typical of those used by outfitters and white water enthusiasts.

Three main factors should be considered in evaluating the navigability of a river: the boat, the river characteristics, and the operator's capabilities. The river characteristics are set at each sustained flow; however, the type of boat and the experience of its operator can have infinite variability. Because the resources available for this test were limited, only one powerboat could be chartered to make the test cruises. We selected the type of boat that is in most prevalent use on the Middle Snake River by Federal and

[1] Granite Creek Rapids was selected as the upstream terminus because it is generally recognized by professional boaters as the practical upstream limit of power-boat navigation.

State agencies and professional guides. Professional operators familiar with this reach of the river were hired to pilot the boat. The most prevalent type of boat used by guides and agencies on the Middle Snake River varies in length from 20 to 30 feet, is of welded aluminum construction, and is powered by an inboard engine or engines with jet-pump propulsion units. It is shallow draft, and draws only 1 to 1½ feet of water when underway. The particular boat used in our survey was 24-feet long and was powered by a 455-cubic inch, 330-HP engine *(Plate 14.1)*.

RESULTS AND DISCUSSION

Evaluation Forms

Response to the forms was limited. Only five operators returned the evaluations; two of them covered all five days of the test and three covered only the last three days. Two of the forms returned covered the last three days, but were not specific on which flows they navigated. A tabulation of data from the returns is shown on *Table 14.1*. While these data are too limited for any real statistical significance, they are helpful in developing some preliminary evaluations.

Table 14.1 Response to Navigation Evaluation Forms

Flow-cfs	Number of Responses	Boat Type Jet I. B.	Jet O.B.	Purpose of Trip Recreation	Study Team	Other	Ranges Used	Degree of Difficulty Routine	Challenge	Hazard	Damages[1]
27,000	2	1	1		2		Occasionally	1	1		None
18,000	2	1	1		2		Slightly	1	1		Hull (1)
12,000	5	4	1	2	2	1	To a Degree	1	3	1	Hull (1)
7,700	5	4	1	2	2	1	To a Degree	1	3	1	None
5,000	5	4	1	2	2	1	All to None		2	3	Hull & Jet Unit (1)

[1] See text for information on other damages.

Boat Data: Four of the five boats were classed as jet-aluminum. The other boat was a "Hewes Craft," powered by a 100-HP outboard jet. Boat length varied from 18 to 24 feet.

Purpose of Trip: Two of the boats were used for transporting the study teams, although one also checked all of the other purposes on the evaluation form. Two boats were used only for recreation and one was used to haul materials.

Ranges Used: Existing navigation ranges were used only slightly during high flows, but were used increasingly more as the flows became less. The one professional operator responded that he did not use the ranges at any flow. One operator stated that the ranges were of no use below 7,700 cfs. The exact use of ranges is difficult to ascertain from the replies.[2]

Degree of Difficulty: The responses indicate that the degree of difficulty in powerboat navigation increased with decreasing flows. The operator who considered navigation "challenging" at 27,000 cfs indicated he had a small boat (18') and that this was his first time on the river. The other operator considered navigation "very easy" at 27,000 cfs, except Rush Creek (RM 231.2) upstream, which he considered "challenging." The same classifications were also noted for the 18,000 cfs flow.

At 12,000 cfs flow the inexperienced operator began to find some "hazardous" conditions, and for other operators "routine" changed to "challenging." At that flow, a commercial operator began reporting, and he found both the 12,000 cfs and 7,700 cfs flows "routine." There was little difference

[2] Although the forms indicated limited use of the navigation ranges by some respondants, and no use by the responding commercial operator, it is known that the ranges are used extensively by commercial and private boaters.

in reporting of the degree of difficulty between the 12,000 cfs and 7,700 cfs flows, except one operator changed his opinion of Rush Creek upstream from "challenging" to "hazardous."

At 5,000 cfs most of the operators considered navigation "hazardous," and even the commercial operator considered it "challenging."

Damages: One boat operator reported hull damage in the form of popping rivets at 18,000 cfs. That same boat also experienced a cracked hull and smashed jet unit at the 5,000-cfs flow. This latter damage occurred at Upper Kirby Creek Rapids (RM 219.2). The only other damage reported was a dented stern, but the flow and location where damage occurred were not noted. The problem with popping rivets indicates the apparent desirability of welded construction.

Point(s) of Particular Difficulty: The response to this item, as well as to item entitled Degree of Difficulty, was highly variable, depending upon the experience of the operators. All the boats were of the same general type, i.e., all were jet powered and from 18 to 24 feet in length.

There were no points of particular difficulty noted for flows above 12,000 cfs. At 12,000 cfs flow, one operator designated Rush Creek (RM 231.2) as being difficult. Another stated that the "low water made trip hairy," but he did not designate the flow rate nor any particular point.

At 7,700 cfs, one operator reported difficulty at Cottonwood and High Range Rapids (RM 209.2 and 206.4).

At 5,000 cfs, the points of difficulty were listed by an operator as "many" and "every shallow ripple." Upper Kirby Creek Rapids (RM 219.2) was cited by one operator who damaged his boat there.

Test Cruises

The following descriptions of the test cruises made by the chartered boat are based on notes and recorded narration made during the trips. The descriptions used are subjective, and what may be "exciting" to one person may be quite routine to another person more accustomed to navigation on the Middle Snake River.

18,000 cfs, Thursday, 22 March 1973: Travelling upstream on the reach below the mouth of the Salmon River (RM 188.2), Shovel Creek Rapids (RM 174.2), and Grotto Falls Rapids (RM 176.2) were noted to be pretty bumpy. The Snake River flow below the Salmon was about 22,500 cfs, with the Salmon River flow about 4,500 cfs. Above the Salmon, Lower Sheep Creek Rapids (RM 189.8), Imnaha Rapids (RM 191.4), Sulfur Creek Rapids (RM 199.8), Dry Creek Rapids (RM 200.9), and Lower Campbell Rapids (RM 205.0) were also bumpy going through. Upstream from Johnson Bar Landing (RM 229.8), the head of the authorized navigation improvement project, the trip was exciting, with occasional bumpy going through Rush Creek Rapids (RM 231.2), Waterspout Rapids (RM 233.7), and Bernard Creek Rapids (RM 235.2), but posed no particular navigation problem.

Travel downstream was exciting, but no navigation problems were encountered.

12,000 cfs, Firday, 23 March 1973: Travelling up the river, no problems were encountered up to the mouth of the Salmon River. The Snake River flow below the Salmon was about 16,500 cfs, with the Salmon River flow continuing at about 4,500 cfs. Proceeding upstream, the Imnaha Rapids could be run on either side. The trip to RM 205 was routine, using the normal procedure of slowing down to enter a rapids and then accelerating on up through it. The boat operator noted that High Range Rapids (RM 206.4) would be "tougher" at lower flows, but it was not difficult at 12,000 cfs.

No problems were encountered on up to Granite Creek Rapids (RM 239.1). Rush Creek and Waterspout Rapids are considered fairly difficult passages at this flow, but our boat had no particular difficulties with them either way. The trip downstream was, again, somewhat routine. The river was considered to be easy to negotiate, with only Imnaha Rapids called "rough"; downstream passage through it was on the Idaho side.

7,700 cfs, Saturday, 24 March 1973: The flow at Lewiston was approximately 13,000 cfs, with Salmon River inflow amounting to about 5,000 cfs. The trip upstream was called relatively uneventful (which may be the result of greater familiarity of the river run by the crew). The navigation channel was narrow at several locations and greater care and knowledge of the river was required to negotiate the rapids to prevent hitting rocks. A small sunken barge *(Plate 14.2)* was observed partially exposed on the left bank at Dug Bar (RM 196.7). It is a navigation hazard when landing on the beach, particularly when covered by a few feet of water.

Photo by Merle Mews, Idaho Parks & Recreation Dept.

Plate 14.2 Sunken barge shown here at 7,700 cfs first becomes exposed at 18,000 cfs. This is also the location of Chief Joseph's historic river crossing.

A group of three additional jet boats met the crew boat in the vicinity of Kirby Creek to travel on upstream as a group. Nothing significant occurred until we reached Rush Creek Rapids where one of the less-experienced boat operators had some difficulty in passing over the rapids. The remainder of the upstream trip to Granite Creek was generally routine, but with some fairly bumpy going, and exciting periods while passing through white water.

No particular problems were noted on the downstream trip.

During the review of this trip, it was observed that the Roland Bar ranges (RM 203-204) are questionable at low flows, and depict a navigation channel that is located very close to some rocks on the right bank.

5,000 cfs, Sunday, 25 March 1973: The flow at Lewiston was about 11,500 cfs, with Salmon River inflow about 5,000 cfs. Two rocks were bumped during the upstream trip, but there was no serious damage to the boat. The first contact was below Eureka Bar and the second was in Whitehorse Rapids. The crew boat proceeded upstream only to Rush Creek Rapids. One boat navigated the rapids at 5,000 cfs flow, but reported minor hull damage. The passage either way at this flow is considered very hazardous.

On the downstream trip, the crew boat and another jet boat hit rocks at Lower Pleasant Valley Rapids (RM 213.5). Although no appreciable damage was done to the crew boat from hitting rocks at the 5,000 cfs flow, one jet boat was badly damaged at Upper Kirby Creek Rapids, and another at Rush Creek Rapids.

Summary of Test Cruises: In general, the rapids became easier for the chartered boat to run as the flows receded. The reason for this was that the rapids became shorter and their upper ends usually became smoother. This condition results in a series of relatively smooth, low-velocity pools connected by short rapids, and the total time for the trip is actually less than at higher flows. In addition, some rapids that are primarily caused by flow velocity became barely noticeable when flows dropped below 12,000 cfs. Exceptions to this are certain rapids that are rougher at low flows, those that are rough at any flow (such as Imnaha Rapids), and those where there was questionable depth. Whitehorse Rapids (RM 194.5) and Cottonwood Rapids (RM 209.2) are difficult at low flows because they are wide and shallow.

The navigation aids (ranges) were found to be correct in most of the rapids. They are set to obtain the smoothest and safest course for a flow in the range of 12,000 to 15,000 cfs. At lower flows the ranges *(Plate 14.3)* must be used with discretion, and a skillfull operator will rapidly "read the water" and then steer the best course.

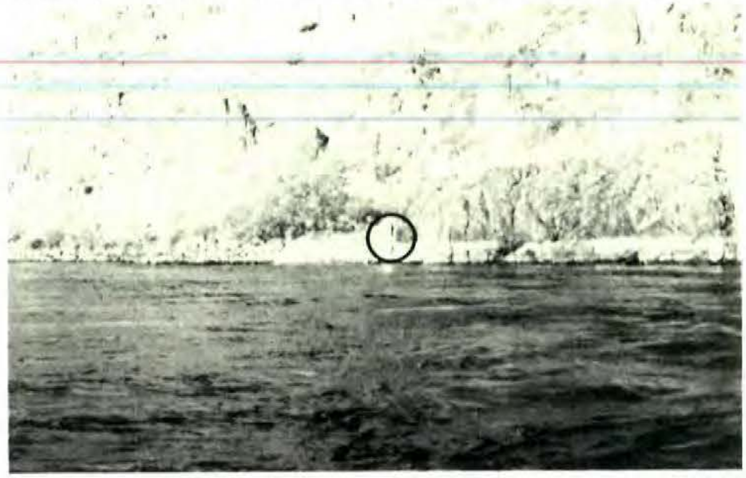


Photo by K. Bayha, BSF&W

Plate 14.3 Navigation range markers have been installed and maintained by the Corps of Engineers to aid safe navigation upstream to Johnson Bar.

CONCLUSIONS

Any conclusions reached concerning the navigability of the Middle Snake River will require some reservations. The type of boat used and the experience of the operator were found to be the principal factors involved. A 20-foot to 30-foot-long welded aluminum craft powered by an inboard jet-pump unit and operated by an experienced operator, appears to have only minor difficulties in running the navigable reach of river at all the flows tested.[3] The foot of Granite Creek Rapids is presently considered the practical upstream limit of powerboat navigation, and no attempts were made to go farther.

It is assumed that most people who operate a boat on the MIddle Snake River, other than commercial operators, do so primarily for the thrill and challenge of open-river boating. At what point a "challenge" becomes a "hazard" depends on the equipment used and the operator's ability. Even this limited test reveals a considerable range in evaluating the degree of difficulty of navigating at various flows. Since the experienced operators considered the cruises "routine" except for the 5,000 cfs flow, it might be concluded that a minimum flow conducive to relatively non-hazardous powerboat navigation between the mouth of the Salmon River and Granite Creek Rapids is between 7,700 and 5,000 cfs. There will always be some hazards involved regardless of flow, however, and anyone navigating the Middle Snake River should carefully consider the capabilities of both his boat and himself.

From the standpoint of riding comfort, speed of travel, and relative safety from hazard, the optimum flow appears to be in the range of 8,000 to 9,000 cfs.

The conclusions do not apply to other than jet-propelled boats in the 20-foot to 30-foot size. Past studies indicate that boats of this type comprise 70 to 75 percent of the powerboat traffic above the Salmon River.[4]

OTHER CONSIDERATIONS

FPC License Modification

There is presently a petition before the Federal Power Commission (FPC) requesting a modification of the license for the Hell's Canyon hydroelectric project in the interest of navigation. The

[3] The crew boat stopped at Rush Creek on the 5,000 cfs flow.

[4] In a report submitted by Fish Commission of Oregon to FPC, January 1970. Data are for recreational use in 1968-1969.

petition was filed by Lewiston and Clarkston Chambers of Commerce, and requests that the license be modified to require the release of a minimum flow of 10,000 cfs from Hell's Canyon Dam, or alternatively the amount of inflow of Brownlee Dam.

Plate 14.4 Rivers Navigation Company delivers mail to isolated ranches weekly.

The Corps of Engineers was requested to investigate the navigation problem in this connection to provide FPC information to act on the navigation interests' petition. The Corps completed its report in March 1972, in which it recommended that any modification in the license should await further development of ongoing regional water-use studies and the water-resource plans of the states involved.

Existing Navigation Project

A navigation project for Snake River from Lewiston to Johnson's Bar (RM 140-232) was authorized by the River and Harbor Acts of 1902 and 1935. No definite channel depth or width is specified, only that rocks and reefs be removed in attempting to secure a navigable channel for a three-foot stage in Lewiston. A limited number of rock points or reefs have been removed over the years to improve the channel at restrictive locations. Ranges have been set to assist passage through the more difficult passages.

Mail Boat

The Rivers Navigation Company holds a contract with the U.S. Postal Service for official delivery of mail to ranches along the river *(Plate 14.4)*. On Wednesday and Thursday, the mail run is made each week. If necessary, higher flow releases (about 8,500 cfs) are scheduled from Hell's Canyon Dam to provide adequate flow for the weekly mail run; however, this is not a requirement of the FPC license. While not a part of the data observed during the period of the controlled flow test, Mr. Rivers reports that 10,000 cfs is required by his boat, the Idaho Queen II, when heavy freight loads are carried. According to Mr. Rivers, these larger freight loads are most likely to occur in the months of December, January, February, and March *(Plate 14.5)*.

Photo by Dick Rivers, Rivers Navigation Co.

Plate 14.5 The Idaho Queen II is the largest commercial boat operating on the Snake River and requires a flow of 10,000 cfs.

The minimum FPC license flow requirement of 13,000 cfs at Lime Point (RM 169.8) provides adequate depth downstream from the mouth of the Salmon River.

Effect of Flow on Lower Snake River Navigation

The magnitude and rate of change in flow releases from Hell's Canyon Dam will have negligible effect on Lower Snake River navigation. This is because the flow required to operate the navigation locks is a small portion of the total river flow below Lewiston, Idaho.

ACKNOWLEDGMENTS

The boat used in the test runs was chartered from Mr. Norm Riddle, a Lewiston outfitter. Either he or Mr. Ed Portin operated the boat during the test runs. Both are well experienced in navigating the Middle Snake River.

Navigation evaluation forms were completed by Will W. Reid (Study Team) from Caldwell, Idaho; Floyd W. Harvey, a Lewiston, Idaho outfitter; J. Carroll Adkison, Grangeville, Idaho; Jack Bird, Lebanon, Oregon; and Ken Witty (Study Team) from Enterprise, Oregon.

The Corps of Engineers' survey team consisted of Don Mathews, team leader; Ernie Hesser, fishery biologist who assisted other teams in the Pittsburg Landing area; and Dean Hilliard, Operations Division, who observed navigation conditions as they related to the authorized channel project.

Controlled Flows on Middle Snake River
(Period of 17 Mar 73 – 27 Mar 73)

STUDY DATA

Power Boat Owner-Operator Data

Name ______________________________ Date ____________

Address ______________________________

Boat Data

State of Registry ____________________ Hull Type ____________

Length __________ Power & Type ____________________

Purpose of Trip

Number Occupants ______ Sightseeing ______ Fishing ______ Duration of Trip ______

White Water Boating ______________ Study Team ______________

River Stage

Approximate Flow-cfs ______________ Moorage Problems at ____________

Navigation

Ranges Used ______________ Corps Engrs. Nav. Charts ______________

______________ Enter at ______________

Destination ______________ Exit at ______________

Degree of Difficulty: Routine __________ Challenging __________ Hazardous __________

Point(s) of Particular Difficulty ______________________________

____

Damages During Trip, If Any

To Hull ______________________________

To Engine and Drive ______________________________

Where Did Damage Occur on River ______________________________

____

When completed return to:

Keith Bayha
BSFW
550 West Fort Street
Boise, Idaho 83724

or

Don Mathews
Corps of Engineers
City-County Airport
Walla Walla, Wash. 99362

CHAPTER 15

POWER AND WATER SUPPLY

Jack McLeod, Bureau of Reclamation
Bruce Mitchell, Idaho Power Company
Larry Dean, Bonneville Power Administration

INTRODUCTION

Identification of power and water supply needs was not an objective of the Hell's Canyon Controlled Flow Study.

This subject has been afforded chapter status because the flows found in the Hell's Canyon reach of the Snake River are a result of the Idaho Power Company's complex of dams and their operations. Data on the operations and the laws governing those operations are expressed in this chapter in order that the reader may be better oriented to the problems and potential solutions to providing

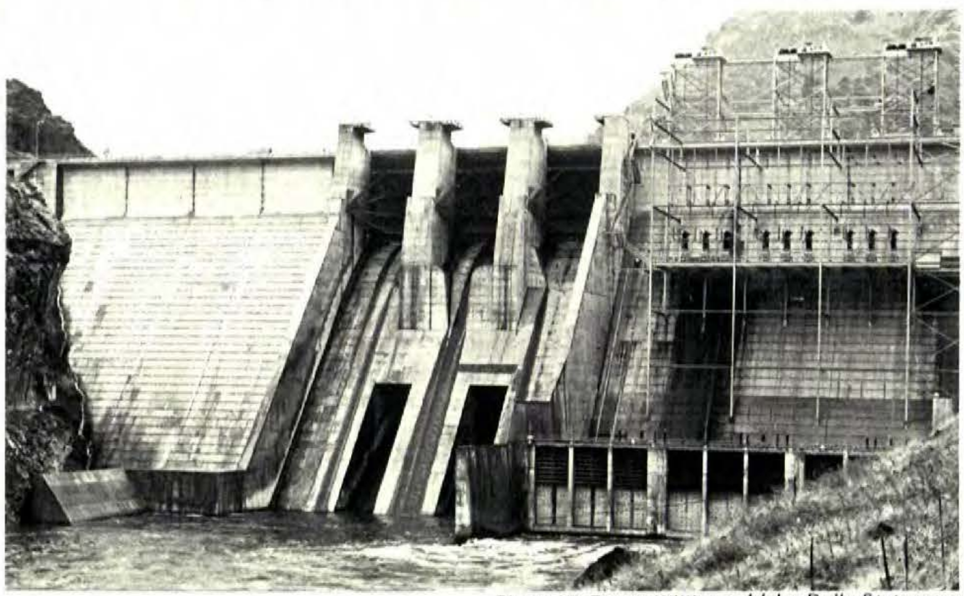


Photo by Royce Williams, *Idaho Daily Statesman*

Plate 15.1 Hell's Canyon Dam provides the ultimate control of releases to the study reach.

stream resource maintenance flows. This chapter also describes the power exchange that was required to provide the study flows.

EXISTING POWER FACILITIES

Nearly one million kilowatts, about 75 percent of the total capacity of the Idaho Power Company's hydroelectric system, is installed at the power-producing complex – Brownlee, Oxbow, and Hell's Canyon. River mile (RM) location, hydraulic and nameplate (NP) capacities, and full pond, forebay, and tailwater elevations of these projects are as follows:

Project Name	RM	Hydraulic Capacity, cfs	NP KW	Forebay Elev. Ft/msl	Tailwater Elev. Ft/msl
Brownlee	284	23,400	360,400	2,077	1,805
Oxbow	271	28,800	190,000	1,805	1,688
Hell's Canyon	247.7	33,000	391,500	1,688	1,475

In contrast to the seasonal load characteristics of the Pacific Northwest power system as a whole, the Idaho Power Company system loads peak during the summer. The most practical means the company has to shape system generation to meet power loads is the 980,250 acre-feet of usable storage at Brownlee Reservoir. Only limited reservoir storage capacity is available at the other sites (5,000 acre-feet at Oxbow and 11,800 acre-feet at Hell's Canyon). There are additional commitments upon the use of storage at Brownlee such as seasonal flood control requirements and other particulars identified in the Federal Power Commission License.

ACTIONS PRECEDING AND DURING "CONTROLLED FLOW" OPERATION

Considerable effort and negotiation was required prior to implementing the controlled flow operation. Of primary importance was the necessity for the Idaho Power Company to secure a waiver for temporary departure from some of the requirements of the Federal Power Commission License.

It was also necessary to select a study time when diversity existed between Idaho Power Company's generation capability and the Bonneville Power Administration system and to obtain an operation arrangement between the Idaho Power Company and Bonneville Power Administration so that generation could be exchanged when Idaho Power Company reduced their generation to implement scheduled flows for the study. The study required flows of 27,000; 18,000; 12,000; 7,700; 5,000; and about 24,000 cfs scheduled for 24 hours each with the minimums set for the weekend when power loads normally are lowest. The minimum of 5,000 cfs required by the Federal Power Commission License was observed during the study as measured at Johnson Bar. However, the rate-of-flow change requirements (1 ft/hr) were waived for the period of study by special order of the Federal Power Commission dated March 16, 1973.

Under a letter agreement dated February 20, 1973, the Idaho Power Company and Bonneville Power Administration formalized an exchange of energy. That agreement covered a period of time prior to March 20, 1973, terminating on April 30, 1973. The period of controlled flows was March 20-25, 1973.

Power Exchanges

On March 20, the flow was stabilized at Hell's Canyon by the Idaho Power Company for 24 hours and reduced for the subsequent days as scheduled. All reductions were made at noon at Hell's Canyon when the loads exceeded the Idaho Power Company generation. Power which had been generated by the Idaho Power Company plants prior to March 20, 1973, and delivered to the Bonneville Power Administration system, was returned to carry load on Thursday, March 22,until noon on Friday, March 23. On March 24, additional stored energy was returned to the Idaho Power Company, and by prior arrangement with Pacific Power and Light Company and the Washington Water Power contract deliveries were reduced. Generation and flows were returned to normal on Sunday afternoon, March 25.

Flow Implementation

The higher value flows for the study (18,000 to 27,000 cfs) were released from Brownlee Reservoir and passed through Oxbow according to the power needs. The flow at Hell's Canyon was

[1] Plate 15.1

adjusted to maintain a discharge of about 27,000 cfs. During intermediate flows (about 12,000 to 18,000 cfs), water was also drafted out of Hell's Canyon pond, providing additional space necessary to re-regulate for the 7,700 and 5,000 cfs flows.

Enough water was released at Brownlee to fill the previously vacated space in Hell's Canyon pond. The flows that were released from Brownlee flowed through Oxbow into Hell's Canyon and generated power that met Idaho Power Company's share of the load.

The maximum Hell's Canyon drawdown was 15 feet on Thursday, March 22, and on Sunday, March 25, the storage space was filled to within 3 feet of maximum water surface. This operation (March 20-25) made optimum use of inflow, storage, and pondage to meet the Company's share of load and provide study flows.

DOWNSTREAM SYSTEM EFFECTS

Seven federal hydroelectric plants are located on the Snake and Columbia Rivers downstream from where the Hell's Canyon controlled flows study was conducted. Those plants, Little Goose Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville have a total water-to-energy conversion factor of about 45.8 kw/cfs. The effect of the controlled flows study on those plants reduced the power production on Friday, March 23, through Sunday, March 25, below that which normally would be expected during March. Water stored during the study period was necessarily released at some other time during the spring months. Although it was anticipated that there was a significant probability that this stored water would not be usable at downstream federal powerplants, it turned out to be all very nearly usable because of the extremely low 1973 spring runoff. The loss in power generation to the Idaho Power Company system was about 660 megawatt-hours on March 23 and about 1,410 megawatt-hours on March 24.

WATER SUPPLY

Table 15.1, Inflow to Brownlee Reservoir, is from the February 1973 Columbia River Water Management Group publication, "Provisional Report on Modified Flows at Selected Sites, 1928-68, for the 1970 Level of Development, Columbia River and Coastal Basins." The flows *(Table 15.1)* are depleted (or adjusted) flows from studies for the entire system above Brownlee, in which historical flows were re-regulated to meet 1970 level of development.

For planning purposes, median values for power production are usually used as the expected amount of generation to be obtained from any given plant. Also, the minimum inflows are evaluated as the maximum liability to which a generation plant might be subjected. This covers the range of operation which may be experienced at least half of the time.

Man's major control of runoff on any stream is implemented by the existence of and the use of storage. The amount of control he may exercise is a function of the volume of inflow and the volume of storage and the efficiency of man's use of storage is directly related to his ability to forecast (predict) runoff. Therefore, the "rules" (and/or parameters) for the use of storage are based on inflows to a storage site.

The flood control provisions in the Brownlee license state that the pool elevation be at 2,034 feet msl by March 1, and, if required as determined by forecast, additional space will be made available to elevation 1,976 feet msl and will be refilled on a schedule related to the Columbia River flood control operation.

Figure 15.1 shows the monthly average inflows or the median water condition corresponding

Table 15.1 Columbia River Water Management Group

No. 13289710 — MEAN MONTHLY FLOWS, IN CFS. — BROWNLEE — Snake River Mile 285.0
No. 13290049 — OXBOW — Snake River Mile 273.0

YEAR	JULY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	ANN
1928-29	10740	10300	11910	14560	18030	13810	16020	14850	15660	18200	14710	13980	14380
1929-30	9453	9022	10450	11520	12870	13150	9894*	20720	12650	11890	12100	10090	11920
1930-31	9042	9884	9411	11840	12340	11730	10870*	15080	13210	11790*	9273	10090	11010
1931-32	7146*	7724*	7818*	9224*	11150	11010	10540	10240*	19470	21140	21400	7922*	12840
1932-33	9869	8965	10830	12010	12470	12040	11850	12590	13870	16890	16710	19190	13090
1933-34	9289	9473	10770	11980	12530	12600	13610	12870	12680	18610	9103*	8235	11800
1934-35	7726	8341	8479	10270	10890*	10740	10670	10540	11310*	15710	13240	12470	10860*
1935-36	8755	9027	9139	11200	11150	10370*	11260	12120	14970	25840	21800	15350	13400
1936-37	9678	10060	11370	11770	12320	11540	11590	11920	13020	14520	13520	10970	11850
1937-38	8767	8702	9566	11480	12180	15020	12710	14490	20420	31070	31590	24860	16730
1938-39	13180	9983	11580	13350	14870	13970	12150	18600	19710	20370	14080	10370	14320
1939-40	9421	9642	11200	12140	12150	11680	12450	18090	20970	23380	16760	10880	14040
1940-41	9164	9290	11690	12900	13740	13350	13640	20470	19160	16450	15610	16410	14270
1941-42	9944	10280	11550	13030	13960	16310	13970	17860	16790	24140	19800	21180	15700
1942-43	11060	10140	11960	12540	14600	15680	20200	26170	40030†	62480	33180	32540	24130
1943-44	19970†	10990	12270	18550	18840	15980	18480	18140	13380	15950	13990	18620	16250
1944-45	11720	10480	11560	13690	14990	13370	15550	21610	15150	17850	24750	19390	15790
1945-46	10940	10360	12700	16890	17910	16940	21930	21790	29180	38510	36310	20590	21150
1946-47	11090	11100	13310	17180	18740	18530	18710	23080	19260	19420	24210	20130	17850
1947-48	10500	10940	12810	16580	15870	15620	18810	19360	15610	18980	25540	31010	17600
1948-49	11320	10790	12780	14650	14610	14690	17340	18970	23880	26050	28530	16770	17520
1949-50	9538	10130	11950	12840	15110	14620	17210	20170	18940	39060	18630	25640	17740
1950-51	14620	11130	12760	20770†	20710†	20470	20580	28660	22860	46630	32810	20910	22670
1951-52	11270	12020	12700	18930	19220	18490	22430	23690	26710	70190†	56420†	26500	26500†
1952-53	13610	10940	12650	15410	15070	15350	22470	22110	16070	22270	20640	38150†	18660
1953-54	13930	10780	13630	14010	14100	14310	17630	20910	19350	27350	21190	21250	17320
1954-55	11120	11020	12640	13750	14070	13820	15230	17330	12460	15300	16040	14550	13910
1955-56	10370	10210	11390	13120	14110	20650	24010	21950	27950	44220	37330	31980	22240
1956-57	11370	11200	12630	17240	17480	16560	17370	24000	26490	41690	46240	29260	22590
1957-58	10610	11180	12880	15290	16430	15820	16920	27680	20110	36540	42510	26810	20990
1958-59	10800	11350	13340	13500	13960	14360	14480	18810	15220	16180	15260	16110	14410
1959-60	9957	12140	16690†	14870	13770	13510	12850	19690	21110	21370	17230	18100	15900
1960-61	9352	10820	12350	13390	14670	12720	12110	16630	15530	13600	14390	11620	13070
1961-62	8578	9022	10310	11980	12360	11990	11310	18790	13580	23040	20210	16690	13930
1962-63	9630	10330	11730	16030	15540	15960	13500	25900	13250	20920	22750	26690	16760
1963-64	10480	10300	13110	14000	14050	14110	13500	16880	14380	26310	23310	32840	16890
1964-65	10490	10700	13010	14160	14550	24290†	28640†	39490†	28539	51030	41600	35650	25870
1965-66	14910	13120†	13750	16770	19660	17030	21210	18670	15780	14720	13270	11030	15810
1966-67	10040	10340	12220	13260	13210	13290	13990	18100	14170	12770	19920	25290	14680
1967-68	11600	10750	12170	14510	16640	15480	16710	23480	16630	13530	12660	14030	14810
MEDIAN	10163	10010	11982	13597	14332	14339	14852	18886	16347	21029	20063	18901	
AVERAGE	10780	10320	11880	14030	14770	14770	15860	19560	18490	25650	22720	20030	16530

Modified, 1970

Drainage Area: 72590, 72800 Square Miles — Provisional — January 19, 1973

Figure 15.1 Brownlee Reservoir Rule Curve Median Water Condition

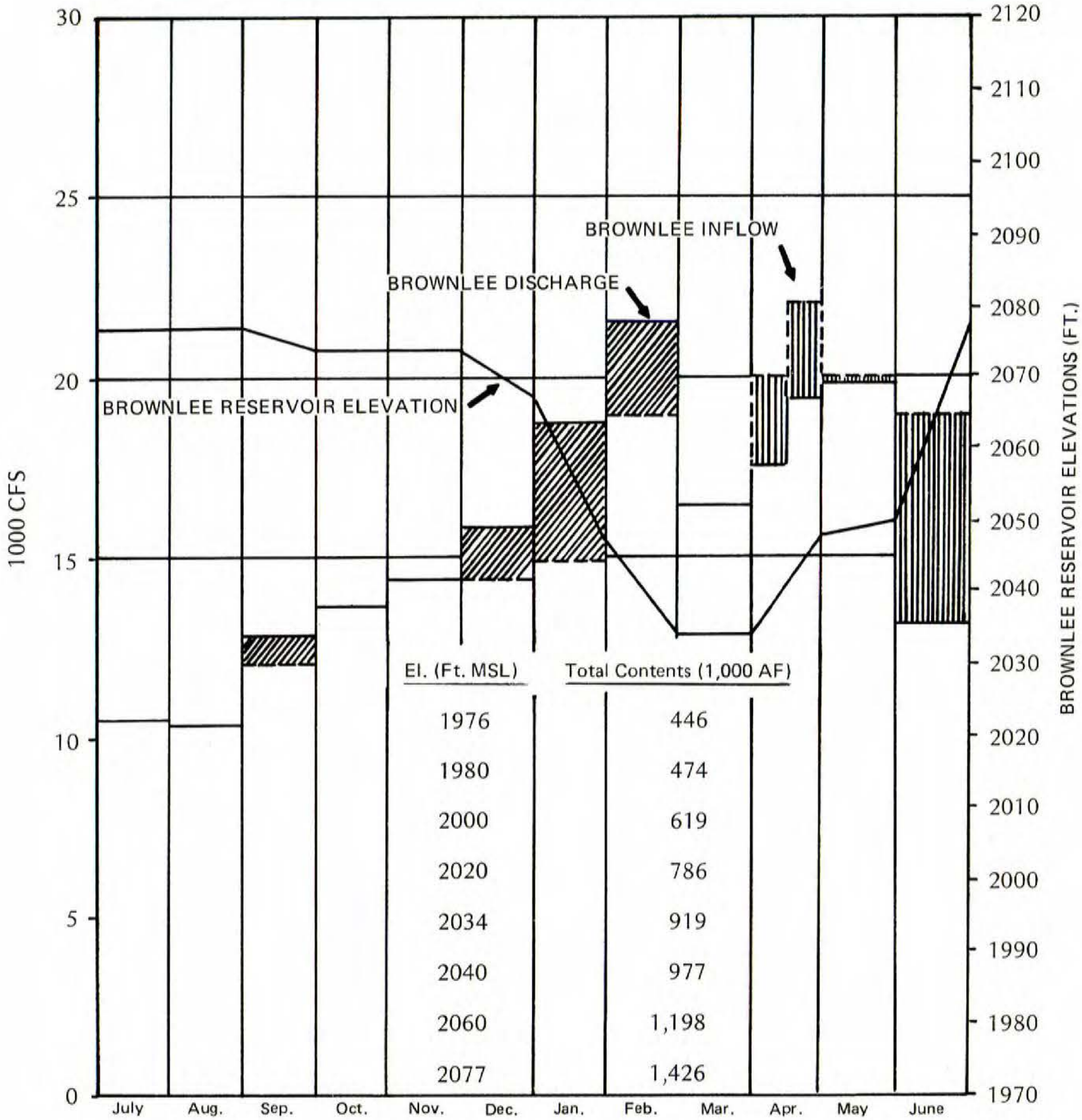
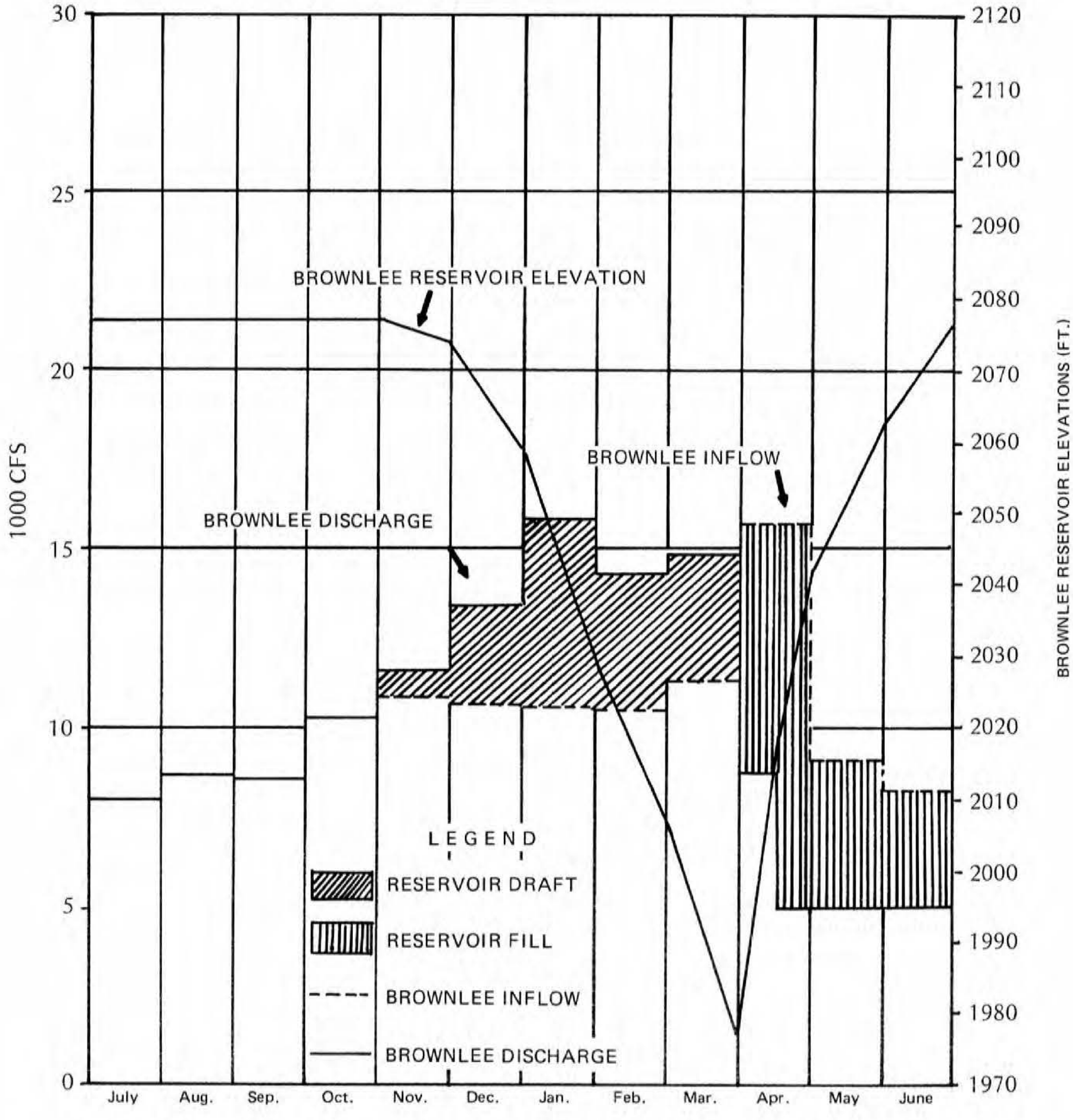


Figure 15.2 Brownlee Reservoir Rule Curve Critical Water Condition



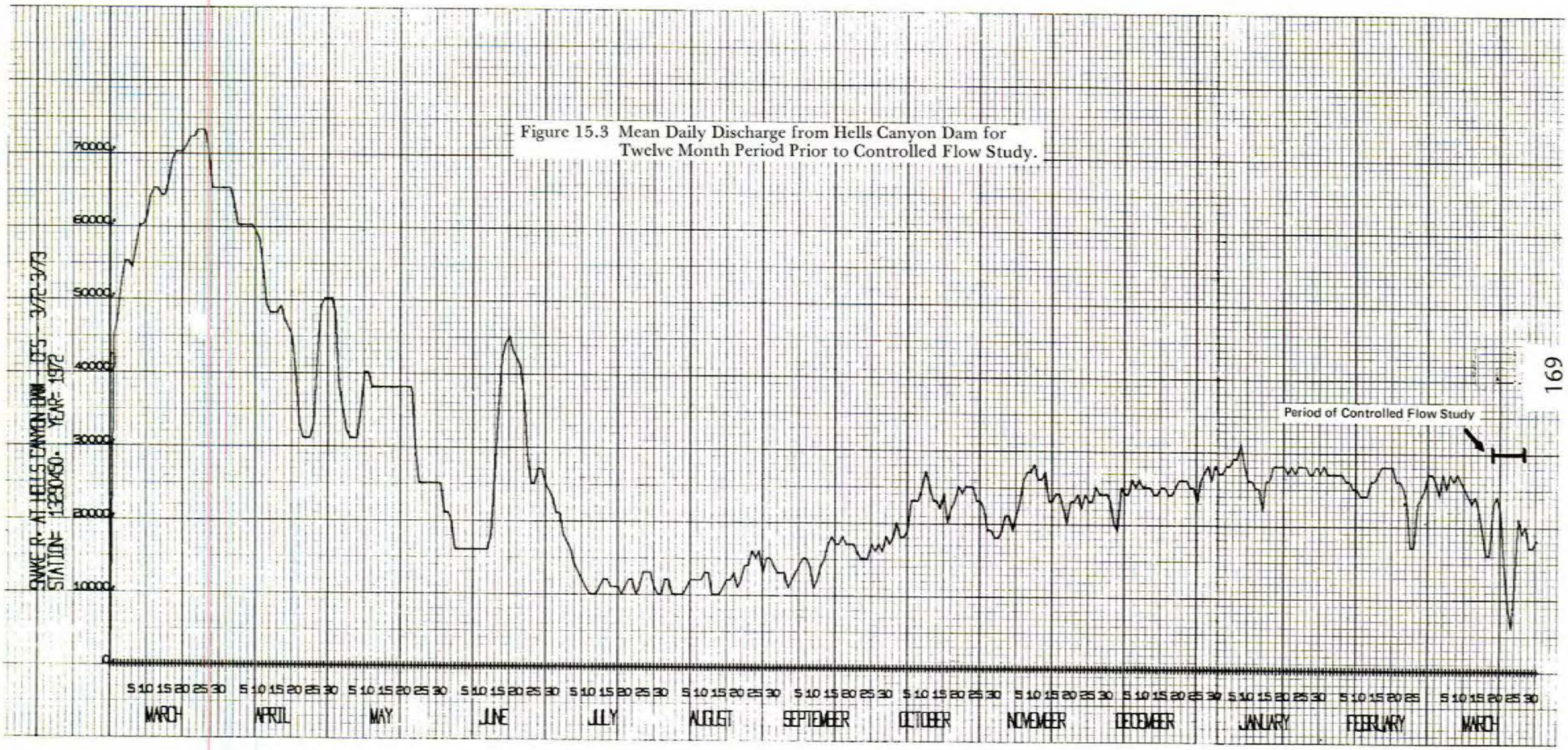


Figure 15.3 Mean Daily Discharge from Hells Canyon Dam for Twelve Month Period Prior to Controlled Flow Study.

elevations for Brownlee Reservoir, and the corresponding median discharge curve. This rule curve was developed to coordinate power operations of the Brownlee Reservoir with those of the Northwest Power Pool[1] and was based on their operating program whereby all of the Northwest operations are coordinated. *Figure 15.2* shows a similar picture for minimum (critical) operations. This minimum period was established for the 1934-35 seasonal volume.

The discharges which shaped the River below Hell's Canyon Dam during the 12 months prior to the study are shown in *Figure 15.3.* These data are mean daily discharges and display the pattern of daily fluctuations not shown in mean monthly data. The 5,000 cfs flow which occurred as a result of the study is shown as slightly greater than 6,000 cfs. This occurs because a different 24-hour period (midnight to midnight) was averaged rather than the 24-hour period during which the controlled flows for the study were implemented (noon to noon).

SUMMARY AND CONCLUSIONS

Increase and decrease of flows at a hydroproject correspondingly increases or decreases power production. However, the value associated with an increase or decrease in power production is measured in the framework of a usable pattern of power delivered to a given point for a given period of time. Also, water required for system needs sometimes becomes more valuable when retained in storage (to maintain the head for capacity) than when released for energy.

The impacts on power generation in direct relation to the "controlled study flows" are not meaningful because this range of flows does not provide enough evidence or detail to scope the nature of power generation with respect to the system and the entire Pacific Northwest area. Such factors as system characteristics, system demands, diversity, and flexibility are the type of detail required to identify for planning and operating such impacts for present and future conditions.

However, it is apparent that an increase in sustained minimum flow requirements would have an adverse impact upon the project (Brownlee, Oxbow, and Hell's Canyon) and the system, and on the future expansion of both. Since Brownlee Reservoir was constructed (August 1958), regulations involving minimum flows have been made to facilitate reservoir filling. Relative to the last 15 years of project operation, the minimum license flow (5,000 cfs) has rarely been experienced.

Article 41 of the FPC License states:

"The project shall be operated in such manner as will not conflict with the future depletion in flow of the waters of Snake River and its tributaries, or prevent or interfere with the future upstream diversion and use of such water above the backwater created by the project, for the irrigation of lands and other beneficial consumptive uses in the Snake River watershed."

Past, present, and future operations anticipated by the Idaho Power Company System are governed by the above article.

The ability to fill Brownlee Reservoir and beneficially utilize annual storable flows is paramount for power because the use of storage at Brownlee Reservoir is necessary to reshape the generation pattern of the other plants in the Idaho Power Company system on a daily and seasonal basis to match the load requirements. This is done by utilizing the 980,000 AF (usable) storage at Brownlee

[1] Article 39 of the FPC license states: *"The licensee shall operate the project and its system in coordination with the Northwest Power Pool, and shall arrange for such transmission facilities as may be required for such operation."*

and the ability to fill this space each year makes this possible. As future inflows to Brownlee Reservoir are depleted, the frequency of utilizing a minimum release to insure filling the reservoir will increase. As the sustained minimum flow is increased above 5,000 cfs, the ability to fill will decrease. Acceptance of any power-producing impairment will be dependent upon the ability to replace lost energy with an equivalent resource and the associated costs thereof.

GLOSSARY OF TERMS USED IN CHAPTER 15

Generation – The act or process of producing electrical power.

Power – The time rate of transferring energy – a commodity of capacity and energy. (i.e., energy shaped to fit a useful load pattern).

Energy – That which does or is capable of doing work – energy is generated by a hydro-electric project or system over a specified period.

Capacity – The maximum load for which a generator, powerplant, or system is rated.

Load – (1) Average load is the amount of electric power delivered for a stated period of time at a given point. (2) Peak load is the maximum load in a stated period of time.

Load Shape (or load pattern) – The characteristic variation on the magnitude of the power load with respect to time – daily, weekly, annual, or specified period.

Peaking – (capacity) – Powerplant operation to meet the variable portion of the maximum specified load.

Head – Gross head is the difference of elevations between water surfaces of the forebay and tailwater. Effective head is the gross head adjusted for hydraulic losses.

Diversity – The occurrence of two different events happening at noncoincident times in such a manner that the result of the combined operation of the two is greater than the coincidental sum of the two.

Hydraulic Capacity – The maximum volume of water that will flow through any given turbine, gate, orifice, or other water-controlled device, at any given head.

Duration Curve – A cumulative frequency distribution curve that shows the length of time that specified values were equal or exceeded in any given period.

Rule Curve – The pattern of drafting and refilling any given reservoir with respect to time.

Median Streamflow – The rate of flow at a given point for which there are equal numbers of greater and lesser flow occurrences during a specified period.

Minimum Streamflow – The minimum rate of flow at a given point during a specified period.

Depleted Flow – The controlled rate of flow at a given point during a specified period resulting from upstream and at-site reservoir operations, diversions, return flows, and consumptive uses.

Pondage – Reservoir power storage capacity of limited magnitude that provides daily or weekly re-regulation.

Re-regulating Reservoir – A reservoir located downstream from a hydroelectric peaking plant having sufficient pondage to store the widely fluctuating discharges from the peaking plant and release them in a relatively uniform manner downstream (both Oxbow and Hell's Canyon Projects provide re-regulation).

Storage Project – A project with a reservoir of sufficient size to carry over from high flow season to the low flow season and thus to develop a firm flow substantially more than the minimum natural flow (Brownlee is a storage project).

CHAPTER 16

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

Hell's Canyon Controlled Flow Task Force

INTRODUCTION

The preceding chapters cover, in part or in total, seven functional uses (water quality, navigation, fish and wildlife, recreation, esthetics, power and water supply and environment) of flows in the Hell's Canyon reach of Snake River, and a total of fourteen phases or aspects of those uses. Thus, they vary in subject matter, study methods, objectivity, and results. Each, however, reports the results of one aspect or element of this investigation, and each comprises the best information available on the subjects covered at the present time. Until more definitive studies are made, the results of this study, together with pertinent published literature, should be helpful in making decisions regarding the water requirements for instream uses in the reach of Snake River from Hell's Canyon Dam to Lewiston, Idaho.

This report is concerned only with amounts, uses and needs of instream flows in the river section studied. However, water uses and needs of the Snake River and its tributaries upstream and in the Snake and Columbia River downstream must also be considered in evaluating the potentials for achieving recommended flows in the study area. These potential upstream and downstream effects are beyond the scope of this study and could be determined only by additional investigations.

A glossary of technical terms used in this chapter is provided at the end of this chapter.

OBJECTIVES

The primary objectives of this study were: (1) to determine the lower level of acceptable flows for maintenance of the biological ecosystem and man's recreational and other uses of the Hell's Canyon reach of the Snake River; (2) to determine what flows would be optimum for those purposes; and (3) to make appropriate recommendations to be included in water planning studies. To formulate these recommendations, a 35-man task force (Chapter 1, Exhibit E) was formed to evaluate the functional data and prepare this report.

LIMITATIONS OF THE OVERALL STUDY

A major obstacle to the achievement of these objectives was the short study period. Because of the nature of the operating demands placed on the major hydropower complex immediately upstream, and because of the nature and needs of the biota resident in the stream, it was necessary to confine the study effort to a short period in the spring, when the impacts of the study itself could be tolerated. Further, time and economics dictated that the study format be limited to five controlled flows in five days. This meant that the functional studies involving biological resources were confined to one short portion of the spring season.

To develop a flow regime for a typical year, data gathered during the study must be examined and projected through all seasons of the year. In order to project these data, some dependency on past research, professional expertise, and reasoned judgment must be exercised.

The five flow format imposed an additional burden upon those studies relying on qualitative data. Because there was no way of interpolating the effects of flows between the stabilized flows observed, the results of these studies were less definitive than some of the others where quantitative data were collected.

For these reasons, specific flows were not recommended for every purpose and use considered in the study.

SUMMARY OF PRECEDING CHAPTERS

Chapters 2 through 14 covered six beneficial uses of water, and a total of 14 aspects of, or considerations pertinent to, those uses. Hydropower generation was not a part of the field study, but its relationship to flow is reported in Chapter 15 as an additional instream use. *Table 16.1* displays in matrix fashion a summary of those chapters. They are summarized in more detail as follows:

Time of Travel

It was found that average velocity of the stage wave was very close to that predicted prior to the study, ranging from about 12.9 fps, at 7,700 cfs, to 11.4 fps at 5,000 cfs. However, the average velocity of the water mass was much slower than predicted. Observations for the first 59 miles indicated that the water mass moved at a rate of about 2.3 fps at 7,700 cfs, and 1.7 fps at 5,000 cfs. Based on observations of the above flows, it would take a minimum of three days for a particular segment of water to move from Hell's Canyon Dam to Lewiston, Idaho (a distance of 107.7 miles).

Water Quality

A substantial amount of data was collected which indicates the water quality of this river reach was good in late March. No deterioration in water quality was found as a result of reducing the flows in March. However, to make a valid recommendation of instream flow requirements to maintain adequate water quality throughout the year would require repeated sampling of a range of stabilized flows throughout the year.

Aquatic Vegetation

The aquatic vegetative community was stratified on the river's substrate in a pattern apparently influenced at least in part by temporal changes and flow conditions. The area which is repeatedly dewatered as a result of fluctuations in releases from upstream power projects appeared as an ash-grey zone. The color of this zone is due to the bleached remains of periphyton adhering to the rock surfaces. Although this zone contained populations of insects and live algae, the diversity and total quantity were somewhat reduced compared to other zones. Below this zone was a productive algal community, dominated by Cladaphora sp. No specific flow recommendations were made, since it was felt that the aquatic plant community would re-establish itself under any given flow regime which would maintain an adequate, continually wetted zone. However, it appears obvious that the greater the magnitude of seasonal and daily fluctuation in flow, the greater the area of reduced productivity.

Benthic Insects

Intensive sampling of insect drift and standing crop occurred at each flow. Mortality of stranded benthic invertebrates was measured as well as the degree of migration of stranded insects during periods of decreasing flow. These data revealed that rapidly curtailed flows (even within the legal limits of one foot of stage change per hour at Johnson Bar) had a marked impact on the strand-

Chapter	27,000 cfs	18,000 cfs	12,000 cfs	7,700 cfs	5,000 cfs
2-Time of Travel Average Flow Velocities Stage Wave: Water Mass: (*Not Studied)	*	*	*	12.9 fps 2.3 fps	11.4 fps 1.7 fps
3-Water Quality	No problem anticipated	No problem anticipated	Problems associated with temperature could occur during the summer months when flows are low.		
4-Aquatic Plants (Sampled at waters edge)	Low density blue-green algae	Ash grey zone, dessicated diatoms in matrix	Dense <u>Cladaphora species</u> zone		<u>Cladaphora sp</u>. with shorter elements
5-Benthos (Sampled at 9-14" depth)	Insect numbers, diversity, and biomass low in area sampled; thus loss through exposure of substrate is relatively minor.		Increased insect diversity, numbers, and biomass found in area sampled (Cladophora zone); thus loss through exposure is of major significance.		
6-Catchability	Inadequate sample to enable conclusions				
7-Salmonids	More than optimum requirements	Between optimum and lower level of maintenance flow	.Requirements for rearing of salmonids	Inadequate	Inadequate
8-Warm Water Fishes	More than optimum requirements	Improving conditions	Probably near optimum conditions	Reduced habitat quantity balanced with improved quality at about 7,700 cfs	
9-Sturgeon	No adverse impact noted	No adverse impact noted	Impact would be through loss of food organisms which would begin at about 14,000 cfs		
10-Stranding	Stranding is a function of stage fluctuation rather than flow. Recommend restricting magnitude of daily fluctuations and re-examination of adequacy of monitoring stage at Johnson Bar.				
11-Wildlife	Impacts would be through loss of organisms in the food chain which would begin at about 12,000 cfs				
12 - Recreation Conditions for water activities: Aesthetic appearance:	Poor High	Improved from 27,000 cfs flow Good	Best observed at some sites Deteriorating 1/	Very good to very poor depening upon site Deteriorating 1/	Best to worst depending upon site Deteriorating 1/
13-White-water Boating	Above the optimum International System Rating: V - VI	Missed this flow	Near Optimum V	Below optimum (Travel time greatly increased) IV	Undesirable Conditions IV
14-Navigation	No adverse impact noted; more engine power required	No adverse impact noted	Optimum about 8,500 cfs; minimum between 7,700 and 5,000 cfs; 10,000 cfs on Wednesday & Thursday from Dec. to Mar. and 8,500 cfs April to Nov. for the mail boat.		
15-Power	Maximum Capacity of Generators				FPC license minimum

1/ A subjective evaluation based on the decreasing turbulence of rapids and on the temporary exposure of algae along the shoreline.

Table 16.1 Some Evaluations of 14 Aspects of Water Uses Related to the Five Controlled Flow Releases from Hells Canyon.

ing, translocation, and drift of these animals. But the data concerned only a relatively small segment of their life cycle and the seasonal insect population. A complete understanding of the benthic community would require year-round sampling under controlled-flow conditions. No flow recommendation was made based on this limited investigation. However, it was recognized that the benthic community is capable of becoming established on the river substrate which is consistently wetted. Drastic fluctuations of flow severely limit the diversity and quantity of the river's benthos and the area of suitable habitat.

Catchability and Fish Food Habits

Efforts to establish the relationship of flow to fishing success and food habits of fish suffered from insufficient sampling. Fish sampling was given secondary consideration by most study participants because of other priorities. Also, angling is typically slow in late March and when water flow is fluctuating. However, it appears that fishing for bass is better at the lower flows and that other fishes might be more accessible to the angler due to better definition of pools and riffles. But in the opinion of experienced biologists, long-term fishing success would be influenced by total productivity of the fish resource which could be expected to decrease with the reduction of habitat resulting from reduced flows.

Salmonids

Prior to the study, established methodology and criteria were available for evaluating habitat requirements of salmonid fishes. Investigations into the flow requirements of salmonid fishes requirements of salmonid fishes conducted during the controlled flow study produced the best-documented flow recommendations of any of the study functions. The optimum flows and lower level of resource maintenance flows thus determined are shown in *Table 16.2.*

Table 16.2 Identified Stream Resource Maintenance Flow Regimen for Salmonid Fishes to be Released From Hell's Canyon Dam.

	January	February	March	April	May	June
Minimum Acceptable	14,250*	14,250*	14,250*	15,050	15,050	15,050
Recommended Optimum	22,000*	22,000*	22,000*	23,425	23,425	23,425

	July	August	Sept.	Oct.	Nov.	Dec.
Minimum Acceptable	14,250*	12,000	12,000	12,000	15,050	14,250*
Recommended Optimum	22,000*	12,000	12,000	12,000	23,425	22,000*

* Flow levels during the egg incubation and fry emergence must be compatible with the prevailing flows during the spawning period. If the prevailing flow during the spawning period is more than those recommended (15,050 and 23,425 cfs), an adequate flow for incubation, like wise, will be more than those recommended. If it were to become necessary to regulate the river flow upwards from an agreed flow regime during the period of fish spawning, fishery agencies should be consulted to determine subsequent flows adequate for incubation and fry emergence.

Evaluations for anadromous salmonids were conducted which related to flows needed for passage of adult fish, spawning, egg incubation, and rearing of juventiles. All flows examined were adequate for fish passage. The interrelationships between spawning and egg incubation and flow were evaluated using a combination of factors. Depth and velocity measurements, dewatered salmonid redds, intra-gravel dissolved oxygen, and egg mortality were among a few of the factors examined. Rearing flow requirements are complex and must accommodate the need for food production, living space, shelter, and water quality. Information from some of the other chapters was used in determining the rearing flows.

Warm-Water Fishes

Lacking an established methodology for studying flow requirements of warm-water fishes, a subjective evaluation was made from direct aerial observations and examination of aerial photographs by an experienced fishery biologist familiar with the river reach. He discussed his observations with other experienced biologists involved in the study. Conclusions were that the best flow for warm-water fishes was between 7,700 and 12,000 cfs released from Hell's Canyon Dam. Higher flows result in less area with suitably low water velocities (partial criteria for warm-water fish habitat) and lower flows limit the quantity of habitat by dewatering side channels, sloughs, and other low-velocity areas.

Sturgeon Fishery

Investigations of the sturgeon fishery conducted during the controlled flow study were a small part of a major on-going study of the life history of white sturgeon in the Middle Snake River. No flow recommendations could be made as a result of this short term effort. However, curtailed flows will have an indirect impact on sturgeon through reduction of the organisms comprising the sturgeon's food supply.

Fish Stranding

Stranding of fish and exposure of redds occurred even though the fluctuation and minimum flow requirements stipulated by the Federal Power Commission license (one foot change of stage per hour and 5,000 cfs as measured at Johnson Bar) were not violated during the study. Fish stranding appears to be directly related to dewatering of those zones fish are most accustomed to occupying. Flow releases below 18,000 cfs and especially below 12,000 cfs expose chinook redds and spawning gravels of other salmonids. Minimum flows since 1967 have exposed fall chinook redds during incubation periods. However, the study flow conditions did not approximate normal operating conditions for the late March period. (Normally flows of a magnitude lower than 12,000 cfs would be rarely experienced, and then only under abnormal conditions.) Stabilized flows with a minimum of fluctuation would minimize stranding of fishes. Data suggest that the Federal Power Commission stipulations on rate of flow changes and location of monitoring should be re-evaluated.

Wildlife

No substantive studies of the impact of flow on wildlife were made because it was felt the major effect would occur through the impact on lower trophic levels of flora and fauna comprising the food chain for the affected wildlife species.

Recreation

The effects of flow levels on various general recreation activities were monitored and subjectively evaluated using a modification of the Kanawha River Basin Method. Specific information was recorded such as slope of shoreline, amount of exposed beach, and conditions of pools adjacent to the shore, as well as the subjective evaluations of the team members. In spite of limitations described in Chapter 12, such as the few sites observed and the subjective procedures used, it appears that the most favorable flows for general recreation activities are in the middle range of flows observed (12,000 to 18,000 cfs).

White Water Boating

The evaluation team in two kayaks and one inflatable raft ran the 18-mile white water reach from Hell's Canyon Dam to Sheep Creek at 27,000, 12,000, 7,700, and 5,000 cfs. Because of transportation difficulties, the 18,000 cfs flow was missed. In general, the higher flows produced bigger waves and more violent conditions, while the lower flows required more technical maneuvering around rocks. Wild Sheep and Granite Creek rapids should be run only by expert kayakers or rafters, and a very minimum size raft would be a seven-man capacity. At all flows, kayakers had an easier time than did the rafters. Below flows of 12,000 cfs, the time of travel was markedly increased. The best overall flow, all factors considered, for both rafting and kayaking, would be near 12,000 cfs.

Navigation

The effects of flow levels on navigation were monitored by direct observation during test cruises with a jet boat of the type prevalent on the river. Navigation evaluation questionnaires were also completed by other boatmen operating on the river during the study period. It was concluded that Granite Creek Rapids should be considered the head of navigation. The optimum flow for navigation is in the 8,000 to 9,000 cfs range released at Hell's Canyon Dam. The flow required for reasonably hazard-free navigation by experienced jet boat operators on the reach between Salmon River and Granite Creek Rapids was between 7,700 and 5,000 cfs. However, it should be noted that the team did not run above Rush Creek Rapids at 5,000 cfs, and no evaluation of the requirements of propeller driven boats was made. A 1968 Corps of Engineers report considered 8,500 cfs, measured at Joseph gage, the minimum flow for prop-driven boats. Further, the Rivers Navigation Co. states that releases of 8,500 cfs are needed on Wednesdays and Thursdays to accommodate the commercial boats, Idaho Queen III and IV (April-November), but the Idaho Queen II requires 10,000 cfs (December-March).

Power and Water Supply

The flows (during the study period) did not approximate normal operating conditions at Brownlee-Oxbow-Hell's Canyon. The regulations, power exchanges, agreements, and reduction of load, together with the power losses and system effects incurred by implementing study flows, were discussed in Chapter 15. The basic parameters which govern the present hydropower operations which shape the discharge downstream were reviewed.

As inflows to Brownlee Reservoir are further depleted, the need for a minimum release to fill the reservoir will increase. If the sustained minimum flow were to be increased above 5,000 cfs, the ability to fill would be further decreased.

In order that the reader may put the proposed flows into perspective, the following examination of the water supply is provided.

Figures 15.1 and 15.2 (Chapter 15) show Brownlee Reservoir Rule curves for median and minimum water supply conditions, respectively. Storage is normally released December through March, and refilled April through June. For the period from July through November, inflow is normally passed. Hence, the discharge during that latter period is a direct reflection of the inflow. This regulation follows the load requirements of the Northwest Power Pool. Idaho Power Company's license requires the river regulation for power to be operated in coordination with the Northwest power pool. Another license requirement is flood control operation as directed by the Corps of Engineers. (See Chapter 15.)

Figure 16.1 is a duration curve (a cumulative frequency curve that shows the percentage of time that monthly values from *Table 15.1* are equaled or exceeded during the 40-year period 1928-68). The proposed lower level of stream resource maintenance flows, by months, from *Table 7.3* is also shown. These data indicate that the study reach receives an inflow from the basin of the Snake River above the study area sufficient to meet the proposed lower level of stream resource maintenance flow 51 percent of the time. This occurs under utilization and management practices presently employed within the Snake Basin.

Figure 16.2 (reprocessed data from *Table 15.1*) shows the number of years during the 40-year period in which the suggested flow is available during each month together with the proposed lower level stream resource maintenance flow *(Table 7.3)*. It may be noted that the lower level of resource maintenance flows discussed in this report could be met most of the time by inflows to Brownlee in 9 of 12 months without any adjustment in management of upstream storage.

Figure 16.3 was taken directly from *Table 15.1*. The mean monthly maximum, minimum and median flows are plotted together with the proposed lower level of stream resource maintenance flows from *Table 7.3*. This figure reveals that the shortage in July, August, September, and November could be provided with improvements in water management. The mean monthly inflow to Brownlee for the 40 year period of record is 16,530 cfs *(Table 15.1)*.

INTERRELATIONSHIPS OF BIOLOGICAL FUNCTIONS

Many of the biological components (i.e., aquatic vegetation, benthic insects, mollusks, fish, wildlife, etc.) are interrelated and depend in part on similar flow conditions. The demise or reduction in productivity of certain components of the aquatic ecosystem may ultimately cause a similar reduction in other components. For this reason, a suitable flow regime must be established which will satisfy, to the greatest practicable extent, the total biological community.

Aquatic vegetation (Chapter 4) forms the base of the aquatic food web. Benthic organisms (Chapter 5), such as insects and crayfish, are dependent upon the plant community for food and shelter. Salmonids (Chapter 7) are dependent upon aquatic insect life for a major part of their food source, and benthic insects depend on the periphyton for their food source and partly for shelter. Other game fish (Chapters 6, 8, and 9) also are dependent upon this same base of production, although there may be other organisms in the food web. Some wildlife species also depend on aquatic life for their food supply (Chapter 11).

Flows recommended for salmonid rearing would appear to provide an acceptable habitat for these lower trophic levels, although higher flows would be needed to obtain the optimum quantity of wetted substrate. Flows less than 12,000 cfs result in a significant decrease in substrate available for food production. The character of the wetted substrate changes as the volume of flow decreases. Concentrations of gravel-rubble, so important to benthic organisms, were found in bars along the edges of the channel where eddies are prevalent at normal high flows. The larger boulders and steep rock walls, which possess less surface area, dominate the wetted substrate at the lower flows. Food organisms such as algae and insects would no doubt recolonize successfully at these lower flows, but

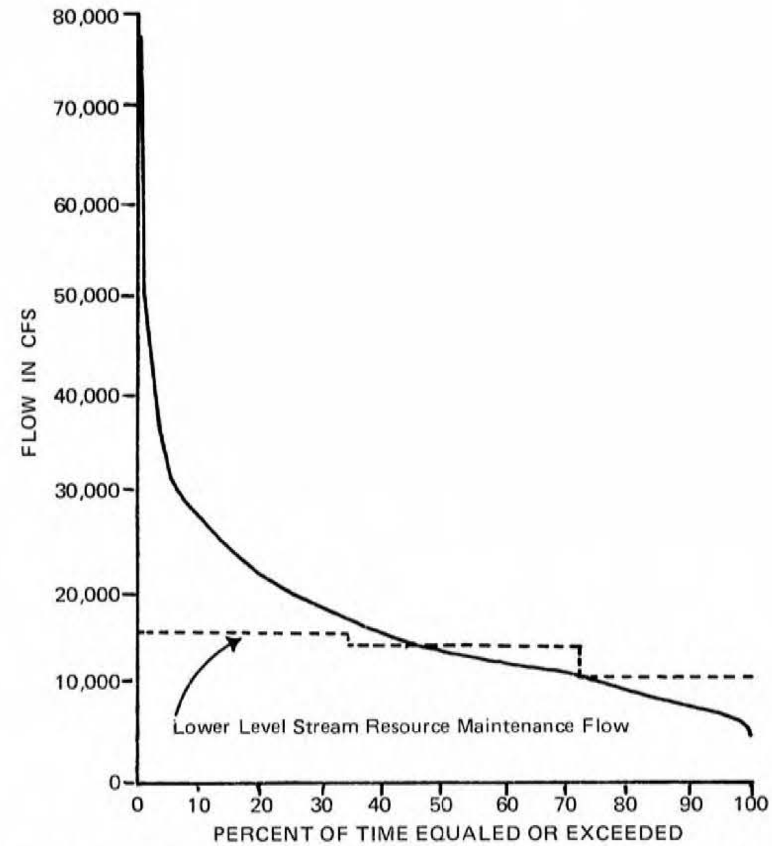


Figure 16.1 Brownlee Inflow Duration Curve Based on Median Monthly Inflow for the Period 1928-68 (Table 15.1).

FIGURE 16.2-YEARS OF AVAILABILITY (1928-68)

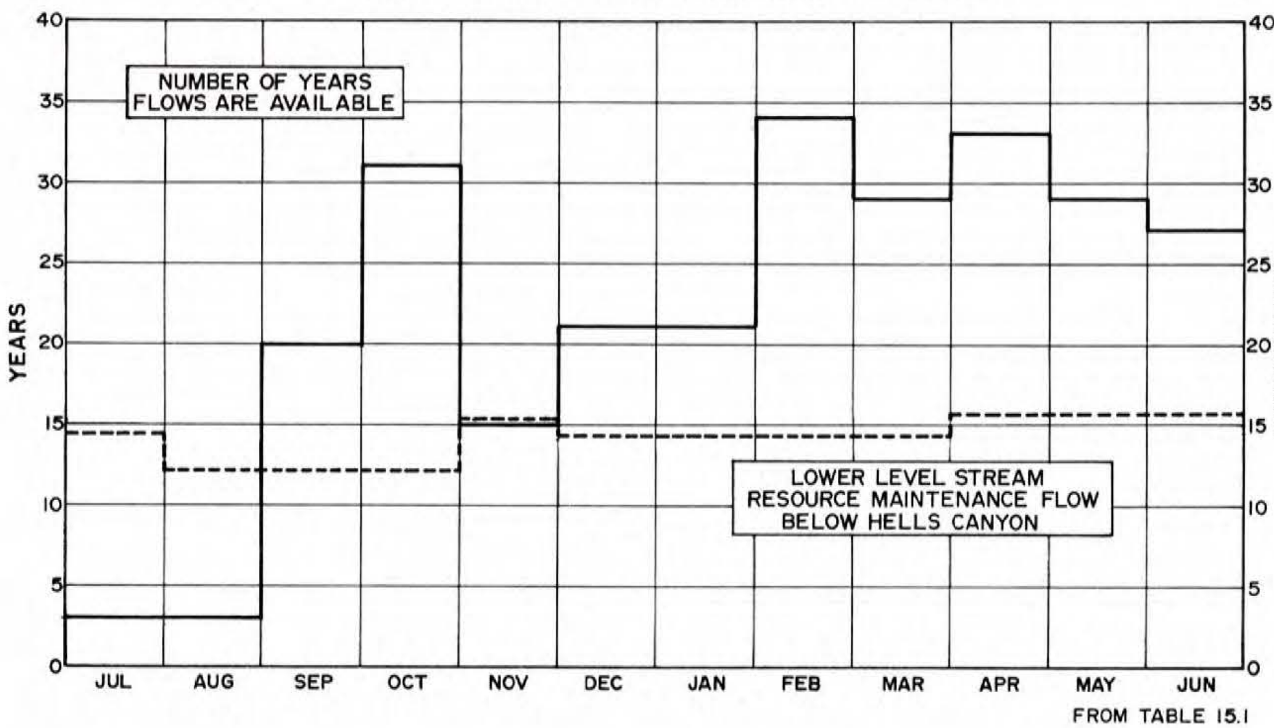
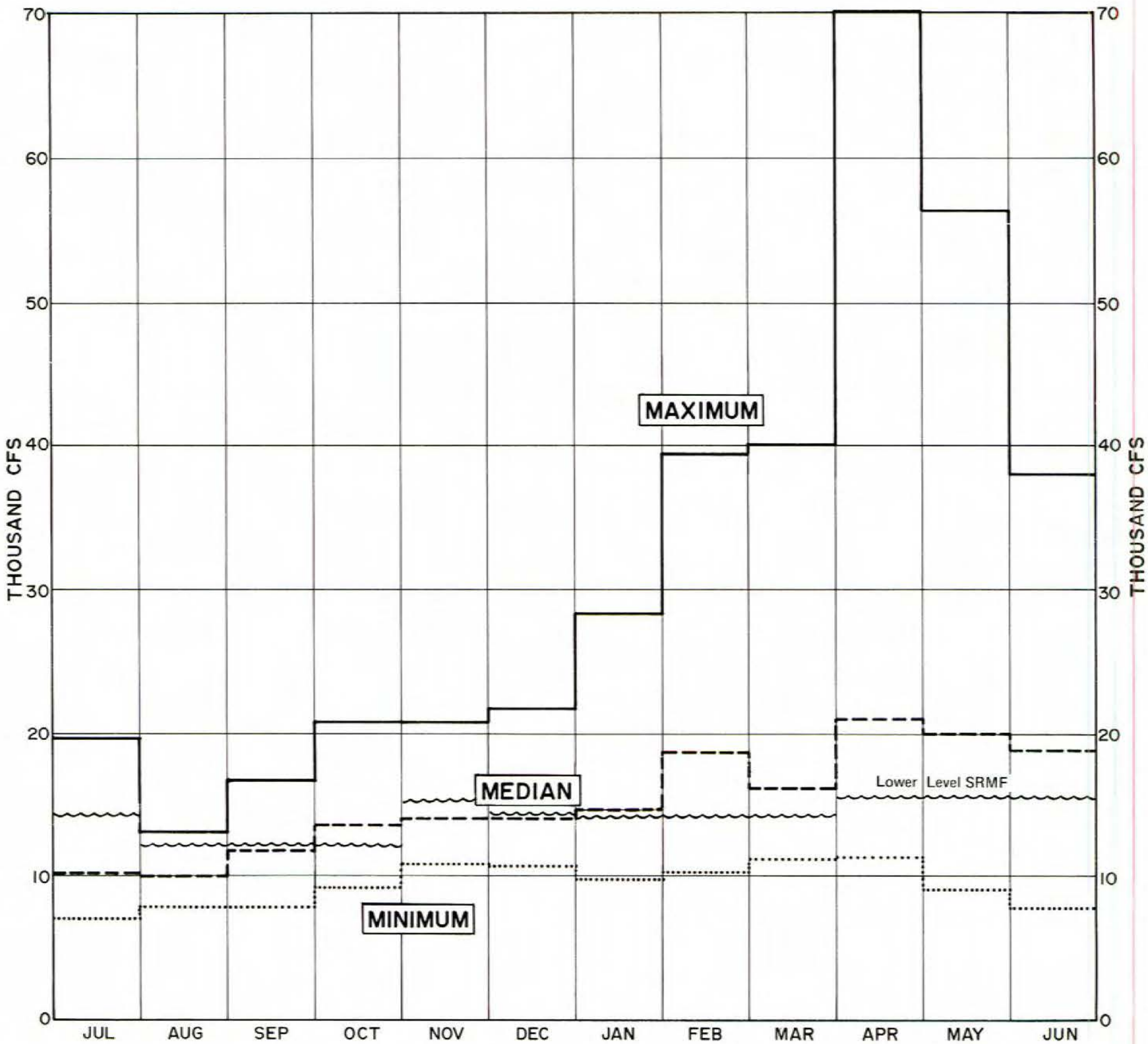


Figure 16.3 Mean Monthly Inflows to Brownlee Reservoir (1928-68)



FROM TABLE 15.I

the quantity of production would be reduced proportionately to the amount of suitable substrate. In terms of fish production, the carrying capacity of the river is determined partly by the amount of food produced.

Another interrelationship involved the magnitude of the flow fluctuations and the productivity of the aquatic ecogystem. Because a wide range of fluctuations adversely affect a greater amount of substrate surface than does a narrower range of fluctuations, the periphyton, benthic insects, fishes, and predators of fishes all are likewise adversely affected.

The species composition of the periphyton community is dependent in part on depth of water, turbidity, and duration of water fluctuation at various levels. The ash-grey zone, as described by Bailey, Chapter 4, is a relatively unproductive zone even when it is inundated (Chapters 4 and 5). Manipulation of water levels between about 14,000 and 27,000 cfs has caused periphyton in this zone to grow and die periodically. This has seriously reduced the biomass and productivity of aquatic vegetation, as well as their dependent organisms, to levels far below the potential of the area involved. To re-establish and maximize the biomass and productivity in the ash-grey zone, flows would need to be maintained at or near 27,000 cfs. However, it appears that about 12,000 cfs would provide an adequate level of insect production for the rearing stage of salmonids and other fish species.

The optimum flow requirements for resident fish other than salmonids is also near 12,000 cfs, with 7,700 cfs being near the point of lowest acceptable flow. Resident fish would benefit from the stable productivity which could be expected from a flow of 12,000 cfs.

Water quality is similarly related to fish life. Without suitable water quality, there is an adverse impact upon fish and lower trophic levels on which they depend. Conversely, a healthy aquatic vegetative community enhances water quality by supplying dissolved oxygen through photosynthesis. Turbidity resulting from algal blooms during the summer, and siltation from freshets would affect the primary production through reduction of photosynthesis. Although data collected in Hell's Canyon during March show that all water quality parameters are acceptable for fish life (Chapter 3), the potential for pollution from upstream sources exists. High temperature, low dissolved oxygen concentrations, and dissolved gas supersaturation seem to be the most likely potential pollutants. Again, in each case, salmonid fish life would be one of the first indicators of adverse conditions.

INTERRELATIONSHIPS OF MAN'S INSTREAM USES OF THE RIVER

Man's primary uses of this river reach are power generation (Chapter 15), commercial and recreational powerboat navigation (Chapter 14), float-craft recreation (Chapter 13), fishing (Chapter 6), and general recreation and aesthetic appreciation including some swimming and beach-related activities, primarily in the lower reaches (Chapter 12).

For power generation and flood control, higher flows with significant latitude for fluctuations are generally desirable. However, sand beaches in the upper portion of the study reach are decreasing as a result of entrapment of sediments in the reservoir complex and the eroding effect of fluctuating flows.

Power peaking and other flow fluctuations originating at upstream dams can produce adverse impacts on navigational use by dropping the river level and stranding boats tied up at shore. In the past, this has been a problem, but in recent times efforts by Idaho Power Company have reduced the frequency of such unfortunate incidents by keeping the people better informed of the timing and magnitude of river fluctuations.

Access for the recreationist is largely by jet boat; thus navigation flows are important to recreation use. Commercial navigation, including recreation outfitters, comprises 70-75% of the traffic in the canyon above the confluence of the Salmon River. A flow of about 8,500 cfs, if needed, can be scheduled from Hell's Canyon Dam Wednesdays and Thursdays to accommodate the mail boat. During the heavy freight hauling periods from December through March, the large Idaho Queen II needs 10,000 cfs for these weekly trips. Low flows are not normally a problem during this time of year.

Navigation below Lewiston is little influenced by flows through Hell's Canyon because of the augmentation provided by inflows from the Grande Ronde, Salmon, and Clearwater Rivers, the existence of slack-water pools, and the very small water requirement for operation of navigation locks at the lower Snake dams.

CONCLUSIONS

The foregoing discussion of the functional study results and conclusions, and the interrelationships of the biological components and man's uses, sets the stage for identifying a proposed lower level of acceptable flows for this river reach for planning purposes.

The best-documented functional recommendation within this report is that for salmonid fishes (Chapter 7). It appears from the data collected that the rearing flow recommended for salmonids would satisfy most other biological requirements, including water quality, and some of man's use requirements, insofar as can be determined at this time.

Accordingly, it is concluded that the flow regime recommended for salmonids should be considered as the tentative lower level of instream water requirement, with the exception of hydropower, and that the beneficial and adverse impacts of adopting such flows should be evaluated.

Various chapters reported the need for further study of certain aspects of the ecosystem, and man's uses and management of the river. There were also shortcomings in the study related to duration, timing and methodologies. It is concluded that additional studies should be made to serve those needs and offset recognized shortcomings.

RECOMMENDATIONS

The Hell's Canyon Controlled Flow Task Force reached no unanimous recommendations for instream flows. The majority recommends that the flow regime shown in *Table 16.3* be used by water planners in the Snake River Basin as a planning guide for those instream uses studied. These recommendations do not take into consideration upstream or downstream effects on irrigation, recreation, municipal and industrial water, fish and wildlife, flood control, power, or other uses. The Pacific Northwest River Basins Commission's level B studies for the CCJP should evaluate the beneficial and adverse impacts of providing these flows as a prerequisite to decisions about implementation and means of providing the finally adopted flows.

Table 16.3 Recommended Lower Level of Acceptable Flows, Released from Hell's Canyon Dam.

January	February	March	April	May	June
14,250	14,250	14,250	15,050	15,050	15,050

July	August	Sept.	October	Nov.	Dec.
14,250	12,000	12,000	12,000	15,050	14,250

The Task Force also recommends early action to accomplish the studies identified below.

1. Implementation of any "new minimum" discharges from Hell's Canyon Dam would require a new system-wide study of all storage in the Columbia River System to identify ways and means of providing the water.

2. Additional multi-agency studies are needed to identify instream water requirements, both upstream and downstream from the study reach, so that all instream flow requirements within the basin can be knit into a fabric which can be effectively utilized in formulation and analysis of plans and management programs for the Snake River.

3. Evidence collected during this study indicates a need for a multi-agency investigation of the impact of power peaking operations and associated water level fluctuations on the aquatic ecosystem and general aesthetics of the Middle Snake River. In addition, criteria methods and points of monitoring stage should be re-evaluated to assure adequate protection of the aquatic ecosystem.

4. Further studies should be initiated to verify the proposed formulae expressed in Chapter 2. Additional air and water temperature measurements should be collected in order to model future temperature regimes.

5. Water quality data should be collected during all seasons in order to assure that the water quality standards are being met.

6. Studies should be conducted to assess the seasonal variations of the algal biomass and species compositions.

7. Additional studies should be conducted to establish the relationship of fluctuating water levels on the life cycle of all benthic organisms, including mollusks, crustaceans, and particularly the egg stage of aquatic insects.

8. There is a need to develop a more definitive methodology for determining recreation flow requirements in large rivers such as the Snake River. There is also a need for improved methodologies in other aspects of instream use.

GLOSSARY OF TERMS USED IN CHAPTER 16

Algae: Small non-vascular plants either attached to the bottom or floating.

Aquatic Insects: Insects dwelling in water.

Benthos (Benthic): Bottom dwelling animals.

Biological Ecosystem: Deals with the relations between living organisms and their environment.

Carrying Capacity: The maximum average number of a given organism that can maintain itself indefinitely in an area.

Cladophora: A filamentous green algae attached to the substrate.

Function: A use of water.

Instream Flow Requirements: The flow required for all the collective uses of water in a stream (commercial boating, water quality, hydroelectric production, recreation, fish and wildlife, other biological forms, aesthetics, etc.).

Man's Use: Such as boating, power generation, etc.

Periphyton: A general term encompassing all aquatic algae attached to the substrate.

Redds: Nests of fishes.

Salmonid: Of the fish family Salmonidae, i.e., trout, salmon.

Standing Crop: The abundance or total weight of organisms existing in an area at the time of observation.

Stream Resource Maintenance Flow: A range of flows within which fish, wildlife, other aquatic organisms, and related recreational activities are maintained or protected.

Substrate: The surface of objects in the aquatic environment upon which organisms grow.

Trophic Level: A specialized term referring to levels of nutrition or food organisms.

Warm Water Fishes: Such as bass, crappie, catfish, etc.

Photo Appendix

The first ten plates are comparative photographs of selected sites which provide visual evidence of the effects of the five flows studied. These sites portray the variety of shoreline found in the study area.

The eighteen color photographs supplement the photos incorporated in the text in conveying to the reader some of the esthetic values available in the study reach.

Plate 1. RM 228.0 Sand Creek Camp boat landing site at the five flow levels observed. This location is Recreation Observation Site 6.

Photographs by Jake Szramek

In each 5 picture series the flows shown follow this cfs sequence:

27,000
18,000 – 12,000
7,700 – 5,000

Plate 2. RM 196.5 Relative exposure of gravel bar at Dug Bar Ranch.

Photographs by Merle Mews

Plate 3. RM 196.0 Salmonid transit site near Dug Bar, at the five flows observed.

Photographs by Duane West, OGC

Plate 4. RM 195.9 Four-shot series showing emergence of "island" below Dug Bar. Note relative turbulance of surface water.

Photographs by Merle Mews

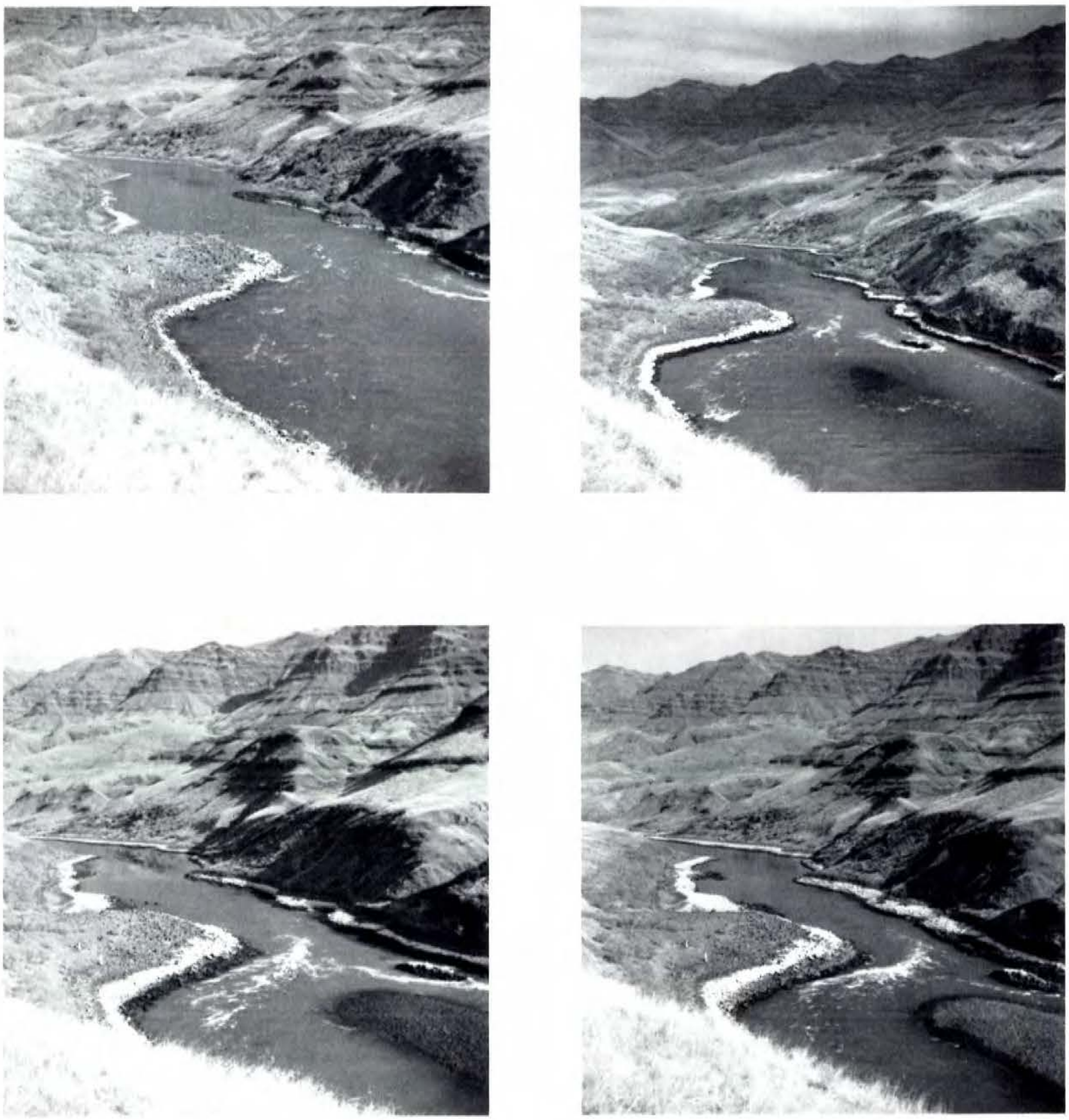
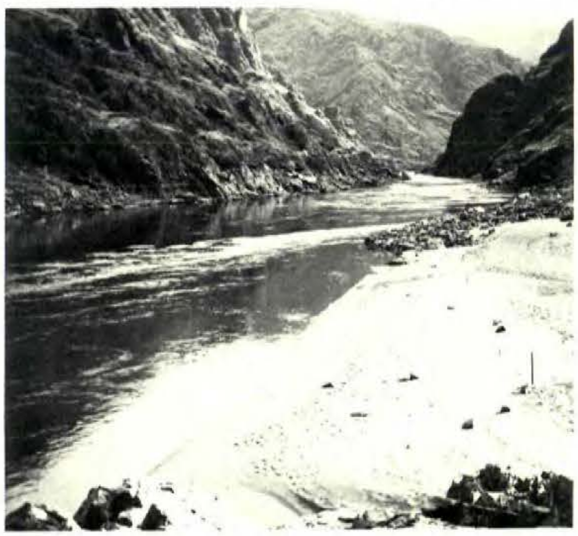


Plate 5. RM 192.3 Beach at China Bar (Joseph Gage) at the five flows observed. This location is Recreation Evaluation Site 3. Low Mt. Sheep dam site is in the background.

Photographs by Jim Morris



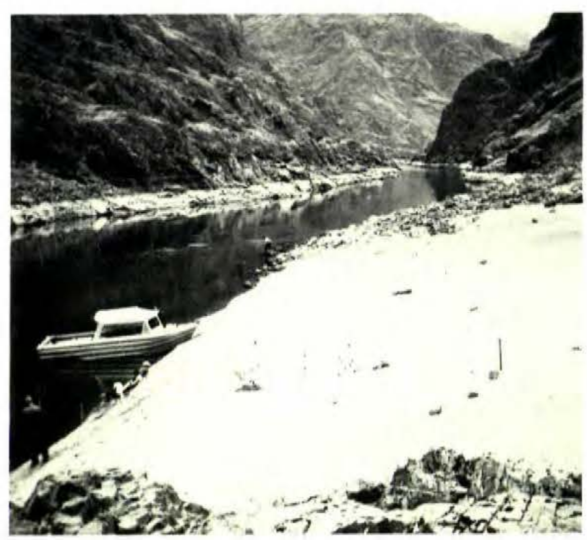


Plate 6. RM 191.4 Imnaha Rapids at the five flows observed. These rapids become difficult to navigate at 7,700 cfs.

Photographs by Jim Morris

Plate 7. RM 188.1 Flow through channel around gravel "island" located just below mouth of Salmon River ceases between 12,000 and 7,700 cfs.

Photographs by Jim Morris

Plate 8. RM 187.7 Beach below confluence of Salmon River with Snake River. This is Recreation Evaluation Site 2.

Photographs by Jim Morris

Plate 9. RM 168.3 Boat launch below mouth of Grande Ronde River. This is Recreation Evaluation Site 1a. Flow designations are releases from Hells Canyon Dam. Additional inflow is about 6,500 cfs.

Photographs by Jim Scott

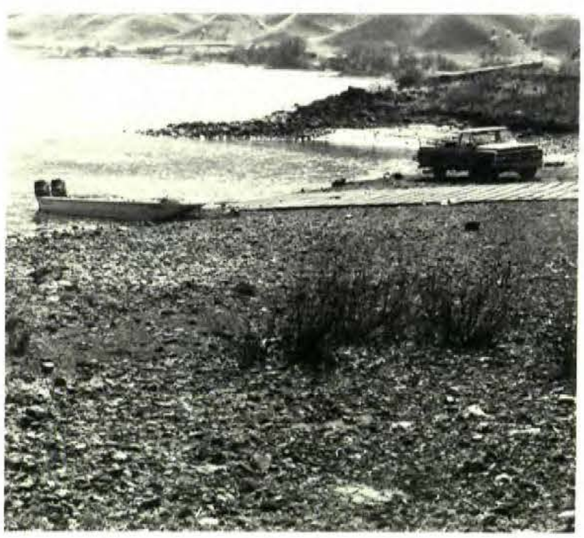


Plate 10. RM 162.5 Taplin Ferry site at the five flows observed.

Photographs by Jim Scott

Photo by Ben Pulliam, NMFS

Snake River at River Mile 146.7, just downstream from Hell's Canyon Dam.

North America's deepest gorge rises from a river bed elevation of 1500 ft., msl, to the 9,410-foot He Devil peak in the Seven Devils Mountains. (RM 245)

Photo by JIm Graban, IF&G

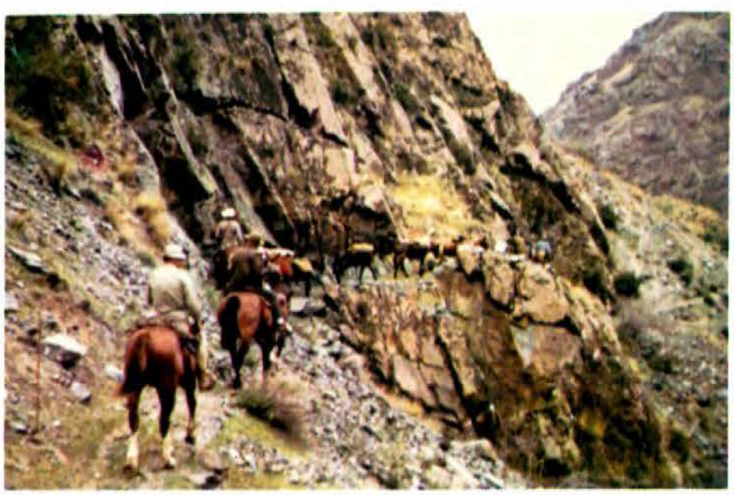


Photo by Wade Hall

Viewing Hell's Canyon from horseback or on foot offers the recreationist an outstanding esthetic experience.

Oregon Hole at River Mile 238 is a well known sturgeon fishing location.

The depth of the canyon provides the visitor with an intriguing variety of lighting conditions.

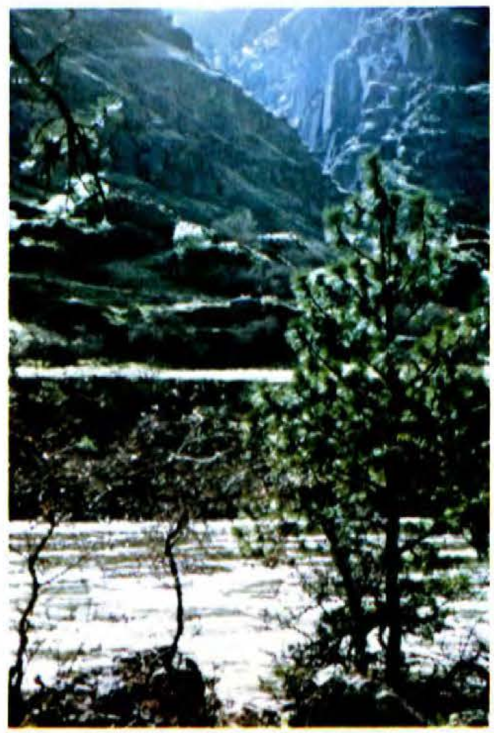


Photo by Keith Bayha, BSF&W

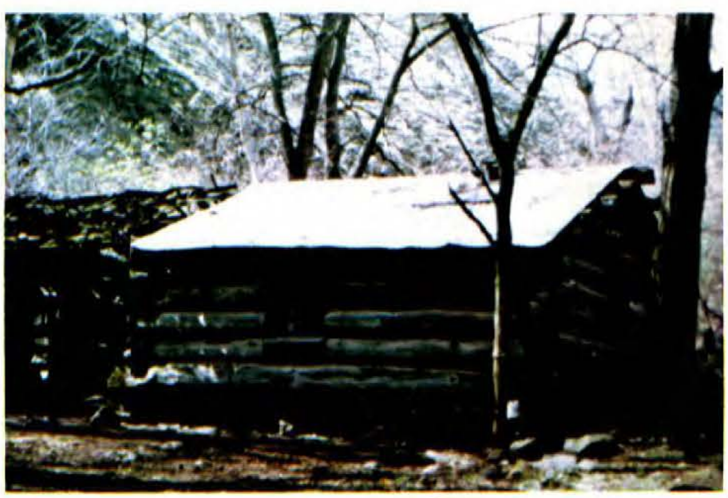


Photo by Keith Bayha, BSF&W

This old cabin at Sluice Creek is steeped in the history of Hell's Canyon. (RM 231.7)

Photo by Charles Koski, NMFS

The view from Pittsburg Saddle is impressive.

Ancient man left his mark on the boulders at numerous locations along the river. The Hell's Canyon area is exceptionally rich in archeological history.

Photo by Charles Koski, NMFS

Photo by Dick Rivers, Rivers Navigation Co.

Lower Pleasant Valley Rapids near the lower end of Pittsburg Bar (RM 213.5) is also the Pleasant Valley dam site.

Photo by Terry Holubetz, IF&G

Snake River at Roland Bar (RM 203.5) displays some of the variety that is Hell's Canyon.

The brown hills and steep terrain near Five Pine Rapids (RM 202) is ideal habitat for game birds and mule deer.

Photo by Terry Holubetz, IF&G

Photo by Keith Bayha, BSF&W

Low Mountain Sheep dam site is located just upstream from the mouth of the Imnaha River at RM 193.

Photo by Keith Bayha, BSF&W

This old foundation for an ore mill at Eureka Bar (RM 190.6) dates back to when early-day miners scoured the canyon for gold.

Cache Creek (RM 178) area typifies the Snake River below the mouth of the Salmon.

Photo by Terry Holubetz, IF&G

Photo by Charles Koski, NMFS

The Salmon River, of major significance to migrating anadromous fish, enters the Snake River at RM 188.3.

Photo by Terry Holubetz, IF&G

Wild Goose Rapids is the first significant white water encountered above Lewiston. (RM 173)

Snake River at Lime Pt., above the mouth of Grande Ronde, marks the downstream end of the major canyon topography. (RM 169)

Photo by Keith Bayha, BSF&W

Photo by Keith Bayha, BSF&W

Typical reach of Snake River between Grande Ronde and Lewiston. (RM 165.3)

APPENDIX B: Agency Comments

REPRESENTING OVER 2,000,000 ACRES OF IRRIGATED LAND

Idaho Water Users Association, Inc.

(Formerly Idaho State Reclamation Association, Inc.)

AFFILIATED WITH NATIONAL WATER RESOURCES ASSOCIATION
201 IDAHO BUILDING TELEPHONE 344-1541 BOISE, IDAHO 83702

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Nampa—District 12
ROY MILLER
Parma—District 13
JOE HENGGELER
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DONALD ZUCK
Associate Member

April 8, 1974

Mr. Keith Bayha, Fish & Wildlife Biologist
River Basin Studies
P.O. Box 6
Boise, Idaho 83707

Dear Keith:

I wish to congratulate you and the Task Force on the fine job that you did in organizing and conducting the study on the Hells Canyon segment of the Snake River. I feel that the data that you have gathered will be invaluable in the organization and conducting of further investigations on the river, both generally and for specific purposes.

Because of the original objectives of the investigation and the short time during which the investigation was conducted, I do feel that Chapter 16, Conclusions and Recommendations, is too definite. The Idaho Water Users Association does not feel that recommendations for minimum flows should be based on such a brief analysis of the river. We would, therefore, reserve our endorsement of the publication for this reason.

I would be happy to discuss this further with you, if you so wish.

Sincerely,

Sherl L. Chapman
Executive Director

cc: Mr. Tom Cotton, President

SLC:ed

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April 5, 1974

William Catlin
Pacific N.W. River Basin Committee
I Columbia River
P.O. Box 908
Vancouver, Wa. 98660

Re: Anatomy of a River

Dear Mr. Catlin and members of the committee:

I would like to preface all remarks by stating that, as a "civilian", that I have no professional expertise in either criticising or correcting the text as was compiled on the Snake River by the Controlled Flow Task Force. Those additions or corrections I am certain will be made by those with the background for such matters.

However, I would wish to address myself to the committee as an Idaho native, in business, living in Lewiston, Idaho. I believe this study is extremely important because it is the first comprehensive report that begins to explain the effects on fish and wildlife, boating, power production, and water quality resulting from specific inflows due to the control exerted by upstream Snake River dams. It would be a mistake not to begin further studies because of the number of rivers that have impoundments in which no prior knowledge existed as to what would result by placing the dams. We need such serious reports to indicate what we can expect by artificial control of the water.

Therefore, my only recommendation is to stress the critical importance of in-depth research in the field of controlled flows, and this text shows that we have had an excellent beginning.

Very truly yours,

Keith Stonebraker

Keith Stonebraker
Stonebraker Insurance, Inc.

c.c. Keith Bayha, Division of River Basin Studies
Task Force Chairman
Box 06, Federal Bldg., U.S. Courthouse
550 W. Fort Street
Boise, Idaho 83702

CECIL D. ANDRUS, Governor

Office at 1365 N. Orchard St.
Boise, Idaho

STATE OF IDAHO
IDAHO WATER RESOURCE BOARD

Statehouse, Boise, Idaho 83720
C. STEPHEN ALLRED, Director

Phone 208-384-2170

April 9, 1974

Mr. Donel Lane, Chairman
Pacific Northwest River Basins Commission
1 Columbia River
P. O. Box 908
Vancouver, Washington 98660

Dear Mr. Lane:

The Idaho State Study Team commends the Middle Snake River Controlled Flow Task Force for completing the study entitled "Anatomy of a River." The report summarizes basic data and information collected in March, 1973, for instream water uses in the Hells Canyon reach of the Snake River. This information fills a much needed area of study and will assist in formulation of a comprehensive plan for the water resources of the Snake River Basin.

The Idaho State Study Team supported this study when it was first conceptualized and take pride in its completion. Many members of the team participated in the field studies and gained valuable knowledge of the technical and practical aspects of instream flow studies. The effort provides an outstanding example of coordination and accomplishments for others to follow.

Sincerely,

Warren D Reynolds

WARREN D. REYNOLDS
Idaho State Study Team Leader

WDR:ks

UNIVERSITY OF IDAHO

MOSCOW, IDAHO 83843

College of Forestry,
Wildlife and Range Sciences

IDAHO COOPERATIVE FISHERY UNIT

April 1, 1974

Bureau of Sport Fisheries & Wildlife
Division of River Basin Studies
Box 06 Federal Bldg. -- U. S. Courthouse
550 West Fort Street
Boise, Idaho 83724

Dear Sirs:

We have reviewed our chapter on sturgeon and find no significant changes.

We have reviewed the draft of "Anatomy of a River" and think this report is an acceptable report and support publication.

Sincerely,

T. C. Bjornn   R. R. Ringe   John Coon

T. C. Bjornn
R. R. Ringe
John Coon

TCB:va

SNAKE RIVER
HYDRO POWER

IDAHO POWER COMPANY

BOX 70 BOISE, IDAHO 83707

March 19, 1974

ROBERT J. O'CONNOR
Vice President
Administration

Mr Keith Bayha, Coordinator
Hells Canyon Controlled Flow Study Report
Bureau of Sport Fisheries & Wildlife
Federal Building
550 West Fort Street
Boise, Idaho 83724

Dear Mr Bayha:

Our Company recognizes the effort exerted by participants, including Idaho Power Company, in the preparation of the report being submitted by the Middle Snake River Controlled Flow Task Force to the Pacific Northwest River Basins Commission.

In view of the consideration of the report by the Commission, the Company believes it is imperative to point out that the establishment of minimum flows below Hells Canyon Dam greater than the flows required by the Company's existing Federal Power Commission license, is opposed by the Company. The existing flows were incorporated in the Federal Power Commission license only after long and extensive hearings at which testimony was presented, and witnesses were subjected to extensive cross examination as to the required flow. Whether the flows are labeled minimum, maintenance, preservation, etc, makes little difference in their ultimate impact. The proposed increased flows would work a major hardship on the ratepayers of the Company, its customers, on the overall economy of the area, and upon the water users present and future of southern Idaho and eastern Oregon.

The Company also wishes to emphasize the point that the task force was split on the flow release recommendation. We further point out that a single five day study represents merely a start, not a comprehensive basis for a minimum flow recommendation and that electric power and other needs were not taken into consideration in the recommendations. As a result, piecemeal studies such as this must be folded into an entire river basin study, with a consideration of all water uses and requirements before any valid recommendations can be made.

We therefore believe that this study cannot reasonably be used as anything more than a start on an overall study and should not form the basis for any recommendation.

Very truly yours,

R. J. O'Connor

RJO:rm

STATE OF IDAHO
DEPARTMENT OF WATER ADMINISTRATION
STATE OFFICE

Cecil D. Andrus
Governor

R. Keith Higginson
Director

614 State Street
Statehouse – Annex 2
Boise, Idaho 83720
(208) 384-2215

Water Rights Administration
Water Resource Investigations
Dam and Reservoir Safety
Water Well Drilling
Waste Disposal Wells
Stream Channel Protection
Geothermal Resources

March 20, 1974

Mr. Keith Bayha
Coordinator, Hells Canyon Controlled
Flow Study Report
Bureau of Sport Fisheries & Wildlife
Federal Building, 550 W. Fort Street
Boise, Idaho 83724

Dear Mr. Bayha:

We appreciate the opportunity of reviewing the revised text of the report on the Middle Snake River Controlled Flow Study. In reviewing the plan of study dated February 2, 1973, it was clear that the purpose of the study was to establish minimum flow requirements for fish and wildlife, water quality and recreation. These are, of course, only a few of the many uses of the Snake River and its tributaries, both upstream and downstream. Before any minimum flow requirement is adopted as a planning guide, other aspects of water use must be taken into full consideration. I am therefore pleased that you have agreed to modify your recommendations on Page 113 to indicate that such recommendation was not unanimous and that it does not take into consideration other present and future uses of the river. The recommendation should be used for fish and wildlife, water quality and recreation planning only. With these changes, I support publication of the report.

Very truly yours,

R. Keith Higginson

R. KEITH HIGGINSON
Director

RKH:mjr

CECIL D. ANDRUS, Governor

STATE OF IDAHO
IDAHO WATER RESOURCE BOARD

Statehouse, Boise, Idaho 83720
C. STEPHEN ALLRED, Director

Phone 208-384-2170

IDAHO WATER RESOURCE BOARD

Office at 1365 N. Orchard St.
Boise, Idaho

March 20, 1974

Mr. Keith Bayha
Coordinator & Task Force Chairman
Hells Canyon Control Flow Study Task Force
Bureau of Sport Fisheries & Wildlife
Division of River Basin Studies
Box 06, Federal Building - U.S. Courthouse
Boise, Idaho 83724

Dear Keith:

As a follow-up of our letter of February 15, 1974, I would like to indicate that subject to changes we will suggest at the Commission meeting on March 21st, we have no objection to the Hells Canyon Control Flow Study Report being published. We understand that the recommendations contained within the report are intended for use as a planning guide. We understand that other water uses, both upstream and downstream, and their economic, environmental, or social effects have not been evaluated in the studies. We would intend to utilize information contained within the report as part of our planning activities in developing a State Water Plan and in working with the State Study Team in developing the Comprehensive Coordinated Joint Plan for the Pacific Northwest.

Sincerely,

C. Stephen Allred

C. STEPHEN ALLRED
Director

CSA:lm

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Nezperce National Forest
Grangeville, Idaho 83530

REPLY TO: 2610

March 18, 1974

SUBJECT: Official agency review of Hells Canyon Controlled FLow Study Report, Chapter 16, Conclusions and Recommendations

TO: Coordinator and Task Force Chairman
Bureau of Sports Fisheries and Wildlife
Division of River Basin Studies
550 West Fort Street
Boise, Idaho 83702

Fisher
Hamilton
Nee
Miller
Rose
Sundstrom
Norberg
Bayha ✓
Nadeau
Resch
Hayes

Al Espinosa, our Zone Fisheries Biologist, has completed a review of the final chapter of the November 8 study report draft. The conclusions and recommendations set forth by Task Force members are supported by the data derived from the controlled flow study and detailed in the 15 chapters of the draft report.

With the exception of a few typographical and grammatical errors, the final chapter reads well and represents a fine job of synthesis. The last part of the third sentence on page 16-11, paragraph #2 appears to be incomplete and probably should be re-stated.

We fully endorse the publication of a properly reconciled draft. Thank you for the opportunity of reviewing the draft report of the Hells Canyon Controlled Flow Study.

WILLARD C. CLEMENTSON
Acting Forest Supervisor

Director / Carl N. Crouse

Assistant Directors / Ralph W. Larson
Ronald N. Andrews

Game Commission

Arthur S. Coffin, Yakima, Chairman
James R. Agen, LaConner
Elmer G. Gerken, Quincy
Claude Bekins, Seattle
Glenn Galbraith, Wellpinit
Frank L. Cassidy, Jr., Vancouver

DEPARTMENT OF GAME

600 North Capitol Way / Olympia, Washington 98504

March 18, 1974

Mr. Keith Bayha
Bureau of Sport Fisheries and Wildlife
Box 406 Federal Building - U.S. Courthouse
550 West Fort Street
Boise, Idaho 83724

Dear Keith:

Thank you for the opportunity to review and comment on the draft report and proof copy of the Hells Canyon Controlled Flow Study Report.

We have no further comments regarding the report and endorse its publication.

Sincerely,

THE DEPARTMENT OF GAME

John Douglas

John Douglas, Deputy Chief
Environmental Management Division

JD:jb

THE STATE OF WYOMING

State Engineer's Office

STATE OFFICE BUILDING CHEYENNE, WYOMING 82001
WYOMING WATER PLANNING PROGRAM
2001 CENTRAL AVENUE

February 22, 1974

Keith Bayha
Bureau of Sport Fisheries & Wildlife
Division of River Basin Studies
Box 06, Federal Building
U.S. Courthouse
550 West Fort Street
Boise, Idaho 83700

Dear Mr. Bayha:

We have read and reviewed the report, "Anatomy of a River - An Instream Controlled Flow Investigation of the Middle Snake River; Hell's Canyon Reach; March 20-26, 1973", and find it acceptable. However, we do have reservations concerning the magnitude of possible recommended minimum flows.

Sincerely,

John W. Jackson
Water Resource Economist
Wyoming Water Planning Program

JWJ/peb

February 13, 1974

State of Washington
Department of Ecology

Mr. Keith Bayha
Snake River Study Coordinator
U. S. Bureau of Sports
  Fisheries and Wildlife
Box 06
U. S. Courthouse
550 West Fort Street
Boise, ID 83724

Dear Mr. Bayha:

The State of Washington, Department of Ecology, has reviewed the Hells Canyon Controlled Flow Study Report and agrees that it should be published and distributed to serve as an information source for making decisions about minimum flows on the Snake River.

Endorsement of the report for publication does not necessarily mean this Department is in agreement with each specific finding and recommendation. However, implementation of the report's recommendations for future study should greatly improve the region's capacity to develop a detailed comprehensive water management program for the Snake River. In the interim we do feel that the report will serve as an important data source, providing its use is tempered by full awareness of the study's limitations.

Sincerely,

John Biggs

John A. Biggs
Director

JAB:sb
6/27

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION
ROOM 365, FEDERAL BUILDING & U.S. COURTHOUSE
BOX 036; 550 WEST FORT STREET
BOISE, IDAHO 83724

February 21, 1974

Mr. Keith Bayha, Chairman
Hells Canyon Controlled Flow Study
Task Force
U. S. Bureau of Sport Fisheries
and Wildlife
Room 435, FBUSCH
550 W. Fort Street
Boise, Idaho 83724

Dear Keith:

We have reviewed the report on the Hells Canyon controlled flow study with emphasis on chapters 2 and 16, in which streamflow records were involved. All of our comments, both oral and written, submitted earlier, have been considered by the authors. The questions we raised have been satisfactorily resolved by minor changes in the text.

Sincerely yours,

Hal K. Hall
District Chief

United States Department of the Interior

BONNEVILLE POWER ADMINISTRATION
P.O. BOX 3621, PORTLAND, OREGON 97208

OFFICE OF
THE ADMINISTRATOR

February 26, 1974

In reply refer to: AD

Memorandum

To: Keith Bayha
Coordinator and Task Force Chairman

From: Harold Kropitzer, Alternate
United States Entity

Subject: Report on Hells Canyon Controlled Flow Study
(March 19-26, 1973)

We have reviewed the subject report and do not object to its publication.

Harold Kropitzer

Doug Tippett
Rt. 1 Box 141
Joseph, Ore. 97846

March 12, 1974

Mr. Keith Bayha
Bureau of Sports Fisheries and Wildlife
Division of River Basin Studies
550 West Fort St.
Boise, Idaho 83724

Dear Mr. Bayha;

I have reviewed the revised text of the Middle Snake River Controlled Flow Study and have no objection to publication.

I would like to see more study given and more information collected on the effect of the daily fluctuations of flow and how this effects sport fishing, pleasure boating and commercial boating.

I realize that during your short study you did not have the opportunity to give the normal daily fluctuation any consideration. This area is the main concern of the ones who live along the river and especially if they are in the guiding business.

Thanking you for the chance to comment on the study, I remain

Sincerely yours,

Doug Tippett

Doug Tippett

IN REPLY REFER TO:
Land Services

United States Department of the Interior

BUREAU OF INDIAN AFFAIRS
PORTLAND AREA OFFICE
POST OFFICE BOX 3785
PORTLAND, OREGON 97208

FEB 22 1974

Mr. Charles Koski, Field Supervisor
Water Resource Investigations
National Marine Fisheries
Room 441-550 West Fort Street, Box 0-11
Boise, Idaho 83724

Dear Mr. Koski:

After reviewing the accumulation of data and the interpretive effort recorded in the draft report of the Hells Canyon Controlled Flow Study Report, we feel that the information derived will contribute substantially to river management decisions in the future.

Therefore, we recommend that the report be finalized and published. It will be useful for both those directly involved with the river and others who may have related concerns.

Sincerely yours,

for Doyce L. Waldrip
Assistant Area Director
(Economic Development)

STATE OF IDAHO
DEPARTMENT OF ENVIRONMENTAL AND COMMUNITY SERVICES

Cecil D. Andrus
Governor

Statehouse
Boise, Idaho
83720

James A. Bax
Administrator

Environmental Services
February 21, 1974

Mr. Keith Bayha
River Basin Studies
Bureau of Sport Fisheries
and Wildlife
Box 06, Federal Building
550 West Fort Street
Boise, Idaho 83724

Dear Mr. Bayha:

A review of the draft report on the Hells Canyon Study has been completed.

We are satisfied with the document and recommend that it be published.

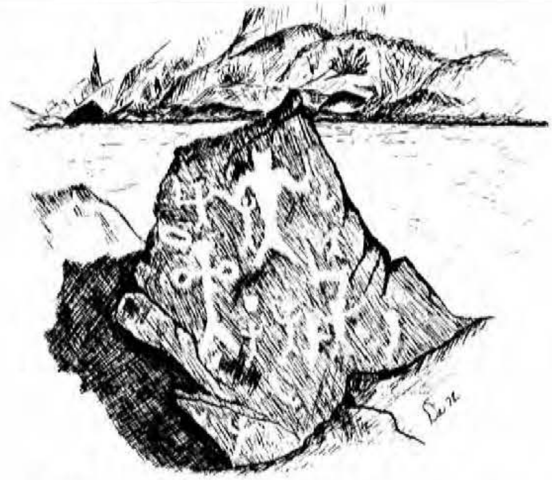
Sincerely,

DEPARTMENT OF ENVIRONMENTAL
AND COMMUNITY SERVICES

Lee W. Stokes

Lee W. Stokes, Ph. D.
Director of Environmental Services

LWS/lr



HELLS CANYON PRESERVATION COUNCIL, Inc.

P. O. BOX 2317 IDAHO FALLS, IDAHO 83401

March 20,1974

WALLOWA CHAPTER
P. O. Box 254
Enterprise, Oregon 97828

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TU-EKA-KAS AWARD

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1971 **BOB PACKWOOD**
United States Senate
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MIKE McCORMACK
United States Congress

Mr. Keith Bayha
Bureau of Sport Fisheries and Wildlife
Box 06 Federal Building
550 West Fort Street
Boise, Idaho 83724

Dear Mr. Bayha:

I have reveiwed the proof copy of the Task Force report and recommend that it be published.

Richard F. Farman

Richard F. Farman
President

"The grandeur and originality of the views presented on every side beggar both the pencil and the pen. Nothing we had ever gazed upon in any other region could for a moment compare in wild majesty and impressive sterness with the series of scenes which here at every turn astonished our senses and filled us with awe and delight."

Captain Benjamin L. E. Bonneville, 1833

IN REPLY REFER TO

United States Department of the Interior

BUREAU OF LAND MANAGEMENT

Idaho State Office
Room 398, Federal Building
550 W. Fort Street
Boise, Idaho 83724

March 20, 1974

Mr. Keith Bayha
Bureau of Sport Fisheries and Wildlife
Room 435, Federal Building
550 W. Fort Street
Boise, Idaho 83724

Dear Keith:

We have reviewed the revised draft of Anatomy of a River and commend you and the group of people working with you for this excellent effort on the Hells Canyon Controlled Flow Study. The study is a fine achievement in interagency cooperation and sets the stage well for synthesizing various water uses as well as the possible future establishment of instream flow requirements. As you know instream flow requirements (based on total Snake River management) on various stretches above Hells Canyon would be invaluable to us in determining better land use allocations.

Our review of the draft was overall rather than technical. We believe that it provides a good basis for future water resource planning and endorse its publication.

Sincerely yours,

Richard Petrie

Richard H. Petrie
Acting State Director

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION X
1200 SIXTH AVENUE
SEATTLE, WASHINGTON 98101

REPLY TO ATTN OF: M/S 633

Mr. Keith Bayha
Coordinator, Hells Canyon
Controlled Flow Study
Fish and Wildlife Service
Box 06 Federal Building
Boise, Idaho 83724

Dear Mr. Bayha:

We have reviewed the Hells Canyon Controlled Flow Study draft report transmitted by your November 8, 1973 and January 28, 1974 memoranda, and believe that the water quality considerations have been accurately treated.

We therefore endorse the publication of this document.

Sincerely yours,

L. Edwin Coate

James L. Agee
Regional Administrator

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

Region 6
P.O. Box 3623, Portland, Oregon 97208

3520
February 25, 1974

Mr. Keith Bayha, Coordinator
Hells Canyon Controlled Flow Study
Bureau of Sport Fisheries and Wildlife
Division of River Basin Studies
Box 06, Federal Bldg.,
U. S. Courthouse
Boise, Idaho 93724

Dear Mr. Bayha:

We appreciate receiving a copy of the Hells Canyon Controlled Flow Study and Chapter 16, Conclusions and Recommendations.

As participants in the study, we believe that the knowledge gained can help in better managing the resources of the Middle Snake Canyon. We hope the Pacific Northwest River Basins Commission can publish the work so the information can be used for this purpose.

Sincerely,

Robt B Terrill

ROBERT B. TERRILL
Assistant Regional Forester
Watershed Management

RI-53

UNITED STATES GOVERNMENT

Memorandum

BUREAU OF SPORT FISHERIES AND WILDLIFE
P.O. BOX 3737 PORTLAND, OREGON 97208

TO : Keith Bayha, Coordinator and Task Force Chairman, Hells Canyon Controlled Flow Study Report

DATE: February 25, 1974

FROM : Regional Director, BSFW, Portland

SUBJECT: Review of Hells Canyon Controlled Flow Study Report (your memorandum of January 28)

We believe the report to be generally acceptable and have no criticisms nor suggestions for improvement. It is an important study and a comprehensive report. We hereby endorse it and recommend publication by the Pacific Northwest River Basins Commission.

R. Kahler Martinson

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF OUTDOOR RECREATION
NORTHWEST REGION
1000 SECOND AVENUE
SEATTLE, WASHINGTON 98104

IN REPLY REFER TO:

Memorandum

To: Field Supervisor, River Basin Studies, Bureau of Sport Fisheries and Wildlife

From: Regional Director, Northwest Region, Bureau of Outdoor Recreation

Subject: Final Draft of Hells Canyon Controlled Flow Study Report

Detailed comments were provided on Chapters 1 - 15 by memorandum dated December 5, 1973, and on Chapter 16 by phone on February 4, 1974.

This report well documents the objectives, procedures, and findings of each of the individual study groups. A careful attempt has been made to describe the limitations of the study and of the data collected and to present the conclusions in such a way as to avoid misinterpretation. However, some portions of Chapter 16, Conclusions and Recommendations, could be interpreted to imply specific recommendations or conclusions not fully supported in the main body of the report. Such conceptions, we believe, can be tempered with the understanding that any conclusions or recommendations contained in the report are meant only for purposes of plan formulation in conjunction with the Pacific Northwest River Basins Commission's (PNWRBC) Comprehensive Joint Plan.

We recommend that this report be presented at the next quarterly meeting of the PNWRBC for approval.

Maurice H. Lundy

Maurice H. Lundy
Regional Director

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Room 345, 304 North Eighth Street, Boise, Idaho 83702

February 20, 1974

Mr. Keith Bayha
Coordinator and Task Force Chairman
Bureau of Sport Fisheries and Wildlife
Division of River Basin Studies
Box 06 Federal Building
550 West Fort Street
Boise, Idaho 83724

Dear Keith:

We have reviewed Chapter 16 of the draft report for the Hells Canyon Controlled Flow Study.

We stated in our comments on the first 15 chapters of the draft that we feel the study provided a lot of technical data that should be of great value in water planning studies in the Snake River Basin. In this respect we fully agree with the last sentence in the first paragraph of the Introduction page 16-1 of this chapter--"Until more definitive studies are made, the results of this study. . . should be helpful in making decisions regarding the water requirements for instream uses in the reach of Snake River from Hells Canyon Dam to Lewiston, Idaho."

Inasmuch as the study did involve the State Study Team and since the report is primarily a planning document, perhaps a multi-agency report published by the Pacific Northwest River Basin Commission would be appropriate.

We will endorse the publication of a properly reconciled report which gives consideration to the above comments as well as those of other cooperating agencies.

Sincerely,

Creighton N Gilbert acting

Guy W. Nutt
State Conservationist

cc:
Warren Reynolds, IWRB, Boise
Henry Stewart, PNWRBC, Vancouver
James Mitchell, SCS, Portland

FEDERAL POWER COMMISSION
REGIONAL OFFICE
555 BATTERY STREET, ROOM 415
SAN FRANCISCO, CALIF. 94111

73B & 100-2 (Proj. No. 1971)

February 15, 1974

Mr. Keith Bayha
U.S. Department of Interior
Bureau of Sport Fisheries and Wildlife
P. O. Box 06
Federal Building - U.S. Courthouse
Boise, Idaho 83724

Dear Mr. Bayha:

The San Francisco Regional Office of the Federal Power Commission has made a field level review of your draft report on "Anatomy of a River."

While the Federal Power Commission staff did not participate as a member of the task force in the preparation of the report, the Commission, by Order of March 16, 1973, approved the temporary departure from flow release requirements in Idaho Power Company's license for Hells Canyon Project No. 1971 so that the study could proceed. The Commission stated in that Order that "the study is well-planned and may provide valuable information on instream flow effects for use in future water use planning in the Snake River Basin."

Our comments on the first 15 chapters were general in nature and are contained in our letter of November 29, 1973. Our comments on Chapter 16 are given in our letter of February 7, 1974, and pointed out that the rate of flow change is prescribed in the license for Idaho Power Company's Hells Canyon Project No. 1971 (specifically in Article 43). Our interpretation of that article is that it prescribes regulation in the interests of power production and navigation -- the interest of aquatic wildlife being considered elsewhere in the license. It would appear that Article 43 could only be changed by approval of the Federal Power Commission of the agreements mutually worked out by licensee and other parties.

We feel that the report provides valuable information on instream flow effects for use in future water resource planning, and believe that it would be desirable to have the study published as a report of the Pacific Northwest River Basins Commission.

Sincerely yours,

M. Frank Thomas

M. Frank Thomas
Regional Engineer

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
1700 Westlake Avenue North
Seattle, Washington 98109

Field Supervisor
Bureau of Sport Fisheries and Wildlife
Division of River Basin Studies
Box 106 Federal Bldg., U.S. Courthouse
Boise, Idaho 83724

Dear Sir:

We have appreciated the opportunity to participate in the coordination, funding, and field work of the Hells Canyon Controlled Flow Study. We believe the study was successful, and those individuals involved did a tremendous job in collecting and analyzing the data. Further studies of this nature should be done on other streams to insure that wise decisions are made concerning the use of our water resource.

This letter acknowledges our acceptance of the Hells Canyon Controlled Flow Study report for publication.

Sincerely,

Acting Regional Director

OREGON STATE HIGHWAY DIVISION

HIGHWAY BUILDING • SALEM, OREGON • 97310

TOM McCALL
GOVERNOR

F. B. KLABOE
Administrator of Highways

February 15, 1974

Mr. Keith Bayha
Division of River Basin Studies
Box 06 Federal Building
550 West Fort Street
Boise, Idaho 83724

Dear Keith:

I have reviewed the final chapter of the Hells Canyon Controlled Flow Study Report. The Oregon Scenic Waterways System certainly endorses the publication of such a useful document. We regret not being able to actively participate in the study itself.

Thank you for the opportunity to examine the report.

Sincerely,

Wally Hibbard

Wallace A. Hibbard
Assistant to the Coordinator
Oregon Scenic Waterways System

WAH:jw

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Region 1, Missoula, Montana 59801

REPLY TO: 3520 River Basin Programs

SUBJECT: Hells Canyon Controlled Flow Study

TO: Keith Bayha, Coordinator and Task Force Chairman
Hells Canyon Controlled Flow Study Task Force
USDI, Bureau of Sport Fisheries and Wildlife
Division of River Basin Studies
Boise, Idaho 83724

We appreciate the opportunity to review the draft report of the Hells Canyon Controlled Flow Study.

The results of the salmonid rearing recommendations in regards to satisfying most other biological requirements, including water quality and some of man's use requirements, were noted with interest. We have considered the biological requirements for fish and insect life as good indicators in some of our pollution management programs.

We concur with your findings and summary as written, and endorse the publication of the final report for use by other agencies in developing their instream flow programs.

Ray Karr

STEVE YURICH
Regional Forester

U.S. ENVIRONMENTAL PROTECTION AGENCY

Idaho Operations Office
422 West Washington Street
Boise, Idaho 83702

February 11, 1974

REPLY TO
ATTN OF:

Mr. Keith Bayha, Coordinator
Hells Canyon Controlled Flow Study
Fish and Wildlife Service
Box 06 Federal Building-550 W. Fort Street
Boise, Idaho 83724

Dear Mr. Bayha:

We have reviewed the report on the Hells Canyon Controlled Flow Study and have a few brief comments on the water quality section.

We agree with the statement in the report, indicating the difficulty in making year around predictions of water quality based on the data collected during the five day run. Further analysis and perhaps further monitoring during other critical parts of the year are needed before finalizing minimum flows for this part of the river.

Two situations come to mind, which we think merit further considerations:

(1) During the late summer when algae are exerting the greatest influence on D. O.

(2) During the early summer when air temperature and high flow exert a large influence on total dissolved gas.

We appreciate the opportunity to comment on the report, even if we have been late in responding.

Sincerely yours,

M. Lynn McKee

M. Lynn McKee
Sanitary Engineer
Idaho Operations Office

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

ADDRESS REPLY TO:
COMMANDER (ob)
THIRTEENTH COAST GUARD DISTRICT
618 SECOND AVE.
SEATTLE, WASH. 98104

5050/1-1
8 February 1974

Mr. Keith Bayha
Bureau of Sport Fisheries and Wildlife
Division of River Basin Studies
Box 06 Federal Bldg.-U. S. Courthouse
550 West Fort Street
Boise, Idaho 83724

Dear Mr. Bayha:

In response to your memo of 28 January 1974 requesting comments concerning and review of the Hells Canyon Controlled Flow Study Report, we submit the following:

(a) The U. S. Coast Guard has no comments to offer; particular attention was given to Chapters 12, 13, 14 and 16 in our case.

(b) We do endorse publication of a properly reconciled draft.

Sincerely,

Robert A. Duin

R. A. DUIN
Captain, U. S. Coast Guard
Chief, Operations Division
By direction of the District Commander

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PACIFIC MARINE FISHERIES COMMISSION

342 STATE OFFICE BUILDING • 1400 S. W. FIFTH AVENUE
PORTLAND, OREGON 97201
PHONE (503) 229-5840

February 7, 1974

Mr. Keith Bayha
Coordinator and Task Force Chairman
Hells Canyon Controlled Flow Study
Bureau of Sport Fisheries and Wildlife
Division of River Basin Studies
Box 06 Federal Bldg. - U.S. Courthouse
Boise, Idaho 83724

Dear Mr. Bayha:

I have reviewed Chapter 16, Conclusions and Recommendations of your study report and find it a useful and highly informative document. I urge that you press forward with publication of the entire document, and seek support as necessary from the Pacific Northwest River Basin Commission.

Permit me to congratulate you both on a landmark study project itself and on the excellent organizational achievement in your study report. I am certain that this will prove to be a useful document far beyond Snake River problems and concerns. I am particularly impressed with the effort that has been made to reach reasonably definitive recommendations with the data permitted. Also I am pleased to see the emphasis upon interactions of conditions and upon additional studies required. I believe your report is adequately safeguarded also with provisos having to do with extrapolation of the data from so limited a study to year around implications.

For a number of years the Pacific Marine Fisheries Commission has pressed hard for protection of the Middle Snake River against developments which would be destructive of anadromous fisheries and other natural resources. Our resolutions of the past several years have called specifically for the kind of study which you headed, and more recently for development of a rational management plan that will consider the multiple needs of user groups and particularly will safeguard fisheries and recreational values. Because this documentation may be useful to you, under separate cover I am sending marked copies of recent Annual Reports which carry the text of those resolutions.

If there is any way I can be helpful to you in carrying forward with action on this report, please do not hesitate to let my office know. Again my congratulations to you and your multi-agency staff for a splendid effort in a most important cause.

Yours sincerely,

John P. Harville

John P. Harville
Executive Director

Idaho State
PARKS & RECREATION DEPARTMENT
STATEHOUSE MAIL - 2263 WARM SPRINGS AVE., BOISE, IDAHO 83720
PHONE: (208) 384-2154

STEVEN W. BLY, Director
R. P. Peterson, Deputy Director

CECIL D. ANDRUS
Governor of Idaho

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1122 10th Avenue, Lewiston, ID 83501
EARL GUNNELL, Member
Box 215, Soda Springs, ID 83276

February 6, 1974

Mr. Keith Bayha, Biologist
Bureau of Sport Fisheries & Wildlife
Federal Building, U.S. Courthouse
Box 06 - 550 West Fort Street
Boise, Idaho 83702

Ref: Hells Canyon Controlled Flow Study

Dear Keith:

We have completed our review of the first 15 chapters of the above-referenced draft report and the final conclusive chapter (Chapter 16, Conclusions and Recommendations), and concur with the findings and recommendations of the study report.

Our review of the study draft was overall, with special attention directed toward those chapters dealing with Recreation and White-Water Boating; areas in which we actively participated.

In previous review of the November 8 draft, we suggested certain revisions in the final recommendation and conclusions in order to strengthen the study results. With reference in the final conclusions being directed toward Chapter 7, (Salmonids) as it related to the minimum flow recommendation, with the insertion of Table 16.2, Recommended Low Level of Instream Flow, as well as the accompany Tables, we felt that final recommendations for minimum flow were within the justifiable scope of this study.

We once again commend you and your Task Force Team on their efforts in this study and offer our continued assistance.

Sincerely,

Steve

Steven W. Bly
Director

rk

STATE WATER RESOURCES BOARD

1158 CHEMEKETA STREET N.E. • SALEM, OREGON • 97310 • Phone 378-3671

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Salem

TUCSON H. MYERS, P.E.
Director

February 5, 1974

Mr. Keith Bayha
U. S. Department of the Interior
Fish and Wildlife Service
Box 06
Federal Building - U. S. Courthouse
550 West Fort Street
Boise, Idaho 83724

Dear Mr. Bayha:

We consider the study a major accomplishment in both state-federal interagency cooperation and resource needs evaluation. The report is, in general, a fine documentation of the study and we endorse publication. Specific comments on Chapter 16 were sent under separate letter of January 29, 1974, therefore, we have no further comments regarding the report.

If we can be of any further service, please do not hesitate to contact us.

Sincerely,

Tucson H. Myers

Tucson H. Myers, P.E.
Director

THM/ia

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

1218 S. W. Washington Street, Portland, Oregon 97205

February 4, 1974

SUBJECT: Hells Canyon Controlled Flow Study Report Review

TO: Keith Bayha, Coordinator and Task Force Chairman,
Hells Canyon Controlled Flow Study Task Force

We have reviewed the draft report of chapter 16 of the Hells Canyon controlled flow study report and our comments are as follows:

The recommendations for flows would be more meaningful if present flows could be given for comparison on Table 16.2 or any other appropriate place. This would also show the fluctuation which now occurs.

It seems obvious that the minimum flow, in effect, sets the level of productivity for the Snake River in the study area and that heavy emphasis should be placed on minimizing river fluctuation regardless of flow, especially during the salmonoid spawning and incubation periods.

Identifying the river locations where all flow volumes are given would make for clearer understanding throughout the report.

We would like to see a complete and properly reconciled draft report of the Hells Canyon Controlled Flow Study.

James W. Mitchell

James W. Mitchell
State Conservationist

IN REPLY REFER TO:

United States Department of the Interior

NATIONAL PARK SERVICE

920 N. E. Seventh Avenue
Portland, Oregon 97232

February 4, 1974

Mr. Keith Bayha
Bureau of Sport Fisheries and Wildlife
Box 06, Federal Building - U.S. Courthouse
550 West Fort Street
Boise, Idaho 83724

Dear Mr. Bayha:

The draft of the Hells Canyon Controlled Flow Study report including Chapter 16 has been reviewed in this office.

The report contains a great deal of information which should prove valuable in making decisions on water requirements for instream uses in the reach of the Snake River from Hells Canyon to Lewiston, Idaho. Due to the short time during which the flows were observed many effects of the flows could not be observed nor realized. Additional studies might be beneficial but may never materialize.

We have no objection to printing the report and making it available as a base document for use in determing stream flow requirements.

Sincerely yours,

Edwin L. Arnold

Edwin L. Arnold
Acting Chief, Portland Field Office

12799 Nile Road
Naches, Washington
February 3, 1974

Keith Kayha
Box 06 Federal Building, U.S. Courthouse
550 WEst Fort Street
Boise, Idaho 83724

Dear Keith:

Aside from agreeing with the conclusions and recommendations in the final chapter I have no further comments to make.

I do endorse publication of a properly reconciled draft.

Sincerely yours,

Dee

Dee B. Crouch, M.D.

DBC:vbc

United States Department of the Interior

BUREAU OF MINES

WEST 222 MISSION AVENUE
SPOKANE, WASHINGTON 99201

Western Field Operation Center
February 1, 1974

Memorandum

To: Coordinator, Hells Canyon Controlled Flow Study Team, Bureau of Sport Fisheries and Wildlife, Boise, Idaho

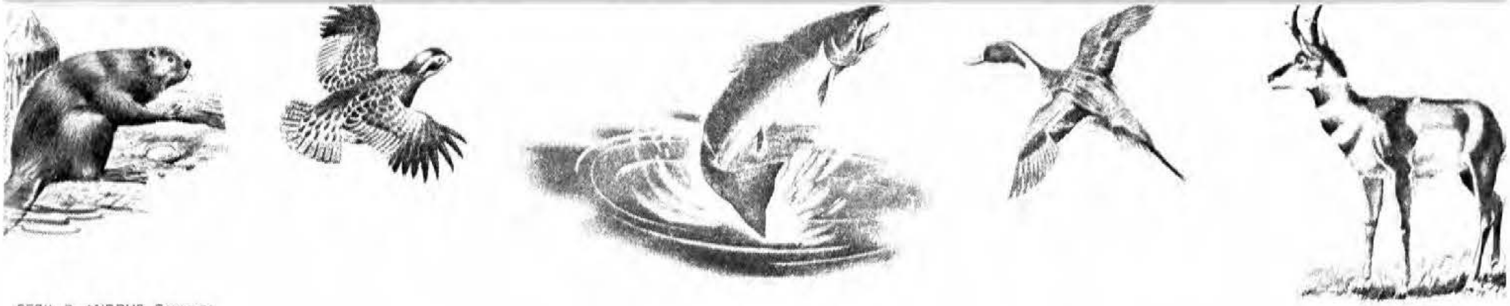
From: Chief, Western Field Operation Center

Subject: Review of Hells Canyon Controlled Flow Study Report

Review of this report, including Chapter 16, shows there is no reference or immediate relationship to mineral development. We, therefore, have no comments to offer.

We appreciate the opportunity to review the report.

R. N. Appling, Jr.



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JOSEPH C. GREENL
Dire

IDAHO FISH AND GAME DEPARTMENT

POST OFFICE BOX
600 SOUTH WALNUT STRE
BOISE, IDAHO 83

January 31, 1974

Mr. Keith Bayha
Bureau of Sports Fisheries and Wildlife
Division of River Basin Studies
Box 06 - Federal Building
550 West Fort Street
Boise, ID 83724

Dear Keith:

I have reviewed all chapters of the Hells Canyon Controlled Flow Study Report draft. I have no comments regarding the draft and you may consider this letter as an endorsement for the publication of the report.

Sincerely,

IDAHO FISH AND GAME DEPARTMENT
Joseph C. Greenley, Director

Terry Holubetz

Terry Holubetz, Water Development
Coordinator, Fisheries Division

TH:r

WASHINGTON
Department of
FISHERIES

EL J. EVANS
OVERNOR

ROOM 115, GENERAL ADMINISTRATION BUILDING • PHONE 753-6600
OLYMPIA, WASHINGTON 98504

THOR C. TOLLEFSON
DIRECTOR

January 25, 1974

Mr. Keith Bayha
Acting Field Supervisor
Bureau of Sport Fisheries and Wildlife
River Basin Studies
Boise, Idaho 83701

Dear Mr. Bayha:

We have reviewed the second draft of Chapter 16 of the Hells Canyon controlled flow study and have the following comments.

First, after reviewing the report in its entirety, we feel that the task force did an exceptional job in the short period of time allowed for the study. However, we must reiterate our previous comment in our letter of February 6, 1973 and urge that recommendations regarding stream flow not be finalized until such time as additional studies have been conducted to identify downstream flow requirements as mentioned under the Need for Future Studies.

We appreciate the opportunity to review this report.

Very truly yours,

Thor C Tollefson

Thor C. Tollefson
Director

DEPARTMENT OF THE ARMY
NORTH PACIFIC DIVISION, CORPS OF ENGINEERS
210 CUSTOM HOUSE
PORTLAND, OREGON 97209

NPDPL-FW

4 February 1974

Mr. Keith Bayha, Coordinator
Hells Canyon Controlled Flow Study
U.S. Bureau of Sport Fisheries and
Wildlife
Box 06 Federal Bldg. - U.S. Courthouse
550 W. Fort Street
Boise, ID 83724

Dear Mr. Bayha:

This letter is in response to your request for comments on the draft report of the Hells Canyon Controlled Flow Study. While we concur with the qualifying statements you make in Chapter 16, Conclusions and Recommendations, as to the limited focus of the study and the fact that the study was of very short duration with limited results, the study team is to be complimented for making a fine start in the collection of needed information.

We would also concur with your conclusion that the best information collected provided insight into minimum flow needs for fish; however, we question the statement made on page 16-15 of the draft Chapter 16 that "other study functions . . . . support the salmonid flow recommendations." Certainly the recommended levels of minimum flows developed for fish are not required for navigation and from our review of Chapter 15, Power, it would appear that a serious adverse impact could be imposed on energy generation if indicated fisheries requirements are fully implemented.

In reading the summary section of Chapter 16, the reader is given the impression that the results obtained in all elements of the study were highly decisive and reliable. Yet in reading the draft of the main report, we find firm statements that indicate the studies on Water Travel Time (Chapter 2), Water Quality (Chapter 3), Aquatic Vegetation (Chapter 4), Benthic Insects (Chapter 5), Catchability and Feeding Habits of

4 February 1974

Fish (Chapter 6), Recreation (Chapter 12), and Power (Chapter 15) to be inconclusive with additional studies needed. Chapter 8 (Warm Water Fish), Chapter 9 (Sturgeon Fishing) and Chapter 11 (Wildlife) also appear inconclusive and are handled by assuming that needs provided for salmonids will achieve minimum needs in these areas.

The subject, "Interrelationships of Man's Instream Uses of The River" is an extremely important aspect of any such study, however, the report treats this matter in an extremely superficial manner. This is probably because of the admittedly limited scope of the study and the lack of necessary information for an adequate comprehensive analysis. However, it is a shortcoming of the report.

Chapter 16 is unclear as to what is being concluded and what is recommended. It appears that the minimum flows shown on Table 16-2 are recommended, but that a number of additional studies are needed related to these flows. Logic would tell us that the studies would have to precede the implementation of new minimums but the relative time sequence of the recommended action components is not spelled out.

We concur with the need for some additional studies in the areas you have indicated although we might not necessarily agree specifically with the priority, scope and description as you have described them in Chapter 16. As indicated previously, we feel all water needs must be considered comprehensively and alternatives for achieving these needs carefully studied. As a matter of fact, the Corps is on record at this time as recommending no change in the F.P.C. license minimum flow requirements for Hells Canyon Project pending completion of the regional water use studies and the water resource plans of the States involved.

In closing, let me again compliment the Northwest fish and wildlife agencies for collecting and evaluating a substantial amount of useful fishery information as it relates to flows in the Middle Snake River area. This new knowledge will serve as a valuable input to the comprehensive water use studies in progress and those that you indicate will be needed in the future. Thank you for the opportunity to comment. I would expect that these comments along with the letters of comment of other agencies and study participants will be appended to and published with the report.

Sincerely yours,

D. E. OLSON, Alternate Member
Pacific Northwest River Basins Commission

FISH COMMISSION

OFFICE OF THE DIRECTOR

307 STATE OFFICE BLDG. • 1400 S.W. 5th AVE. • PORTLAND, OREGON • 97201

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State Fisheries Director

February 6, 1974

Mr. Keith Bayah
Bureau of Sport Fisheries and Wildlife
Room 435, Federal Building
U. S. Courthouse
550 West Fort Street
Boise, Idaho 83702

Dear Keith:

Your letter of January 28, 1974 requests an agency review of Chapter 16, Conclusions and Recommendations, of the Hells Canyon Controlled Flow Study Report. Our comments are basically the same as those presented in Wayne Burck's letter to you of January 23, 1974.

We feel the text of Chapter 16 has strayed somewhat from the stated objectives of the study, largely due to the influence of Chapter 15, Power. We do not believe Chapter 15 is pertinent to the report primarily because the power aspect was not studied, and there are no data or results. The question then arises should power be afforded a separate section of comparable status to the functions which were studied? We think not, and would prefer that all necessary background information on power be presented in the introduction or in Chapters on other functions. The potential impact on power of implementing the minimum flows recommended in the report is not within the scope of the study.

We feel the report should either stay within the stated objectives, or the objectives should be broadened.

With these exceptions, we endorse the draft for publication.

Sincerely,

JAMES B. HAAS
WATER RESOURCES ANALYST

Enclosure

cc Bureau of Sport Fisheries and Wildlife, Portland
Idaho Fish and Game Department
National Marine Fisheries Service
Oregon Wildlife Commission
Washington Department of Fisheries
Washington Department of Game

United States Department of the Interior
BUREAU OF RECLAMATION
PACIFIC NORTHWEST REGIONAL OFFICE
FEDERAL BUILDING & U.S. COURTHOUSE
BOX 043-550 WEST FORT STREET
BOISE, IDAHO 83724

IN REPLY REFER TO: 735
123.

Mr. Keith D. Bayha
Bureau of Sport Fisheries and Wildlife
Room 435, Federal Building and U.S. Courthouse
550 West Fort Street
Boise, Idaho 83724

Dear Mr. Bayha:

We would like to commend you and the group of people working with you for the fine work you have done on the Hells Canyon Controlled Flow study. This study represents a major initial step in the analysis and evaluation of instream flow needs.

In response to your letter of November 8, 1973, and in further response to the letter of January 28, 1974, significant comments are included in this letter. Other major comments on the Abstract, Preface, Introduction, and Chapters 1 through 15 are included in Attachment A.

The Bureau of Reclamation will recommend publication of the controlled flow study draft report if this letter, without attachment, containing Bureau of Reclamation comments is appended to the controlled flow study report. We suggest that all other agency comments be appended to the report.

Chapter 16 contains "Recommended Lower Level of Instream Flow to be Released from Hells Canyon Dam" (Table 16-2). Referring to Glossary of Terms used in Chapter 16, the definition of "Instream Flow Requirements" states "The flow required for all the collective uses of water in a stream (commercial boating, water quality, hydroelectric production, recreation, fish and wildlife, other biological forms, esthetics, etc.)." The two words "flow required" cannot be supported for a majority of the stated use by established and tried methodology. Instead of "flow required," the instream flows for each use would be proposed flows based mainly on judgments made from observations, limited data collection, and modification of available methodology. One exception can be made, and that applies to the flows recommended for the salmonoid fishes. The Oregon Method was used to determine functional requirements although this method was established and used in streams in Oregon that were much smaller in magnitude than the Snake River below Hells Canyon Dam.

It should be distinctly pointed out that the 12,000 to 15,050 cubic feet per second flows primarily relate to the "salmonoid fishery." These flows are tentatively judged to be needed for spawning, hatching, and rearing of salmonoid species including fall chinook salmon and steelhead.

If the salmonoid fishery is not used as a basis for proposing collective use instream flow requirements, the uses of commercial boating, water quality, hydroelectric production, recreation, and esthetics considered separately or collectively could require less than 12,000 cubic feet per second. Examples are the present instream flow requirement of 8,500 cubic feet per second needed on Wednesdays and Thursdays to accommodate the commercial boats Idaho Queen III and IV (April-November) and the Idaho Queen requirements of 10,000 cubic feet per second (December-March). The present Federal Power Commission license requirement for hydroelectric minimum flows is 5,000 cubic feet per second below Hells Canyon Dam.

The last sentence under "Summary of Functional Studies, Fish Stranding," Chapter 16, states that "Data suggest that the Federal Power Commission stipulations on rate of flow changes and location of monitoring should be reevaluated." What documented study data suggest reevaluation of rate of flow changes? How were these data obtained--by tested methodology, observation, judment decisions, or other methods? A new study involving the U.S. Geological Survey and the Federal Power Commission should be initiated to substantiate the above reevaluation.

The statement made in the third sentence of the second paragraph under "Conclusions,"--"The other study functions, to varying degrees, support the salmonoid flow recommendations"--does not appear to state a valid recommendation. What does "to varying degrees" mean and/or represent? The "other study function" does not support "salmonoid flow recommendations."

The last sentence of the second paragraph under "Conclusions," Chapter 16, states "Therefore, the recommended instream flows are shown in table 16-2." We feel that the above statement has to be expanded upon as to who is recommending the instream flows in table 16-2. Is it the Pacific Northwest River Basins Commission, all participating agencies in the study task group, or one, two, or three agencies? The instream flow recommendation should be expanded to specify that (1) it is a tentative recommendation based on the short-duration controlled flow studies, (2) it does not attempt to take into account competing uses of water, and (3) further studies are badly needed. (These studies are listed at the end of the chapter.)

The Bureau of Reclamation supports the recommendations stated under "Need for Future Studies" in Chapter 16, especially study needs (1.), (2.), (3.), (5.) and (8.). Study recommendations (1.) and (2.) should include studies of water use conflicts and of benefits and other values foregone in upstream and other areas if minimum flows in the Snake River below Hells Canyon Dam are increased. The economic and environmental impacts to the States of Idaho and Oregon from increased flows could be of major significance.

Sincerely yours,

Norman H. Moore

Assistant Regional Director

Enclosure

cc: Donel Lane, Chairman PNWRBC, Vancouver, Washington
Regional Director, Bureau of Sport Fisheries and Wildlife, Portland, Oregon
(each w/o enclosure)

DEPARTMENT OF THE ARMY
WALLA WALLA DISTRICT, CORPS OF ENGINEERS
BLDG. 602, CITY-COUNTY AIRPORT
WALLA WALLA, WASHINGTON 99362

NPWEN-PL

20 February 1974

Mr. Keith Bayha, Coordinator
Hells Canyon Controlled Flow Study
U.S. Bureau of Sport Fisheries and
Wildlife
Box 06 Federal Bldg. - U.S. Courthouse
550 West Fort Street
Boise, Idaho 83724

Dear Mr. Bayha:

We have completed our review of the draft of Chapter 16, "Conclusions and Recommendations, Hells Canyon Controlled Flow Study Report," as requested in your letter of 28 January 1974. As stated in our letter to you of 5 February 1974, we concur with the general comments on Chapter 16 provided you by Mr. D. E. Olson of our Division Office. Other comments were given you by Mr. Don Mathews in your telephone conversation of 28 January 1974. Following is a summary of those comments which we still consider valid, along with some additional observations.

Page 16-5, Table 16.1, Chapters 5 and 11. Statements that benthos productivity begins to improve at 12,000 cfs and lower flows should be correlated with flows at which wildlife and sturgeon fishery are impacted. We suggested a minimum of 7,700 cfs for wildlife in our previous comments.

Page 16-5, Table 16.1, Chapter 12. Conditions for powerboating. We do not concur with the conditions noted, since adequate data were not obtained in this study to establish conditions.

Page 16-10. Last two sentences of first paragraph should be deleted since this material was not cited in Chapter 14, "Navigation," and there is no valid source of data to support the last statement on commercial boat flow needs. We note that reference to "head of navigation" has been deleted.

Page 16-11, second paragraph. Change third sentence to read: "Salmonoids (Chapter 7) are dependent upon aquatic insect life for a major part of their food source and on aquatic vegetation for part of their shelter."

Page 16-11. Third paragraph, fourth sentence, should read: "Concentrations of gravel-rubble, so important to production of benthic organisms, were found in bars along the edges of the channel where eddies are prevalent at normal high flows."

Pages 16-13 and 16-14. In discussion of the subject, "Interrelationships of Man's Instream Uses of the River," the relationship of one of man's primary uses of the river, power generation, appears to be treated rather superficially. Particularly, the impact of increased minimum flows on power production capability has not been mentioned. Admittedly, any detailed discussion of this impact is beyond the scope of this study.

Page 16-17. Delete sentences 5 and 6 under Water Supply and substitute "Idaho Power Company's license requires the river regulation for power to be operated in coordination with the Northwest Power Pool."

Page 16-18, Figure 16.1. Word "optimum" should be removed.

Page 16-20, Figure 16.2. This Figure is rather difficult to understand. Perhaps addition of arrows to indicate which ordinates and abscissas go with which flow lines would be appropriate. Our interpretation of Figure 16.2 is that it indicates for 3 months or 25 percent of the year the "maintenance flow" would be available in only 3 years in 40. For 6 months it would be available only 52 percent of the time and in no month is the "maintenance flow" available 100 percent of the time. Thus it appears the last sentence in the first paragraph of page 16-19 is misleading.

Minor corrections to Chapter 14 were also given to you by telephone. They are listed as follows, for the record:

a. Page 14-6. Correct "Cottonwood and High Range . . . . "

b. Page 14-6. Correct "Chartered boat is based . . . ."

c. Page 14-9, (5). " . . . . upper ends usually become smoother."

d. Page 14-10, last sentence. "At lower flows the ranges (Figure 14.2) must be used with discretion . . . ."

e. Page 14-12, fourth paragraph. " . . . . to provide FPC information to act on the navigation interests' petition."

f. Page 14-17. Revise footnote 1/ "See Corps for information on other damages."

It is our understanding that additional revisions have been made to Chapter 14, "Navigation," since we made our 18 January 1974 comments on the draft copy of the report you sent to us on 8 November 1973 for review. To date, we have not received a copy of the chapter showing these latest revisions. We wish to have the opportunity to comment on these revisions prior to preparation of the proof copy since we have been given the responsibility for preparation of Chapter 14, "Navigation." Also, it is recommended that comments of the various participating agencies be included in your final report.

Thank you for the opportunity to comment on the study.

Sincerely yours,

Nelson P Conover

NELSON P. CONOVER
Colonel, CE
District Engineer

WILDLIFE COMMISSION

OFFICE OF THE DIRECTOR

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JOHN W. McKEAN
Wildlife Director

February 22, 1974

Mr. Donel J. Lane
Pacific Northwest River Basins Commission
1 Columbia River
P. O. Box 908
Vancouver, Washington 98660

Dear Don:

The Commission's report on the Middle Snake River study of March 1973 and its flow recommendations in Chapter 16 are fully endorsed by Oregon Wildlife Commission.

The leadership of Bureau of Sport Fisheries and Wildlife and participation of all who made possible a study of this magnitude is mutually appreciated. It is our intention, as that of other participating agencies, to urge that recommendations resulting from the study be incorporated in federal and state planning and legislation affecting the Snake River drainage.

Maintenance of adequate flows in middle and lower Snake River is a vital element of the river's fisheries management program. Perpetuation and development of the white sturgeon, smallmouth bass, rainbow trout, summer steelhead and fall chinook salmon runs, and other game fish are goals of state and federal fisheries management agencies. Any existing or future development of the Snake River drainage which would significantly deplete or alter flows in the middle or lower Snake River would be especially critical to salmonid populations and could adversely affect the warm-water fish species.

Sport fishing and other recreational uses of Middle Snake River rely substantially on boat access. Flows specified for navigation and white-water boating are important to realize much of the value of game fish populations in Middle Snake

River. Among other reasons, boating has made possible a significant and growing recreational use of Hells Canyon reach of the Snake. Additional studies are underway to monitor this use.

The opportunity to have participated on the instream flow study of Middle Snake River and to comment on the River Basins Commission's draft report and recommendations is appreciated.

Sincerely yours,

John W. McKean
Director

cc Bureau of Sport Fisheries & Wildlife, Boise
Fish Commission of Oregon
State Water Resources Board

CECIL D. ANDRUS, Governor

STATE OF IDAHO
IDAHO WATER RESOURCE BOARD

Statehouse, Boise, Idaho 83720
C. STEPHEN ALLRED, Director

Phone 208-384-2170

Office at 1365 N. Orchard St.
Boise, Idaho

February 15, 1974

Mr. Keith Bayha
Coordinator & Task Force Chairman
Hells Canyon Control Flow Study Task Force
Bureau of Sport Fisheries & Wildlife
Division of River Basin Studies
Box 06, Federal Building - U.S. Courthouse
Boise, Idaho 83724

Dear Keith:

Our review comments on the Hells Canyon Control Flow Study Report, as requested in your memorandum of January 28, 1974, are as follows:

GENERAL COMMENTS:

We recommend that the report be published as a product of the Multi-Agency Task Force and not as a Pacific Northwest River Basins Commission's report. The report as now drafted (as a Commission report) would require approval by all members of the Commission. Although we feel the information is of value and warrants publication, we do not feel that sufficient studies have occurred regarding other alternative needs to warrant Commission adoption of recommended minimum flows at this time. Studies are now underway as part of state water planning and CCJP study activities which will better identify and evaluate alternative needs and means to meet these needs.

We further recommend that all of the backup material be published as an Appendix to the Multi-Agency Task Force report. This would ensure that the field data would be readily available to water resource planners concerned with this reach of the Middle Snake River. Without the availability of that data, we feel that a significant benefit of the study would be foregone.

SPECIFIC COMMENTS:

1. Page 16-2, first paragraph: The language should indicate that the primary objectives of the study were objectives No. 1 and No. 2 as shown in the draft. The material following on page 16-2 then logically supports objectives No. 1 and 2. The reason objectives 1 and 2 were pursued was for the purpose of allowing water planners to obtain better information for use in their future study efforts.

2. Page 16-3, third paragraph: The first sentence states that functional studies covered six recognized beneficial uses of water, and etc. I suggest that the six uses be clearly identified (water quality, fish, wildlife, recreation, navigation, power) and that the word "recognize" be deleted.

3. Page 16-4, first paragraph: At the end of the paragraph, the word "greater" does not adequately identify the magnitude of fluctuations and flows that are significant. It should be clarified whether the frequency of fluctuations, the amount of fluctuation, or the combination of the two factors is of primary importance.

4. Page 16-5, Table 16.1: Would the comments shown under Water Quality for the 5,000 cfs, 7,700 cfs, and 12,000 cfs flow be valid if it were assumed that provisions of P.L. 92-500 were fully implemented? The comment for salmonoids shown for the 5,000 cfs and 7,700 cfs flow could be expanded to indicate the consequences which occurred historically when flows fell below this level. The comment shown for wildlife could be expanded to better indicate what the impact had been historically at these various flow levels.

5. Page 16-6, last line: Suggest that the information be included in this chapter in summary form so that the reader does not have to refer back to tables elsewhere in the report.

6. Page 16-8, first paragraph: The last sentence in this paragraph should be deleted. The sentence does not add to the factual study as conducted by the multi-agency task force and is not a conclusion that can be reached based on the limited single purpose study effort that was conducted.

7. Page 16-15, second paragraph: Delete the last sentence of this paragraph and replace with the following: "Therefore the Multi-Agency Task Force concludes that the minimum flow schedule deemed desirable for maintaining salmonoid fisheries in the study reach would equal or exceed those required for water quality, recreation, wildlife, and navigation needs identified for this study reach of the Middle Snake River."

8. Page 16-15, third paragraph: The third paragraph should be deleted. The information in chapter 10 does not suggest that the FPC stipulation on rate of flow change in location and monitoring should be reevaluated. We feel that the single purpose study effort as conducted by the multi-agency task force is not of sufficient depth to warrant this type of conclusion.

9. Page 16-16, table 16.2: Revise table heading to read as follows: "Identified Desirable Minimum Flows for Fisheries, Water Quality, Wildlife, Navigation, and Recreation Uses in Study Reach of the Middle Snake River."

10. Page 16-22, item No. 8: Delete the word "recreation" and include after the words "flow requirement" "for instream uses."

Thank you for the opportunity to comment on chapter 16. If you have any questions, please feel free to contact me or Mr. Warren Reynolds.

Sincerely yours,

Wayne

WAYNE T. HAAS
Deputy Director

WTH:lm
cc: Mr. John Streiff
Mr. Donel Lane

WATER: NOW AND FOR ALL OUR TOMORROWS

PACIFIC NORTHWEST RIVER BASINS COMMISSION

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