Contract No. DACW68-78-M-2586

A REVIEW OF THE IMPACTS OF FLUCTUATING FLOWS ON THE LOWER CLEARWATER RIVER AND RECOMMENDATIONS FOR FUTURE STUDIES

by

Donald F. Haber

Professor of Civil Engineering

and

Beth Moore, William Hicks

November 22, 1978

Idaho Water Resources Research Institute
University of Idaho
Moscow, Idaho

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I. INTRODUCTION

This report is intended to present summaries of the present and potential impacts of flow fluctuations caused by power releases from Dworshak Dam, on the north fork of the Clearwater River to Lewiston, Idaho, on various environmental, recreational, economic and social activities. The summaries were obtained by: 1) personal contact or telephone communications with persons involved in research work specifically concerned with the lower Clearwater; 2) personal contact with persons concerned with recreational activities and business activities associated with the lower Clearwater River; 3) personal contact or private communications with other researchers who have expertise in assessing the effects of fluctuating flows on other river systems in the Northwest; 4) a literature search conducted by the Water Resources Scientific Information Center, at the University of Wisconsin, Madison, and 5) an extensive literature review of previous research work on the lower Clearwater River or similar case studies.

The main body of the report gives an overview of the impacts, present or potential on the major environmental, social and economic activities. Those sources of information that contributed directly to the preparation of this part of the report are referenced in the specific section. Other sources of information which contributed background information are listed in the bibliography.

After each section, an analysis is presented which attempts to prioritize the areas of greatest concern. These analyses were derived from the summaries and an interdisciplinary conference held at the IWRRI, University of Idaho, on September 19, 1978, specifically for prioritizing future research activities on the lower Clearwater River in regard to fluctuating flows. Appendix I lists the people and their positions who took part in the conference on September 19.

Finally, a prioritized list of future research activities which are considered the most important: (1) to assess the impacts at the present level of fluctuation; (2) to assess the impacts at possible increased levels of fluctuations and (3) studies that would address possible ways of lesser potential adverse impacts.

II. APPLICABILITY OF INFORMATION ON FLOW FLUCTUATIONS FROM OTHER RIVER SYSTEMS

The lower Clearwater River has many unique features. A brief summary of these features may clarify the issue of what information may be gathered from other rivers.

1) The lower Clearwater River is approximately 40 miles long and is free flowing until its confluence with the Lower Granite Reservoir.

2) This stretch of flowing water has a very high catchability rate for steelheads returning to Dworshak Hatchery (located 2 miles below Dworshak Dam) compared to the impounded waters of the lower Snake and Columbia Rivers.

3) Dworshak Dam on the North Fork of the Clearwater is approximately two miles upstream from its confluence with the Middle Fork and comprises about one-third of the total flow.

4) Because of the present policy for releases, the water temperature of the lower Clearwater tends to be colder than pre-impoundment temperature in the summer and warmer in winter.

5) Water quality both before and after impoundment is high.

These features tend to make research information on the lower Clearwater site specific. For example, the trout fishery below Libby Dam, Flaming Gorge Dam and Glen Canyon Dam did improve significantly over pre-impounded levels even with large flow fluctuations presumably because of reduced turbidity. Turbidity reduction in the lower Clearwater is present only at certain times during spring run-off.

Another unique feature of the lower Clearwater is the presence of steelhead and the extreme importance of the steelhead fishery. During the fall run of steelhead the lower Clearwater becomes a focal point for fisherman from eastern Washington, northern Idaho and western Montana.

III IMPACTS ON THE FISH FOOD CHAIN

Primary Production

The effect of flow fluctuations on primary production in the lower Clearwater has not been studied. But, conclusions from similar studies stress the importance of isolating impacts on the lowest level of the food chain as higher levels will be influenced in time. In a study conducted on the upper Snake River, Kroger (1972) states that a reduction in primary production caused by flow fluctuations is inherently detrimental to the production of sport fish. The author explains that river bed exposure following sudden flow decreases destroyed algae and higher plant life due to surface desiccation. Destruction of productive habitat limits the production of sport fish by reducing the available food supplied at primary production levels (Kroger, 1972).

Bailey (1974) studied the effects of differing flows on the number and type of planktonic algae for the Hell's Canyon reach of the middle Snake River. Both Bailey (1974) and Brusven et al. (1974) measured a distinct faunal zonation whose vertical and lateral extent depends on hydroelectric power demands and the slope of the shore. Brusven (personal communication) believes that a less obvious and, as yet, unmeasured faunal zonation may exist in the lower Clearwater River. Bailey (1974) made no predictions as to the effects of flow on kinds and number of algae in the river. Variations in algae biomass and species due to fluctuating flows could not accurately be separated from variations induced by other environmental factors.

A proposal to study limnological aspects of Dworshak Reservoir in the 8th and 9th years after filling has been submitted to the Corps by Falter (personal communication). A part of the proposed study would determine the significance of selective water withdrawal. The impact of warmer water releases, should it occur, on both the lower River and the Reservoir would need to be assessed.

Analysis

Although the effects of fluctuations on algae production in the lower Clearwater has not been studied directly, a major consideration can be determined from other researchers' work. Changes in water flow produce a "zone of fluctuation" that, in some cases, destroys productive habitat (Powell, 1958). The severity of such an impact is tied closely to the amount of exposed shoreline and the length of the exposure.

Insects

Kroger's study (1972) conducted on the upper Snake River concludes that insects cannot reoccupy exposed river shorelines at population levels noted prior to impoundment. This is because algae and higher plant forms were destroyed. Existence of insect species depend, in part, on the presence of a stable community of primary producers. For example, Radford and Harland-Row (1971) stated that the number of ephemeropteran species, present on a regulated river in Alberta, was influenced by the scarcity of algae in the tailwaters. Whether for different reasons, Brusven and MacPhee (1976) observed on the lower Clearwater River that both the number of species and densities of insects increased generally with increasing depth from the transient shoreline. Furthermore, results suggest that depth and current velocity determine the distribution of species in terms of biomass and numbers.

Three parameters, depth, water velocity, and substrate, must be considered in accounting for the influence of fluctuating flows on the aquatic community. Stalnaker and Arnette (1976) maintain that the depth parameter is secondary to velocity as a primary agent in maintaining desirable insect communities. Brusven and Trihey (1978) allude to the same conclusion by stating that "velocity may well be 'the' parameter which dictates the conditions of the physical habitat."

Curtis (1959) attempted to determine the quantity of water needed to preserve aquatic life in a steeper gradient section of a river experiencing reduced flows. He found that during major flow reductions, the mean velocity of water exhibits a greater percentage of reduction than maximum depth and wetted perimeter. For river shorelines that are steeply inclined, this statement holds true. But, the percentage of reduction in the wetted perimeter will approach that of the mean velocity of the water as shoreline slope decreases. In conjunction to the above conclusions, Brusven (personal communication) also found that the effects of flow fluctuation and stranding of benthic insects was greatest on shorelines having low slopes on the lower Clearwater.

Minshall and Wagner (1968), as well as, Brusven et al. (1974) found that reductions in flow caused increases in invertebrate drift. Drift may also be triggered by a reduction in living space as discharge decreases. On the lower Clearwater, Brusven (personal communication) notes that both reduction and increase in flow initiate drifting. Drift rates below Dworshak are more heavily influenced by fluctuations than the aspect of bottom density (Brusven and Trihey, 1978). Brusven et al. (1975) recommends that moderate flow regulation during dark hours would prove less detrimental to insect communities than during daylight hours.

Odum (1969) introduced the concept of "pulse stability" in reference to maintaining a certain daily frequency and magnitude of fluctuations below hydroelectric power dams. In a similar light, Brusven and Trihey (1978) suggested that daily fluctuations on the lower Clearwater River within the defined zone impose less direct stress on the insect community than extreme weekly, biweekly or monthly fluctuations would.

Analysis

At the present rate of fluctuation on the lower Clearwater river, a stable aquatic insect community exists (Brusven et al., 1975). Increased levels of fluctuations could reduce these levels, as longer-term analysis may reveal. The amount of flow reduction is the critical unanswered question. Determination of benthos loss may indicate losses in algae production; the reverse of which may also be true.

Moderate flow regulation during dark hours, as well as, daily fluctuations (as opposed to weekly, biweekly or monthly fluctuations) would impose less direct stress on the insect community (Brusven, personal communication). If fluctuations approach some degree of periodicity, similar to a tidal pulse, adaption for insect communities may be slightly favored (Odum, 1969).

IV. IMPACTS ON FISH

Biological

The lower Clearwater River had supported a substantial smallmouth fishery and a minimal resident trout fishery before impoundment. The decline in smallmouth bass abundance and catch rates following impoundment occurred for three reasons according to Pettit (1976):

1) Major spawning areas were lost.

2) Cooler river temperatures affected the time and success of bass spawning.

3) Flow fluctuation, in conjunction with river temperatures, affected growth rates, delayed spawning and reduced nesting success.

Today the smallmouth bass population is reduced to remnant status and as Pettit (1976) states, "... will be unable to recover to their former abundance in the free-flowing portion of the lower Clearwater River above Lower Granite Reservoir."

Although the smallmouth bass harvest started to decline before impoundment and continued to decline after Dworkshak was built, anglers have experienced a high success rate when fishing for trout (Pettit, 1976). This suggests that the resident trout population has increased, in part, because reduced summer water temperatures could have enhanced trout survival and aquatic insect survival (Pettit, 1976).

According to most researchers, current flow fluctuations are thought to have a minimal effect on the adult steelhead in the lower Clearwater. Present variations in velocity induced by fluctuations impose little threat on the survivial chances of the populations

(Stanford Research Institute, 1971). Recent research on steelhead movement during changing water levels shows steelhead move laterally to a habitat that has similar velocity conditions to that, which existed before change in levels (Bjornn, personal communication).

Generally, stream dewelling trout are found to spend 95% of their time at potential resting spaces that comprise 15% of the stream area (Hooper, 1973). The ways in which flow fluctuations on the lower Clearwater River would affect the resident trout's territorial stability have not been studied. Evidence suggests that trout populations may be restricted by the number of unsafe microhabitats in a stream section (Hooper, 1973).

For the lower Clearwater River, Brusven and MacPhee (1976) conducted a diversion and flume study with chinook salmon to isolate some effects of flow fluctuation. For any given flow rate in the simulation channel a larger number of smaller, wild chinook could be accomodated than larger, hatchery chinook. Lack of deep pools for cover in the diversion channel may have caused large numbers of fish to abandon the channel at all tested discharge rates. The researchers speculated that severe fluctuations would decrease drift rates of insects, thereby adversely affecting diet, growth and behavior of stream fish. Severe fluctuations that decrease the supply of food for trout also tend to reduce the size of the population and the rate of fish growth.

The effects of flow fluctuation on juvenile steelhead would depend on the period of their residence in the lower river. Again, if a substantial amount of time is spent in the lower river such that flow impacts on the food chain reduce available food, then there may be an adverse impact on the juveniles. This impact would be small compared to impact on resident fish and the hazards of the downstream migration.

In Brusnven's and MacPhee's study (1976), extreme reduction in flow of 94% had a major influence on out-migration of juvenile salmon. Increased flow in a similar study, Kraft (1972) demonstrated that the number of resident fish in riffle areas decreased significantly by a 90% flow reduction. In contrast, a 75% flow reduction showed no significant change in population number.

Minimal stranding was observed on the lower Clearwater, at present flow regimes, and at Hell's Canyon by several research groups. Kroger's study (1972) dealt specifically with determining recommended flow reduction rates in order to avoid stranding. He concluded that by reducing flows at a rate of approximately 99 cfs, fish and other mobile aquatic fauna could migrate into deeper waters as happens under natural conditions.

Analysis

At the present level of fluctuations, a variety of research indicates minimal direct effects on resident trout. Indirect effects would include disturbance of stable micro-habitats and direct effects on lower trophic levels. Significant effects on lower trophic levels have been defined in the previous section for the present but will need to be reassessed if peak flow fluctuation are increased.

Catchability and Analysis

The greatest potential problem of increased flow fluctuation may be its effect on the catchability of steelhead and resident trout. Following a lengthy creel census investigation, Pettit (1976) concluded that run size and river flows were the two most important factors influencing angler success during the fishing season on the lower Clearwater River. While angler catch rates are directly proportional to run size, the effect of higher or lower than normal flows also influences angler success. In addition, flow conditions determined to a large degree the variability of success between boaters and shore anglers (Pettit, 1976).

During low flows, both boat and shore anglers enjoy greater success than at high flows (Pettit, 1976). This is especially pronounced when shoreline fisherman alone are considered. Low flows have a tendency to crowd fish into pools, reduce the number of hiding locations and increase the angler's visibility of the fish. Further, choice fishing locations such as channel bars, point bars and pools are readily accessible to bank fisherman. Conversely, extreme low flows restrict the involvement of boat anglers, thereby affording shorline anglers a greater proportion of the total daily catch (Pettit, 1976).

At current peak flows, prime holding waters are primarily accessible to boat anglers (Pettit, 1976). Bank anglers do not have the flexability to shift positions and locate steelhead as they move to optimal velocity positions (Bjornn, personal communication). Fisherman complain that increased velocities and greater depths disrupt the normal, smooth behavior of the lure after casting. Undesirable lure movement, for an amateur, increases the number of angler hours required to catch a fish. On the other hand, experienced fishermen seem to be able to compensate adequately for higher flows at the present level of flow (Heincke, personal communication).

During fluctuations, most fishermen agree that catching fish becomes increasingly more difficult on the lower Clearwater (Pettit, personal communication). As discussed earlier, Bjornn (personal communication) found that fish tend to move laterally to a new habitat after water levels stabilize. Having disrupted their stable habitat, flows may inhibit normal behavioral activities until several hours after peaking influences are felt in any given section of the stream (Hooper, 1973). In the case of the lower Clearwater, only adverse fluctuations interrupting an extended period (several days to weeks) of stable flow regimes were found to inhibit resident fish from feeding or steelhead from striking until new microhabitats were re-established (Pettit, personal communication).

The fishing season runs from September through April. In the earlier years following impoundment, the heaviest fishing pressure occurred during October and November. As a result, near constant releases are required from Dworshak dam from October 1 to November 15 because angler success and safety are threatened by fluctuating flows (Nelson et al., 1976). Recent evidence points out that the release of warmer water (39-45°F) from Dworshak during winter and spring months has improved fishing in the lower Clearwater after November (Pettit, personal communication). A shift in angler effort from the fall to spring season warrants that an evaluation of the effects of flow fluctuation after November 15th on the sport fishery be conducted.

Dworshak Dam acts as a sediment trap for the North Fork during periods of high runoff, or local high runoffs due to heavy rains or rapid snow melt. As a result, the turbidity of the lower Clearwater has at times been reduced. Other tributaries (such as the South Fork of the Clearwater) contribute most of the sediment during these periods. If the lower River is turbid and the North Fork remains clear, spring and fall steelhead fisherman are concentrated in a two mile reach below the dam. Rapidly changing water levels during these periods could be a major safety factor as the fluctuations would not have had time to be attenuated.

Large increases above present peak flows would reduce steelhead catch even for the experienced boat fishermen. The peak level of flow before experienced boat fishermen are impacted is not presently known.

V. IMPACTS ON RIPARIAN HABITATS AND ASSOCIATED WILDLIFE

Fluctuating water levels in the lower Clearwater will alter riparian vegetation and productive habitat, to some unknown degree, for some wildlife species. Annual flood control and daily power peaking have altered natural flows in two ways (Fish and Wildlife Service, 1976). Drawdown releases at Dworshak Reservoir cause winter flows to be higher than normal and spring flows to be lower than normal. Daily power peaking operations fluctuate water levels from 4 to 6 feet on the North Fork below the dam and 1 to 3 feet on the Lower Clearwater River above Lower Granite Reservoir (Asherin and Orme, 1978). These changes are outlined because they are important considerations when assessing the influence of flow fluctuation on riparian habitats and the wildlife community.

Riparian Habitats

Asherin and Orme (1978) determined that the lower Clearwater has developed a horizontal zonation of riparian plant communities. Their research concludes that the coyote willow, black cottonwood and bunchgrasses are the predominant plant types affected by fluctuating flows. Coyote willow and bunchgrass communities inhabit frequently inundated floodplains, whereas black cottonwood occurs a few feet higher in elevation. In the future, lower spring flows may cause black cottonwood to dominate areas once occupied by coyote willow. Peaking may also affect the lateral and vertical distributional limits of riparian communities, as well as, their full development. (Asherin and Orme, 1978). Species compositional changes are predicted to be very slow by the researchers.

Substrate

The lower Clearwater River is composed primarily of a variety of size fractions from silt through pebbles and cobbles to boulders. In their study, Asherin and Orme (1978) noticed minimal bank erosion. Areas of extensive rock rip-rap and coarser-sized alluvium are not easily eroded. Lowered spring runoffs may reduce the former rate of island erosion established prior to impoundment (Asherin and Orme, 1978). As a result, channel and point bars may become more fully vegetated.

Asherin and Orme (1978) reported that the upper end of Upper Hog Island exhibits aggradation and that a larger part of the flow is deflected to the left of the two islands. Channel shifting threatens eventual exposue of the right channel around the islands. The authors note that predation may become a problem for Canada geese and water-fowl during nesting season.

Associate Wildlife

If there is an impact on riparian vegetation, then there is an impact on wildlife (Asherin and Orme, 1978). Wildlife species that use rivers heavily and are directly affected by flow fluctuation include water fowl, other birds, upland game, small mammals, terres-trial and aquatic furbearers, amphibians and reptiles. Big game and birds of prey will experience secondary impacts that are diffi-cult to define at the present time. Long term effects may not be obvious for decades.

Upland game, water fowl and other birds utilize the lower Clearwater River's shoreline and islands for nesting, roosting, foraging and brooding. Asherin and Orme (1978) propose that restricted spring discharges may heighten the probability of nesting success on formerly inundated gravel bars or banks. The present flow regime could have an effect on the success of foraging for aquatic plants and insects during the brooding season. On the other hand, beneficial effects to predators would result with the stranding of prey during low flows, making them more available. To date, fluctuations are not severe enough to produce land bridges from most islands to the mainland; therefore, nesting sites are not endangered by predation.

Perhaps more than any other group, the birds will be affected by alteration of the coyote willow habitats. This habitat offers a secure resting area providing cover, camouflage and height.

Terrestrial and aquatic furbearers, like avian species, could benefit from lowered spring flows increasing the stranding of prey. Asherin and Orme (1978) add that in the long run, the effect may be reversed if the base prey is severly depleted. Repeated flooding may increase the mortality rate of small prey mammals due to drowning or predation following exposure.

Aquatic furbearers suffer a similar fate. If water levels are abnormally high, dens may be flooded. On the other hand, if den entrances are exposed, beaver, river otter and mink become easily accessible prey for terrestrial furbearers (Asherin and Orme, 1978). Problems resulting from flow fluctuations present a number of complexities for this group that may threaten their population levels.

Amphibian population levels will be affected by fluctuating flows. Reduced spring water levels will not allow water to fill former breeding pools and sloughs. Indirectly, reptiles will be affected by the population changes of amphibians, as they prey on them (Asherin and Orme, 1978).

Analysis

The impact of fluctuations on riparian vegetation remains a potential problem. Species compositional changes are occurring. One very plausible threat remains; reduced spring runoffs may curtail the development of seedling habitat for certain vegetation types. A buffered spring flood stage may have numerous repercussions on the food base for fish and wildlife. Furthermore, a loss of riparian communities along banks may reduce the river's scenic value.

Seventy-eight percent of the Canada goose nests on the lower Clearwater are distributed between Upper and Lower Hog Islands (Asherin and Orme, 1978). Channel shifting on Upper Hog Island may or may not be caused by flow fluctuations. Potential predation may endanger the nesting season of Canada geese and water fowl.

The threat of reduced population levels for aquatic furbearers is a controversial issue. Users of the lower Clearwater river must ascertain if recreational uses centering around wildlife are a priority when compared to others available. We recommend that a follow up be conducted to determine if wildlife considerations are a high priority item to visitors and users. If flow fluctuations are increased in the future, recreational activities centering around wildlife may be subjugated to others deemed higher priority.

VI. ECONOMICS

Determining the economic benefits of the lower Clearwater River steelhead fishery is a concern of the Idaho Department of Fish & Game, local users, and local businessmen. The trade off between the loss in energy benefits due to operational constraints imposed during steelhead fishing periods and increased benefits due to improved steelhead fishing is considered extremely important. However, quantifying improved steelhead fishing in a reference frame that could be used in comparison to lost energy benefits may prove so subjective that a number of contrasting conclusions could be determined. As an example, Watt (1968) compared gross electric power income with freshwater angler expenditures in California. He concluded that electric power is 77 times more important than sport fishing to the economy of the state. Jenkins in a discussion of a paper by Stephens (1969) used other figures and arrived at a figure of about 1.8 to 1.

Tuttle, et al. (1975) estimated that the value of each adult winter steelhead escaping to spawn represented a net economic value of $68.14. In his analysis, Tuttle recommended that $28.00 per angler-day be used for the value anglers are willing to pay for a day of salmon or steelhead fishing. This figure was to be used as an absolute minimum for evaluating salmon or steelhead fisheries threatened by alternative water-based activities.

Gordon et al., (1973) summarizes the economic evaluation of sport fisheries and attempts to determine the most useful measures available.

The conclusions state the careful use of certain economic estimates may indicate a minimum and preliminary basis for comparison.

Finally, many Clearwater Valley residents now demand a steelhead fishery on the lower Clearwater River regardless of the operation of the Dam (IWRRI interdisciplinary conference opinion). Thus, the process of determining the economic worth of the fishery may be of less value than research to determine operations that could be compatible with this resource (Bjornn, personal communication).

Analysis

Attaching a dollar value to the steelhead fishery is of prime concern to many parties including representatives of the Idaho Department of Fish and Game, local businessmen and many fishermen. However, the results of such an analysis may be of minimum utility unless data can be generated concerning certain demands. A more fruitful area of research would be in determining operational constraints compatible with the steelhead fishery.

VII. RECREATION

Recreational activities on the lower Clearwater River may be divided into two groups: instream recreation and recreation adjacent to the stream (Andrews et al., 1976). Instream recreation consists of fishing, boating, wading, floating or rafting, and waterfowl hunting. Recreation adjacent to streams encompasses more passive activities such as picnicing, hiking, birdwatching, rockhounding or observing flora and fauna.

A survey questionnaire sent to 2000 residents in Idaho clearly indicated that the state of the natural environment is a genuine concern of all Idahonians (Asherin and Orme, 1978). In 1969, Gillespie predicted that the demand for public recreation facilities and traffic use on Highway 12 would triple by the year 2000. Further, he estimated that the value of recreation in the Clearwater region would approach 30 million dollars by 2000. There are few statistics available to indicate the current contribution of various recreation types to the total estimated value.

On the lower Clearwater, the effect of fluctuating flows and minimum flows on recreational activities has not been clearly defined, as very little research has been done on this relationship. Andrews et al. (1976) summarized some of the present methodologies for assessing the impact of changing stream flows on recreational activities. Hyra (1978) describes two methods of quantifying instream flow needs for fish, wildlife and recreation. Other studies investigated proved to be rather subjective.

Andrews et al. (1976) states two basic assumptions that must be considered in analyzing the recreational use of the lower Clearwater. If the flow of a river is altered, a corresponding change in recreation uses will evolve. Despite a shift in recreational use, visitors will still utilize the river if elements of safety and enjoyment are considered and maintained. We need to examine at what point an alteration of flow regime reduces the safety and recreational use of the river. Secondly, the authors state that if a specific recreation is not available at one site, users will go elsewhere. We need to look for nearby alternative user areas.

Hyra (1978) describes a "single cross section" method to determine minimum flow recommendations required for safe boating activities in a given river. The incremental method provides a flow regime recommendation for popular recreation activities during a given season, weekend or daylight hours. Although bias-free methodologies are preferred, some subjectivity is unavoidable in establishing a hierarchy of recreational priorities.

There follows a brief discussion of each activity and an analysis of the possible detrimental effects due to fluctuating and minimum flows.

Fishing

Fluctuating flows should have a minimal effect on the ability of fishermen to reach the river, except for flows at the higher end of the fluctuation spectrum. However, strong currents over 4,400 cfs (Spaulding guage) limit fishing opportunity for steelhead fly fishermen

(Pettit, 1976). Pettit reported that one fisherman was stranded on a gravel bar while wading when flows rose rapidly and he could not reach the side bank (personal communication). There has been an increased proportion of steelhead caught by boat anglers in post impoundment years (Pettit, 1976). The effect on catchability has already been discussed.

Boating

Due to increased mobility, boating is becoming an important recreational consideration on the lower Clearwater. Very low flows could make boat ramps non-accessible. In addition, navigation becomes increasingly difficult around gravel bars. Fluctuating flows also increase the chances of nightime and daytime stranding. This has occasionally occurred in the past, according to Fish and Game personnel.

Swimming

Swimming is very popular during the latter part of the summer. Myrtle Beach and Big Eddy Beach are easily accessible from Highway 12. High flows reduce available beach area and may cause accelerated erosion of these sand beaches. In addition, high velocities may prove to endanger swimmers. At Hell's Canyon, desirable conditions for swimming and wading at several locations were created at middle flow ranges (Northwestern Region Bureau of Outdoor Recreation, 1974). Other studies indicate that optimum water velocities for swimmers range from 0.25-0.75 fps (Andrews et al., 1976).

Floating or Rafting

Raft and innertube floaters are generally unaffected by minor fluctuations or low flows. There are very few white water rapids at present on the lower Clearwater River. Optimum water velocities for floaters range from 1.0-5.0 fps (Andrews et al., 1976). Rafters can handle up to 10 fps. before getting into white water class of rafting, which requires special gear (Andrews et al., 1976).

Water Fowl Hunting

Water fowl rest in coyote willow habitats on shoreline and channel gravel bars (Asherin and Orme, 1978). Power peaking operations may cause inundation or disturbance of foraging or resting areas established by water fowl. The long term impact of flow fluctuations on their preferred habitat cannot be hypothesized. A reduction in their living space or its continual disturbance may affect their availability for hunting or viewing.

Recreation Adjacent to the Stream

Attractive surroundings create favorable sites for passive recreational activities such as picnicing, camping and hiking, and viewing. Several other recreational studies mention that the phenomenon of flow fluctuation is, in itself, intriguing to observe and may alone be a prime attraction to visitors.

In contrast, the scenic value of the lower Clearwater River could be reduced if beaches are eroded away or if riparian vegetation is adversely altered by increased flow fluctuation.

Impacts on riparian habitats and primary production will directly affect the number and kind of wildlife species, as well as aquatic species, found in all habitats (Asherin and Orme, 1978) (Brusven et al., 1974). If flora and fauna levels are diminished in time (decades), visitors may seek alternative nearby areas that satisfy aesthetic demands associated with these recreational activities. It is premature to present the effects of fluctuating flows on this recreational group because they will evolve slowly in time (Asherin and Orme, 1978).

Analysis

Fluctuating flows could have an effect on the recreational uses of the lower Clearwater. The point at which fluctuations for instream recreational use become dangerous is not known. It is recommended that a follow up of this point be conducted to determine a flow regime recommendation for popular recreational activities utilizing the incremental method described by Hyra (1978). In any case, swimmers, boaters and rafters could use the Snake River or the Clearwater River above the confluence with the North Fork if the lower region of the river becomes unsuitable.

Increased flow fluctuations will affect recreational use adjacent to the lower Clearwater River indirectly by either decreasing its scenic value or altering its floral and faunal abundance and variety. As before, there are alternative areas for recreationalists to go to if the lower Clearwater becomes unsuitable.

VIII. RECOMMENDATIONS

By integrating the information provided in this paper with that gathered at the conference held at IWR, University of Idaho, the following prioritized list of potential research areas was developed.

1) The steelhead fishery on the lower Clearwater River is an extremely important economic and recreational consideration to local and state residents, as well as those of Washington, Oregon, and Montana. Future research should be directed at determining in what ways power operations can be made compatible with the steelhead fishery.

This research should address the effect of fluctuating flows on catchability of steelhead during both fall and spring fishing seasons. In order to research these effects, two separate aspects of peaking operations must be considered. They are:

1) the amount and frequency of peaking flows
2) the timing of fluctuations, both seasonal and diurnal

2) Regardless of predicted impacts of future alternative policies on the steelhead fishery and other types of recreation, social acceptance must be considered. At the present time, the Corps focuses on methods of increasing the awareness and involvement of the general public in matters concerning flow management.

In the future, a possible alternative to present aforementioned policies would be to concentrate on encouraging the public to determine what recreational activities are most compatible with power operation policies. A study should be supported to investigate in what manner the public's current recreational patterns can be maximized under the constraints of peaking flows. For example, this might include providing information concerning:

1) the timing of activities
2) the best location for any activity at a given peak flow
3) the potential hazard of an area considering rate of rise and the water level there

As implementing the results of the recommended study may prove difficult, complimentary research should be directed to specifically cope with this problem.

3) Direct impacts of flow fluctuations on primary production and benthos have secondary impacts on the resident game-fish population. Wildlife populations that utilize the river heavily are also effected in a similar manner, but this is of secondary importance. Should resident game-fish populations become a more important factor in recreational values, especially during the spring and summer months, then adverse impacts on lower trophic levels would certainly have a detrimental impact on resident fish population.

At the present time, the resident trout population seems to depend on the residualization of steelhead smolts and very little on the spawning of resident trout. A vigorous trout planting program in the lower river could make this fishery much more important. In such a case, adverse impacts on fish-food organisms due to increased fluctuations would need to be studied in more detail.

4) Riparian vegetation along the lower Clearwater is considered an essential element influencing fish and wildlife habitats and associated recreational activities. Asherin and Orme (1978) present sufficient evidence to suggest that present flow regimes cause species compositional changes, the result of which, up to now, has not seriously

impacted the habitat. Long-term effects may not be obvious for decades. The extent to which reparian vegetation can adapt in the future to greater flow fluctuations, as a function of the season, without serious depreciation requires further study.

5) Because of the uncertainties in extrapolating results of research conducted at the present level of peaking flows to increased levels, any increases or decreases in power operations should be incrementally implemented and carefully monitored to avoid catastrophic alteration of the river system. Future research should be aimed at determining the effects of changing the periodicity of flow fluctuations. The river system as a whole may have a better chance of adapting to increased peak flows if near constant periodicity is maintained. Therefore, frequent changes in flow management should be evaluated and carefully considered.

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X. APPENDIX I

The following individuals were present at the conference on the lower Clearwater River held at the University of Idaho, WRI on 19 September 1978.

1. David H. Bennett	Assistant Professor, Fishery Resources University of Idaho
2. Theodore C. Bjornn	Leader Idaho Cooperative Fish Unit Professor, Fishery Resources University of Idaho
3. Merlyn A. Brusven	Professor of Entomology University of Idaho
4. Robin Church	U.S. Army Corps of Engineers W.E.S. Vicksburg, Mississippi
5. C. Michael Falter	Associate Professor Fishery Resources University of Idaho
6. John S. Gladwell	Director, Idaho Water Resource Research Institute University of Idaho
7. Donald F. Haber	Professor of Civil Engineering University of Idaho
8. Stephen W. Pettit	Senior Fishery Research Biologist Idaho Department of Fish and Game
9. C. B. Stalnaker	Director, Instream Flow Group U.S. Fish and Wildlife Service Fort Collins, Colorado
10. Eugene Trihey	Assistant Director, Idaho Water Resource Research Institute University of Idaho (on leave)
11. Robert G. White	Assistant leader, Idaho Cooperative Fish Unit Associate Professor, Fishery Resources University of Idaho