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HYDRAULIC ENGINEERING and the ENVIRONMENT

HYDRAULIC ENGINEERING and the ENVIRONMENT

Proceedings of the
21st Annual Hydraulics Division Specialty Conference

held at
Montana State University, Bozeman, Montana
August 15-17, 1973

Published by
American Society of Civil Engineers
345 East 47th Street
New York, N.Y. 10017

Price $10.00

FOREWORD

"Hydraulic Engineering and the Environment" is the theme of the conference. This year's conference represents the latest of a continuing series of efforts by ASCE, and specifically its Hydraulics Division, to meet the Society's needs through the application of new information developed by research and analytical studies. The principal aim of the 1973 Conference is to develop an awareness of the effects of new hydraulic information on the environment.

This Proceedings volume is arranged in accordance with the order of presentation of the papers and sessions, for the convenience of the reader.

Committees sponsoring sessions include:

Hydraulic Structures
Sedimentation
Flood Control
Hydromechanics
Research
Surface Water Hydrology
Hydrometeorology
Ground Water Hydrology

Other notable events, in addition to the technical sessions, include:

Research Workshop
Senior Group Meeting
Student Group Meeting
Tour of MSU Engineering Facilities
Tour of Big Sky Recreational Complex

The success of this Hydraulics Division Specialty Conference is largely due to the efforts and interest of:

William A. Hunt, General Chairman
Jacob H. Douma, Program Chairman
and the Sessions Chairmen
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John J. Cassidy
Robert B. Dean
Roderick L. Hall
George E. Hecker
Clifford H. McConnell
Warren J. Mellema
Robert E. Rallison
Merlin C. Williams
E. B. Wylie

Thanks is also extended to all participants and registrants of the conference.

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*Hon. Donald Barnett, Mayor of Rapid City, South Dakota spoke extemporaneously; no manuscript is available.

**Manuscript not available at time of publication.

REHABILITATION OF A CHANNELIZED RIVER IN UTAH

By James R. Barton,[1] M. ASCE and Parley V. Winger[2]

INTRODUCTION

Channelization has resulted in the loss of many miles of fish habitat in streams and rivers throughout the United States. The detrimental effects of channelization are:

1. Loss of holes and cover for fish.
2. Disruption of the riffle-pool sequence.
3. Increased stream velocities.
4. Increased erosion and turbidity.
5. Loss of stream-side vegetation.
6. Loss in stream length.
7. Loss in aesthetic value of the area.

Channelization is usually the result of flood control measures or realignment due to some construction practice. Occasionally channelization is carried out by unknowing persons for other miscellaneous reasons.

Voluminous literature is available concerning the affects of channelization on the aquatic environment. A few of the most pertinent sources are: Alvord and Peters (1963), Bayless and Smith (1964), Beland (1953), Elser (1968), Hunt (1968), Peters and Alvord (1964), and Whitney and Bailey (1959).

Since channelization has been so detrimental and usually compounds the problems of a watershed, legislation and environmental concern have slowed down this type of habitat manipulation (Reuss, 1971). However, it still occurs; when it does, steps should be taken to rehabilitate the altered areas.

Investigations involving rehabilitation measures on the aquatic environment have been conducted by Barton and Winger (1973); Harrison (1965); Hunt (1971); Robinson and Menendez (1964); Saunders and Smith (1962); Shetter, Clark and Hazzard (1946); Tarzwell (1938); and White and Brynildson (1967). Further references can be obtained by consulting the bibliography on channelization and rehabilitation measures compiled by Barton, et al. (1972).

On a recent highway construction contract in Utah where the construction of Highway I-80 resulted in the channelization of several

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stretches of the Weber River, various types of instream rehabilitation structures were installed in the altered sections in an attempt to alleviate some of the detrimental effects of channelization. The influence of these structures on the hydrology and biology of the Weber River was evaluated by a research team from BYU consisting of civil engineers and biologists. Since the study was initiated at the time of construction, no pre-study was possible. For this reason changed or channelized sections were compared to unchanged areas or portions of the river not altered by the present highway construction.

PROCEDURES

The Weber River is located in the northeast portion of Utah. It originates at an elevation of 12,300 feet and drains an area of 5,340 square miles emptying into the Great Salt Lake at an elevation of 4300 feet. The study area was a 10 mile stretch of river beginning below Echo Reservoir and ending above Devil's Slide, Summit County. The flow of the river averaged about 500 cubic feet per second during the summer months with maximum discharges between 2000 and 3000 cfs.

Construction of I-80 resulted in channelization of five stretches of the river varying in length from 640 to 3800 feet and totaling about 1.5 miles. The straightening of the channel resulted in a loss of 0.43 miles or 2270 feet. The straightened channels were 70 feet wide and lined with rip-rap to stabilize the banks. The instream rehabilitation structures were placed in the channel in an attempt to create fish habitat.

Six types of instream rehabilitation structures were installed in the altered sections of the river (Fig. 1). Gabion deflectors (wire baskets filled with rocks) and check dams were placed in three sections and rock deflectors and check dams were placed in two sections. A concrete diversion dam used for irrigation purposes was placed in one section. Random rocks were installed in all sections.

An eight-mile stretch of the Weber River, including the channelized areas, was surveyed and mapped. Location of rehabilitation structures in the altered areas as well as pertinent land marks were included. A profile of the river channel was also measured to show the contours of the bottom in the changed and unchanged areas.

Water chemistry data were collected from water samples collected above and below the channelized areas. Water quality parameters such as pH, phosphate, sulfate, total hardness, alkalinity, turbidity, and temperature were determined using the Hach Chemical Field Kit.

Macroinvertebrate (fish food organisms) organisms were collected monthly from two channelized sections and from two unaltered areas using a circular quarter-meter squared bottom sampler. After sorting, identification, and counting, the numbers and biomass of organisms per square meter were determined for comparison of changed and unchanged areas. A species diversity index was also computed for the populations in changed and unchanged areas (Fisher, et al., 1943).

Fish population data were collected using electrofishing equipment consisting of a 210 volt AC Sears generator with a pulsating DC rectifier. A twelve foot aluminum pram boat was used as the negative electrode, and a probe extending from the front of the boat was the positive electrode. The boat was manipulated from shore by ropes attached to the front of the boat. A person in the boat netted the

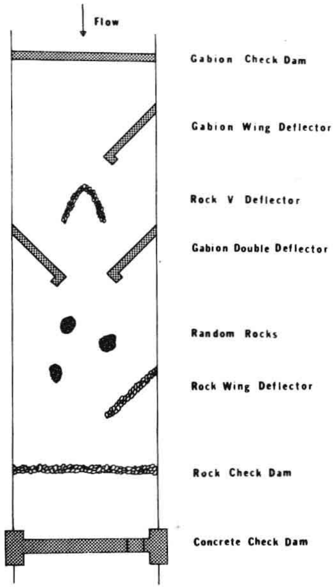

FIG. 1 REHABILITATION STRUCTURES PLACED IN CHANNELIZED SECTIONS OF THE WEBER RIVER.

shocked fish and placed them in a tub of water in the boat. As the fish were shocked, the location in the stream where each fish was netted was marked on the map. The fish were tagged, weighed, measured, and returned to the river.

Actual numbers of fish collected (extrapolated to numbers per acre) in each section of river were used to compare changed areas with unchanged areas as well as population estimates which were derived from tag-recapture information obtained from several shocking periods. Population estimates in changed and unchanged areas were also made using a removal method where the fish collected in each of several passes through an area were removed (Delury, 1947). The decreasing number of fish collected each time was plotted, and the formation of a regression line gave an estimate of the fish population. It was assumed that shocking efficiency was the same in changed and unchanged areas.

DISCUSSION AND RESULTS

River Profiles - In comparing the profiles of the river bottom in changed and unchanged areas, it can be seen that there were as many holes in the changed sections with structures as there were in the unaltered sections (Fig. 2).

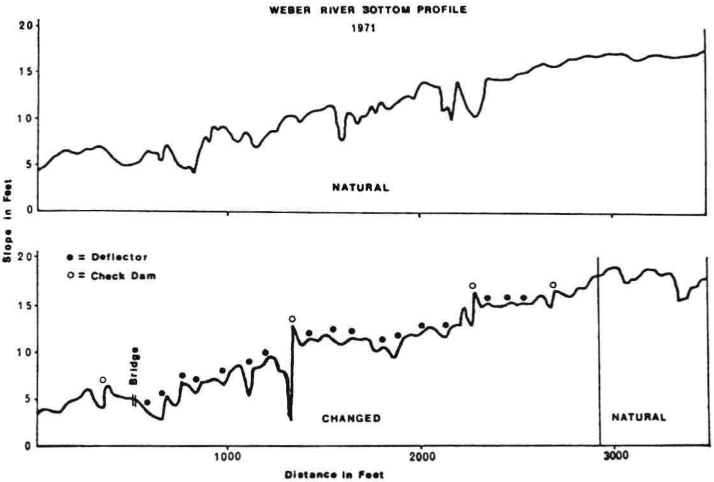

FIG. 2 PROFILE OF THE BOTTOM OF THE WEBER RIVER SHOWING NATURAL AREAS AND POSITION OF STRUCTURES IN CHANGED AREAS. (○ = gabion check dams; ● = gabion deflectors).

In an area that was previously channeled and no instream structures were placed, the stream bottom was virtually uniform with no distinct holes or riffles (this is shown in the upper right hand corner of Figure 2). From the examination of the profile data, it appears that the structures have been effective in creating a stream bottom in the changed areas similar to that found in the unaltered sections. The structures disrupt the near uniform flow and cause holes to be scoured and riffles to be formed, providing areas that are similar in physical characteristics to that in the natural environment.

Water Chemistry - The water chemistry taken above and below the construction areas showed no differences in their values. There was, however, a marked increase in turbidity during and shortly after construction (summer of 1968), but this was relatively short-lived and normal values were obtained within two months after channelization (Fig. 3).

Vegetation Loss - A substantial loss of streamside vegetation occurred as a result of a hundred-foot swath being cleared on each side of the new channel. This may cause an important decrease in the detritus (leaf material) entering the stream which could account for a high percentage of the energy input into a stream during certain times of the year. Usually associated with loss of streambank vegation, is an increase in stream temperatures as a result of more water being exposed to direct sunlight for longer periods of time. There was no apparent change of the water temperatures in the Weber River due to streamside vegetation loss. The factor apparently controlling the temperature in this portion of the Weber River is the amount of discharge from Echo Reservoir. The drastic fluctuation of discharge from Echo Reservoir

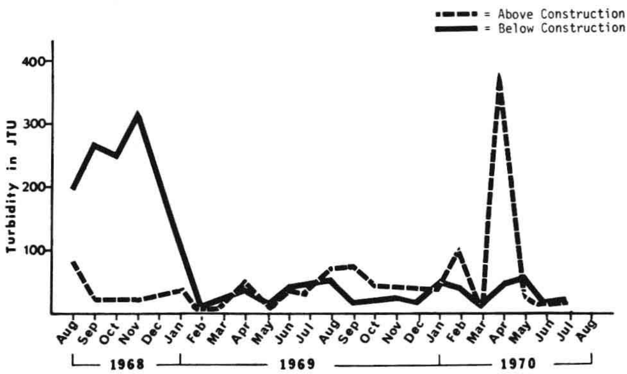

FIG. 3 TURBIDITY OF THE WEBER RIVER ABOVE AND BELOW CONSTRUCTION AREAS.

influenced not only water temperatures but living space, fish spawning areas, and spawning success.

In an attempt to compensate for the vegetation loss along the river, broadleaf cottonwood, and Russian olive trees were planted along both shores of the channelized sections. Unfortunately, nearly all of the cottonwood trees have died, but the Russian olive trees appear to be doing well. Some natural revegetation by willows and grass has occurred mostly along the water line.

Macroinvertebrate Studies - The fish food organisms were, of course, not present in the newly formed channels (Fig. 4). New channels were excavated and then the water diverted into them (summer of 1968). After a period of substantial stream flow in the spring of 1969, during which time extensive erosion occurred and a stable substrate was formed, there was rapid colonization by the invertebrate populations in the unchanged areas (April, May). The establishment of the organisms corresponded closely with the stability of the bottom substrate. The composition of the benthic community and the species-diversity indices were essentially the same in changed and unchanged areas (Fig. 5). The diversity was very low during and shortly after construction but rapidly increased and was similar to that of the unchanged areas within a period of a few months. The diversity of organisms several miles below the construction area (Station 8) corresponded closely to that in the changed and unchanged study areas.

Fishery Studies - Fish populations in the Weber River were composed, mainly of six species of fish; these were whitefish (Prosopium williamsoni, (Girard)), two species of sucker (Catostomus ardens, Jordan and Gilbert; (Catostomus discobolus, Cope), brown trout (Salmo trutta, Linnaeus), cutthroat trout (Salmo clarki, Richardson), and rainbow trout (Salmo gairdneri, Richardson). Fish shocking data indicates that there were as many fish in the changed areas as there were in the unchanged areas (Fig. 6). There was a marked difference in shocking efficiency during low winter flows and high summer flows, however, efficiency

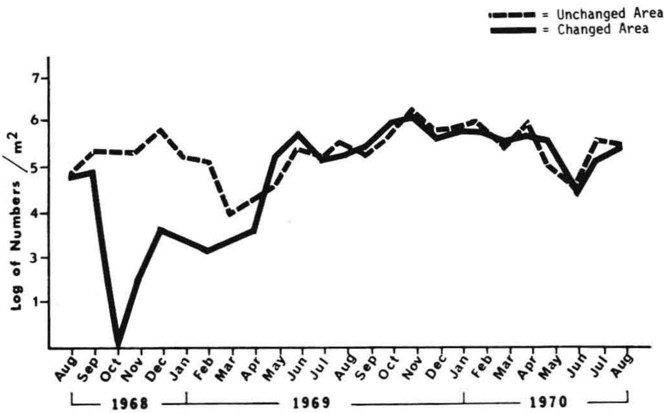

FIG. 4 LOG OF THE NUMBERS PER SQUARE METER OF THE MACROINVERTEBRATE POPULATIONS IN CHANGED AND UNCHANGED AREAS OF THE WEBER RIVER.

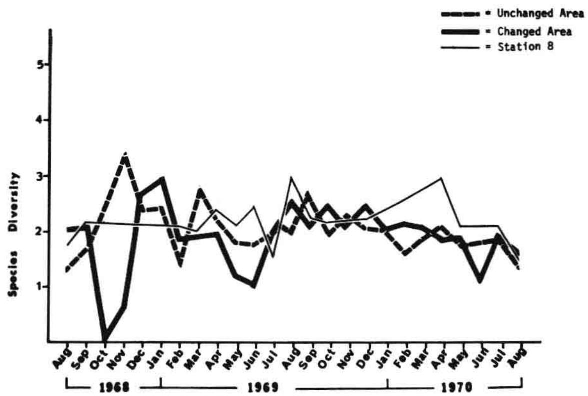

FIG. 5 SPECIES DIVERSITY OF THE MACROINVERTEBRATE POPULATIONS IN THE STUDY AREAS ON THE WEBER RIVER.

appears to be the same in changed and unchanged areas during one particular flow condition. The distribution of fish in the river is not uniform and it appears that certain areas have higher standing crops than other areas. No statistical differences were found between the fish population of changed and unchanged areas.

Population estimates with reasonable confidence limits using the tag-recapture method were limited due to the high mobility of the fish and so few of the total population was tagged. For this reason the removal technique was employed, where two one-quarter mile changed areas

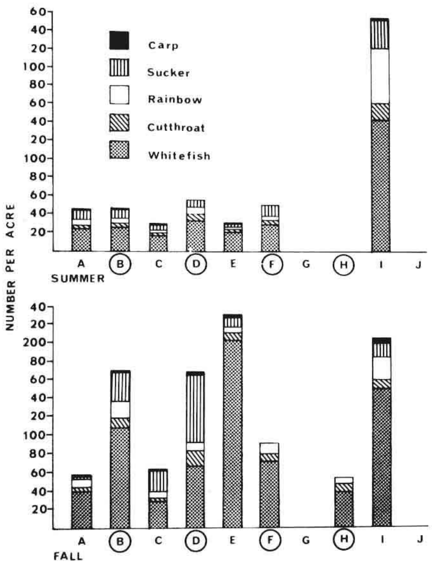

FIG. 6 ACTUAL NUMBERS OF FISH COLLECTED PER ACRE IN THE WEBER RIVER IN THE SUMMER AND FALL OF 1970. (O = CHANGED AREAS).

were compared with two one quarter mile unchanged areas (Fig. 7). These populations estimates were statistically more accurate than the other population estimates, but indicated the same results as was obtained on the previous population estimates and using actual numbers collected per acre. These population estimates provided more conclusive data which indicated that the fish populations were similar in both changed and unchanged areas.

The whitefish were the most abundant fish in the river and the blue head sucker and the Utah sucker being the next most abundant. Cutthroat trout were the most abundant trout. Brown trout were relatively rare and were found only in the unchanged areas with extensive overhead cover. The number of rainbow trout in the river depended upon times of stocking and the time of fish shockings.

Maps showing the locations of fish shockings indicate that the fish collected in the channeled areas were concentrated in the holes formed by the instream rehabilitation structures (Fig. 8) suggesting that the structures have been effective in creating holes that can be utilized by fish.

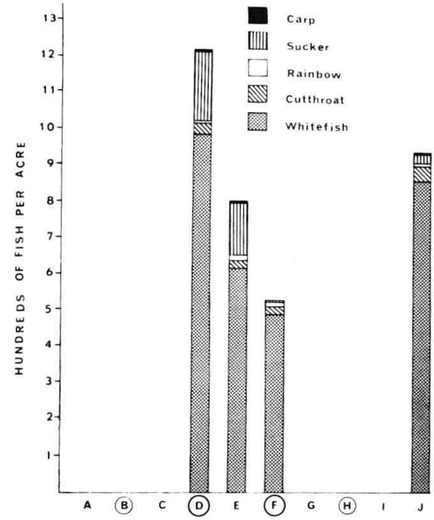

FIG. 7 POPULATION ESTIMATES OF FISH IN CHANGED AND UNCHANGED AREAS IN THE FALL OF 1972. (O = CHANGED AREAS).

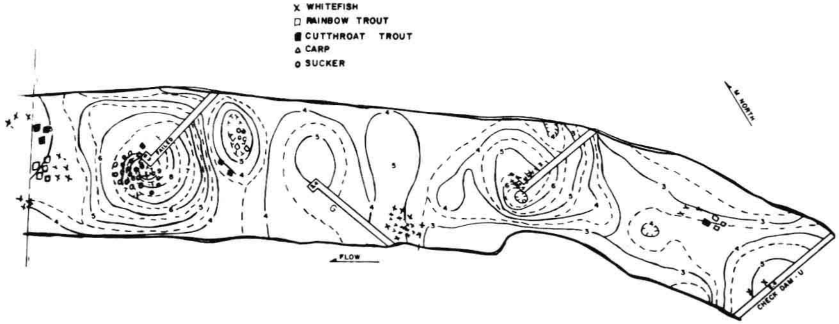

FIG. 8 MAP OF A CHANGED AREA SHOWING THE CONCENTRATION OF FISH NEAR INSTREAM REHABILITATION STRUCTURES.

CONCLUSIONS

The conclusions resulting from this study are summarized in the following list:

1. After a relatively short time, fish populations were the same in changed and unchanged areas in relation to composition, actual numbers per acre, and population estimates. The fish in the altered areas appeared to be concentrated in the holes near the instream structures.

2. Fish food organisms colonized the channeled areas within a few months and no differences could be detected between the populations of the changed and the unchanged areas in species composition, diversity or numbers per square meter.
3. The construction itself and the initially unstable substrate of the altered section caused a marked increase in erosion and turbidity but these were of relatively short duration and seemed to have little long term effect on the biology of the area.
4. The water chemistry and water temperature were not altered by the channelization. Temperature was controlled by flow releases from Echo Reservoir.
5. This study indicates that rehabilitation measures taken on the Weber River have been successful in producing holes and riffle areas that were utilized by fish and fish food organisms.
6. The placement of instream rehabilitation structures is a step in the right direction to reclaim altered areas. However, this should not be considered a complete cure for channelization. Channelization should be avoided if at all possible.
7. The structures did not alleviate the following problems associated with channelization: (1) Loss of stream length, (2) Destruction of the natural aesthetics of the river, and (3) Loss in streamside vegetation. More work needs to be done to develop solutions for these problems.
8. Although most of the structures used on the Weber River did provide some favorable results, more research needs to be done to develop better and more economical ways of rehabilitating a channelized stream. Different structures should be designed and tested as well as determing correct placement of these structures in the stream.

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SWIMMING PERFORMANCE OF ARCTIC GRAYLING

F. J. Watts
C. MacPhee

INTRODUCTION

The principle purpose of this study is to establish design criteria for culverts which will insure the maintenance of fish populations in streams traversed by the proposed Alaska Pipe Line and its supporting highway.

A diversion dam (16' crest length, variable depth), a headgate and approach conduit, a 60-ft. long tiltable 24" diameter culvert and associated head box and tail box were constructed on Poplar Grove Creek in south central Alaska. Flows in the creek range from 0 cfs (frozen solid for several months of the year) to upwards of 250 cfs (estimated). Because of an unusually low snow pack and an early but gradual spring melt, the maximum estimated discharge at the study site during the spring of 1973 was about 45 cfs.

The general procedure used for the culvert part of the study was to block the upstream migration of fish with the dam, seine or trap the fish in the creek, place the fish in the tail box below the culvert, record the number of success or failures per size group for a holding period of not longer than one day for a particular slope and flow condition, then collect all fish and release them in the stream above the facility. In a 12-day period between May 16th and May 20th, 1842 grayling ranging in length from 4½" to 16" and 619 suckers ranging in length from 8" to 16" were handled.

The data presented in this paper are preliminary data and should be used accordingly. Data collection and analysis are proceeding at this time and it appears that all phases of the project will not be completed prior to the summer of 1974.

Financial support for the project was provided by the Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior.

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Dr. Craig MacPhee	Professor, Fisheries Management University of Idaho, Moscow, Idaho