The effects of heavy metals on the distribution and abundance of aquatic insects in the Boulder River, Montana
by William Michael Gardner

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Fish and Wildlife Management
Montana State University

Abstract:
The effects of heavy metals on the distribution and abundance of aquatic insects in the Boulder River were studied during 1975 and 1976. On the upper Boulder River, concentrations of total zinc were highest at Station 2 below derelict mining and milling sites where they averaged 0.25 mg/l. The insect community at this station in August and September samples was 29, 81, and 45 percent lower in average total number, average total weight, and average number of subordinal taxa, respectively, than at Station 1 above the pollution sources. On the lower Boulder River, the highest average concentration of total zinc was 0.31 mg/1 and occurred at Station 5 below the heavy metals laden floodplain. The insect community at this station in August and September samples was at least 30, 19 and 18 percent lower in average total number, average total weight, and average number of subordinal taxa, respectively, than at Stations 3 or 4 above it. The aquatic insect community at Station 5 was at least 62 and 69 percent lower in average total number and average total weight, respectively, than at Stations 6 through 8 below it. The number of subordinal taxa at Stations 5 and 6 were lower than at Stations 7 and 8.

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Date December 23, 1977

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by

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A thesis submitted in partial fulfillment
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ABSTRACT

The effects of heavy metals on the distribution and abundance of aquatic insects in the Boulder River were studied during 1975 and 1976. On the upper Boulder River, concentrations of total zinc were highest at Station 2 below derelict mining and milling sites where they averaged 0.25 mg/1. The insect community at this station in August and September samples was 29, 81, and 45 percent lower in average total number, average total weight, and average number of subordinal taxa, respectively, than at Station 1 above the pollution sources. On the lower Boulder River, the highest average concentration of total zinc was 0.31 mg/1 and occurred at Station 5 below the heavy metals laden floodplain. The insect community at this station in August and September samples was at least 30, 19 and 18 percent lower in average total number, average total weight, and average number of subordinal taxa, respectively, than at Stations 3 or 4 above it. The aquatic insect community at Station 5 was at least 62 and 69 percent lower in average total number and average total weight, respectively, than at Stations 6 through 8 below it. The number of subordinal taxa at Stations 5 and 6 were lower than at Stations 7 and 8.

INTRODUCTION

Hardrock mining for metallic minerals in the Boulder River drainage was intensive in the late 1800's and early 1900's. Roby et al. (1960) summarized the extent of the mining for these minerals in Jefferson County and reported there had been at least 71 ore-producing mines and 15 mills in the upper Boulder and Elkhorn drainages. Presently, few mines are being worked in the drainage.

Mining has produced adverse effects on the Boulder River below the town of Basin. Appraisal of the water quality in the drainage by Braico and Botz (1974) revealed heavy metals from acid mine seeps and mill tailings were causing a "major water quality impairment." Sampling of the sediments in the river channel and floodplain disclosed high concentrations of zinc, copper and lead extending some 40 km downriver below the source areas (Vincent 1975). In the upper Boulder River, Nelson (1976) found depressed standing crops of trout and high mortalities of bioassayed eyed eggs and fingerling rainbow trout (*Salmo gairdneri*) associated with higher heavy metals concentrations in the river. Vincent (1975) partially attributed the low numbers of trout in the lower Boulder River to heavy metals pollution. A preliminary investigation of the aquatic insect fauna in the Boulder River indicated low number of mayfly species in areas of the river containing high concentrations of heavy metals (Vincent 1975).

The primary purpose of this investigation was to determine the effects of the heavy metals on the distribution and abundance of the aquatic insects in the Boulder River. A secondary purpose was to describe the concentrations of heavy metals occurring in the river year around. Field research was conducted from April 26, 1975 to October 10, 1976.

DESCRIPTION OF STUDY AREA

The Boulder River is located in Jefferson County, southwestern Montana. It originates on the east side of the Continental Divide at an elevation of 2,220 m and flows southwest for approximately 120 km to the Jefferson River near Cardwell, Montana. The drainage area is approximately 1,975 square km and is primarily underlaid by the Boulder Batholith which is composed of quartz monzonite. The lower third of the drainage is composed of sedimentary rocks of Precambrian to Tertiary age (Roby et al. 1960). The river has an overall gradient of about 4.8 m per river kilometer. Major tributaries, in downriver progression, are: Lowland, Bison, Basin, Cataract and Muskrat Creeks and the Little Boulder River.

Average annual precipitation is approximately 90 cm at the town of Basin and 30 cm at the town of Boulder (North Boulder Drainage and Jefferson Conservation District 1975). Flows in the river depend primarily on snowpack in the mountains with a number of large springs adding to the river in the lower valley. The average discharge of the Boulder River near the town of Boulder for a 41-year period of record ending in 1972 was 206 m^3/min (112 cfs), while the maximum and minimum discharges were 5,933 (3358 cfs) and 0 m^3/min, respectively (U.S. Geological Survey 1972). During 1975, the first year of this study, discharges were abnormally high. The maximum and minimum discharges for the period April 26 through September 31 were 5,972 (3377 cfs) and

94 m^3/min (53 cfs), respectively. In 1976 maximum and minimum discharges for the period April 16 through October 31 were 3,080 (1760 cfs) and 95 m^3/min (56 cfs), respectively (U.S. Soil Conservation Service 1976). The surface run-off patterns for both years are presented in Figure 1. The major use of water from the Boulder River below the town of Boulder is for the irrigation of alfalfa and hay meadows. In low water years, use is so intensive that irrigation diversions dewater about a 19 km reach in this section of river (North Boulder Drainage and Jefferson Conservation Districts 1975).

For this study, the river was considered to consist of two sections. The river lying above the town of Boulder was designated as the upper Boulder River. In this section the river had a narrow floodplain, a high elevation, and a steep gradient. Riparian vegetation primarily included willows, alder, confiers and, to a lesser extent, cottonwoods and aspen. Rainbow trout (*Salmo gairdneri*), brook trout (*Salvelinus fontinalis*), and mountain whitefish (*Prosopium williamsoni*) were the salmonids found in this study section.

The section of river lying below the town of Boulder was designated the lower Boulder River. This section of the river had a wider floodplain through which the river meandered, a lower elevation and a more gradual gradient. Riparian vegetation was primarily cottonwoods, aspen and willows. Brown trout (*Salmo trutta*) dominated the salmonid fauna in this section (Vincent 1975).

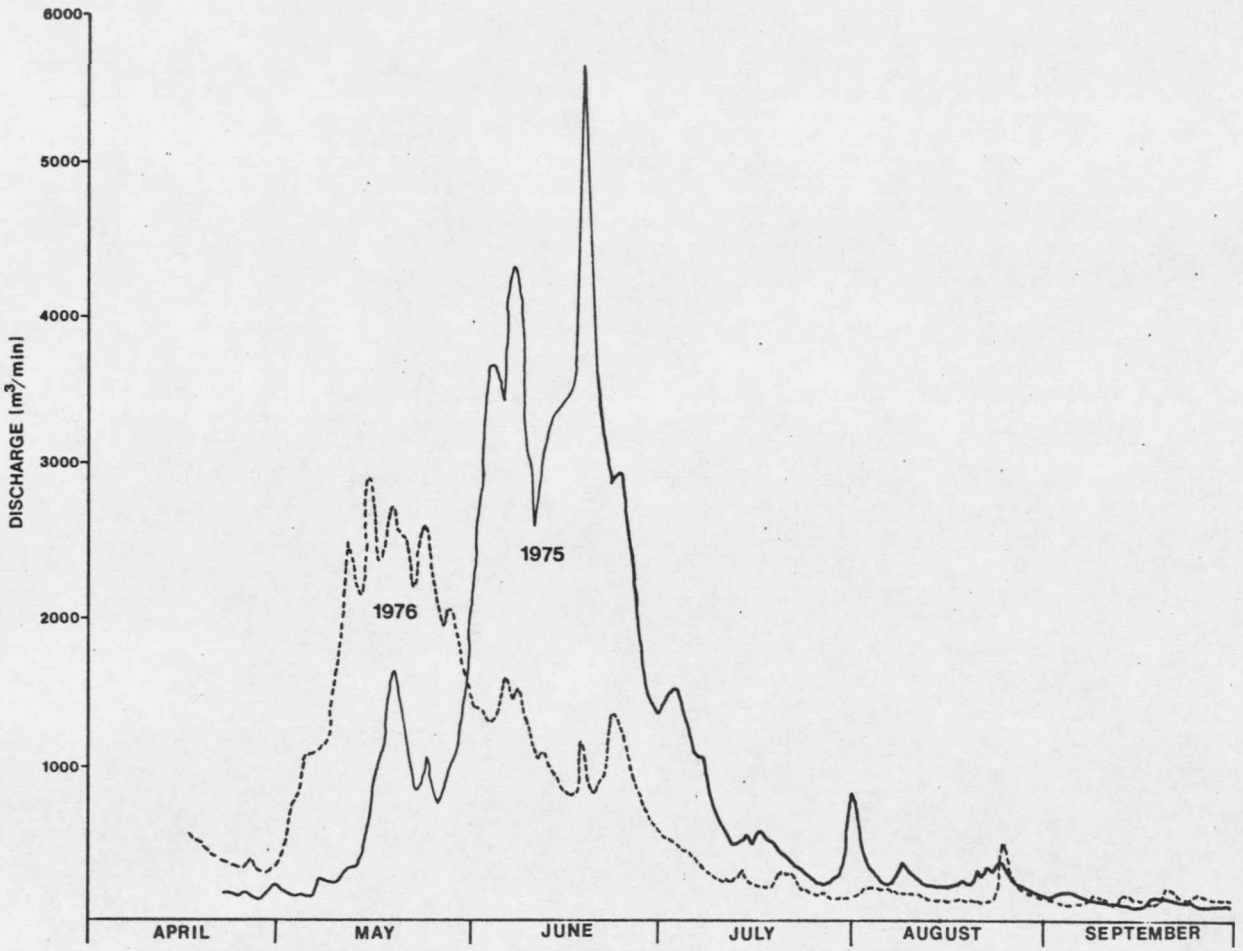

Figure 1. Hydrographs of the Boulder River for 1975 and 1976 at the USGS gaging station 6 km downriver from the town of Boulder. (U.S. Soil Conservation Service 1976).

Nine stations were established in the study area (Figure 2). The locations and distances from the mouth of the river and between stations are given in Appendix Table 1.

Water quality and aquatic insects were sampled at eight sites (Stations 1-8), and water quality only at one additional site (Station 1-A). Stations 1 and 2 served to assess the combined effects of Basin, Cataract, and High Ore Creeks on the upper Boulder River. Bottom types at these stations were comprised of boulders and large cobbles interspaced with large gravel. Station 1-A functioned to delineate the combined heavy metals load of Basin and Cataract Creeks on the water quality of the river from that contributed by High Ore Creek.

Six water quality and aquatic insect sampling stations were installed on the lower Boulder River. Stations 3 and 4 were used to investigate the influence of the Little Boulder River. Stations 5, 6, 7, and 8 were located at approximately equal interstational distances downriver from Station 4 to ascertain the persistence and effect of the heavy metals in the lower reach of the river. Bottom types at these stations were predominantly small cobble and large gravel interspaced with small gravel and sand. Because the habitats in the sections on the upper and lower Boulder River were different, only intrasectional comparisons could be made.