DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

WATER RESOURCES INVESTIGATIONS REPORT 89-4111
SHEET 1 OF 1

Base from U.S. Geological Survey
1:24,000 and 1:62,500 quadrangles,
1959–80

CONTOUR INTERVAL 10 AND 20 FEET
DOTTED LINES REPRESENT 5-FOOT AND 10-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM

Figure 1.--Location of study area and gaging stations used in the study.

Figure 3.--Average annual discharge for (A) Silver Creek near Riley, Oregon, (B) Silvies River near Burns, Oregon, and (C) Donner und Blitzen River near Frenchglen, Oregon, and (D) their combined total discharge and their 15-year weighted moving averages.

1984 FLOODING OF MALHEUR-HARNEY LAKE,
HARNEY COUNTY, SOUTHEASTERN OREGON

By

Larry L. Hubbard

INTRODUCTION

Malheur, Mud, and Harney Lakes are in the largest closed basin in Oregon (about 5,300 square miles). The basin is in the north-central part of Harney County in southeastern Oregon (fig. 1). Total precipitation for the 7-year period 1978-84 was 150 percent of normal and record-high runoff occurred during the 3-year period 1982-84. ("Normal" is the average value of the meteorological element over the time period 1951-80.) This record-high runoff in inflow streams resulted in extensive enlargement and joining of Malheur, Mud, and Harney Lakes, forming a large single body of water that is referred to as Malheur-Harney Lake in this report. On June 27, 1984, Malheur-Harney Lake reached a lake-surface elevation of 4,102.4 feet above sea level, the highest level in recorded history (1903-84), and covered an area of 170,000 acres (266 square miles). The flooded lake inundated 25 ranches, parts of two state highways, several miles of railroad, many miles of county roads, and much of the Malheur National Wildlife Refuge. Unlike riverine floods, the lake-surface elevation did not recede enough between runoff seasons to relieve the flooding. The persistence of high water caused long-term displacement of residents, closure of roadways, and wildlife habitat damage. Flooding can be expected to continue until evaporation from the lake surface exceeds total inflow to the lake for a sufficient amount of time to cause lake levels to decline.

This report presents a flood inundation map for the 1984 Malheur-Harney Lake flood and describes the hydrologic conditions associated with the flooding.

GENERAL DESCRIPTION

Malheur and Harney Lakes normally are two bodies of water separated by the smaller Mud Lake. The water level of Malheur Lake can exceed the water level of Harney Lake by more than 10 feet during normal years. The first exception in recorded history was the merging of the lakes in 1983 when Harney Lake filled to the elevation of Malheur Lake. This caused flooding of Mud Lake and the formation of a large single body of water. The water-surface elevations shown in figure 2 for 1972-82 represent Malheur Lake only. Harney Lake was a separate body of water at a lower water-surface elevation during those years. The elevations shown in figure 2 for 1983-84 represent the water surface of Malheur Lake that resulted when the lakes merged into a single body of water.

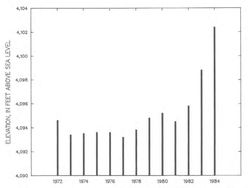

Figure 2.--Maximum water-surface elevation of Malheur Lake for 1972-84.

Water cannot flow out of Malheur Lake toward Harney Lake until Malheur Lake reaches an elevation of 4,092 feet. During non-flooded years when water in Malheur Lake reached or exceeded 4,092 feet, water overflowed from the main body of Malheur Lake through the Narrows into Mud Lake, and if unobstructed by irrigation diversions into Harney Lake (Hubbard, 1975). Harney Lake has no outflow streams; it receives its inflow from the Malheur Lake overflow, runoff from Silver Creek, and from springs around the lake (Phillips and others, 1965). Because of the record-high runoff of 1982-84, Harney Lake filled to such a high level that its elevation reached the elevation of Malheur Lake, thus creating a single body of water. When the lake recedes, the lowest possible elevation at which the two lakes can remain a single body of water is 4,092 feet, the normal overflow elevation of Malheur Lake.

THE FLOW SYSTEM

Water enters the Malheur-Harney Lake from streams, from ground-water springs and seeps, and from precipitation falling directly on the lake surface. There is no surface outflow from the flooded lake. The only means by which water can leave the system is through evaporation.

The flow volumes for the 1984 flood are described through the use of a water budget. The water budget described below is surface-water inflow, plus ground-water inflow, plus precipitation falling directly on the lake surface, minus the evaporation, equals the change in volume of water in the lake.

1984 WATER YEAR MALHEUR LAKE WATER BUDGET

surface inflow + ground-water inflow + direct precipitation - evaporation = change in lake contents

700,000 ac-ft + 120,000 ac-ft + 170,000 ac-ft - 520,000 ac-ft = 470,000 ac-ft

Surface inflow.--The Donner und Blitzen River and the Silvies River are the principal tributaries to the Malheur-Mud-Harney Lake system. Before entering Malheur Lake, the Silvies River forms a bifurcation--the East Fork and West Fork. The Silvies and the Donner und Blitzen Rivers flow into Malheur Lake, while a smaller stream, Silver Creek, flows directly into Harney Lake. Streamflow gaging stations (fig. 1) recorded annual flows of 198,000 acre-feet for the Donner und Blitzen River and 408,000 acre-feet for the Silvies River during the 1984 water year (fig. 3). The 1984 water-year flow of Silver Creek was estimated to be 90,000 acre-feet on the basis of correlations with Silvies River developed from the 29 years of flow data when the streams were concurrently gaged. Lowland flow (such as Malheur Slough) makes only a negligible contribution to the lakes. Lowland flow entering the lake during the 1984 water year was about 4,000 acre-feet, estimated from discharges obtained from periodic current-meter measurements. Thus, total surface inflow to Malheur-Harney Lake was estimated to be 700,000 acre-feet. A log-Pearson Type III frequency analysis indicates that the combined average annual flow (Silver Creek plus the Silvies and Donner und Blitzen Rivers) has only a 2-percent chance of occurring in any one year (table 1). A comparison of table 2 to table 1 indicates that the average flows of the past 2 to 10 years have all had less than a 1-percent chance of occurrence in any 2- to 10-year period.

Table 1.--Computed average annual combined flows (Silver Creek plus the Silvies and Donner und Blitzen Rivers) in acre-feet for selected exceedence probabilities

Exceedence probability	Average surface inflow, in acre-feet: 1-year average	2-year average	4-year average	6-year average	8-year average	10-year average
0.50	243,000	255,000	258,000	256,000	255,000	254,000
.20	375,000	340,000	310,000	295,000	285,000	282,000
.10	470,000	396,000	342,000	318,000	302,000	297,000
.04	598,000	465,000	380,000	343,000	321,000	315,000
.02	699,000	516,000	406,000	361,000	336,000	327,000
.01	804,000	567,000	431,000	378,000	346,000	338,000

Table 2.--Average annual combined flows (Silver Creek plus the Silvies and Donner und Blitzen Rivers) for selected 1- to 10-year periods for 1975 through 1984 water years

Average flows, in acre-feet: 1-year average (1984)	2-year average (1983-84)	4-year average (1981-84)	6-year average (1979-84)	8-year average (1977-84)	10-year average (1975-84)
696,000	702,000	520,000	450,000	390,000	360,000

Ground-water inflow.--During an earlier study, Hubbard (1975) determined that the only appreciable source of ground-water flow into Malheur Lake was Sodhouse Springs near the mouth of the Donner und Blitzen River. With the large increase in runoff during 1983-84, ground-water contribution to the Malheur-Harney Lake likely has increased substantially. However, no direct measurements of ground-water inflow were made for this study; the residual of the water-budget equation was used to estimate the contribution of ground water to the lake. The estimated ground-water inflow to the lake was 120,000 acre-feet for the 1984 water year, but this calculation provides only a gross estimate of net 1984 water year ground-water inflow because it included all the estimation errors of the other variables in the water-budget equation. It also included any seepage to the streams between the gaged sites and the flooded lake.

Precipitation falling directly on the lake surface.--The 30-year, 1951-80, average annual precipitation for Malheur Refuge Headquarters is 9.07 inches. This average was greatly exceeded each year for the period 1978-84. The precipitation for the Refuge in 1984 totaled 12.98 inches (150 percent of the 30-year average). Monthly precipitation measured at Malheur Refuge Headquarters was multiplied by the average surface area of the flooded lake surface for each month and totaled, to determine the annual inflow from direct precipitation. The inflow from direct precipitation was 170,000 acre-feet for the 1984 water year.

Evaporation.--The Malheur Refuge Headquarters evaporation pan at Malheur Lake was not operated in 1984, but evaporation-pan data were available from the Malheur Branch Experiment Station located in the adjacent Malheur River basin. Sixty-eight months of concurrent monthly evaporation data were available for the Malheur Branch Experiment Station and Malheur Refuge Headquarters. The average ratio of the values for evaporation from the Malheur Refuge Headquarters pan to the Malheur Branch Experiment Station pan was 0.9. This ratio was applied to the 1984 data from the Experiment Station to estimate pan evaporation at the Malheur Refuge Headquarters. The pan-evaporation readings also were adjusted by an open-water-area-pan coefficient of 0.74 (Kohler and others, 1959, pl. 3). Estimated monthly evaporation was multiplied by the average area of the flooded lake surface for each month and totaled to determine the 1984 annual evaporation from the lake surface. Estimated evaporation from the Harney-Malheur lake surface was 520,000 acre-feet during 1984.

Change in lake contents.--A lake elevation-contents curve, shown in figure 4, was developed for the condition in which Malheur, Mud, and Harney Lakes would form a single body of water (Malheur-Harney Lake). A bathymetric survey was made when the lake was near its peak elevation of 4,102 feet. An elevation-area curve and an elevation-contents curve were developed for lake levels ranging from 4,092 feet (the lowest elevation at which the three lakes can form a single body of water) to the surveyed elevation of 4,102 feet. These curves were projected to 4,114 feet, the elevation at which water could overflow through Malheur Gap into the Malheur River basin, by computing the area at the 4,110-foot elevation contour and at the 4,120-foot contour from U.S. Geological Survey topographic maps and by interpolating to the 4,114-foot elevation. From the change in lake elevation at the beginning and ending of the water year, it was determined, from the storage-capacity curves, that the lake volume increased by 470,000 acre-feet during the 1984 water year.

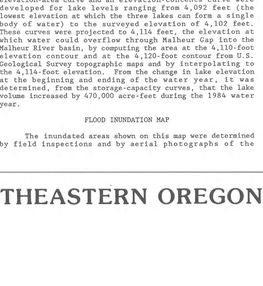

Figure 4.--Relation between water-surface elevation and surface area and volume of water for Malheur-Mud-Harney Lakes. Graph only applies when all three lakes are combined into a single body of water.

FLOOD INUNDATION MAP

The inundated areas shown on this map were determined by field inspections and by aerial photographs of the shoreline made while the lake was at an elevation of 4,102.4 feet.

ACKNOWLEDGMENTS

The cooperation and assistance of many individuals greatly facilitated this study. William Beale, Harney County Watermaster, of the Oregon Water Resources Department, was particularly helpful. His personal knowledge of the area was extremely useful in the flood-boundary mapping phase of the study. Mr. Beale did most of the original flood boundary sketching on the field maps.

George Constantino, Manager of the Malheur National Wildlife Refuge provided valuable assistance, through his staff at refuge headquarters, to the U.S. Geological Survey boat survey crew during the bathymetric mapping phase of the study.

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Piper A. M., and Robinson, T. W., Jr., 1939, Geology and ground-water resources of Harney Valley, Oregon: U.S. Geological Survey Water-Supply Paper 861, 189 p.

Phillips, K. N., Newcomb, R. C., Swenson, H. A., and Laird, L. B., 1965, Water for Oregon: U.S. Geological Survey Water-Supply Paper 1649, 150 p.

ADDENDUM.--Since 1984, annual maximum lake elevations continued to rise until 1986 and then has continually dropped through 1989. The annual maximum lake elevations since 1984 are: 4,102.5 ft (1985), 4,102.6 ft (1986), 4,101.1 ft (1987), 4,099.7 ft (1988), and 4,098.4 ft (1989).

CONVERSION FACTORS AND ABBREVIATIONS

For the convenience of readers who may prefer to use metric (International System) units rather than inch-pound units used in this report, values may be converted by using the following factors:

Multiply inch-pound units	By	To obtain metric units
Length		
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Area		
square mile (mi^2)	2.590	square kilometer (km^2)
Volume		
cubic foot (ft^3)	0.02832	cubic meter (m^3)
acre-feet (acre-ft)	1233.	cubic meter (m^3)

SEA LEVEL: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

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