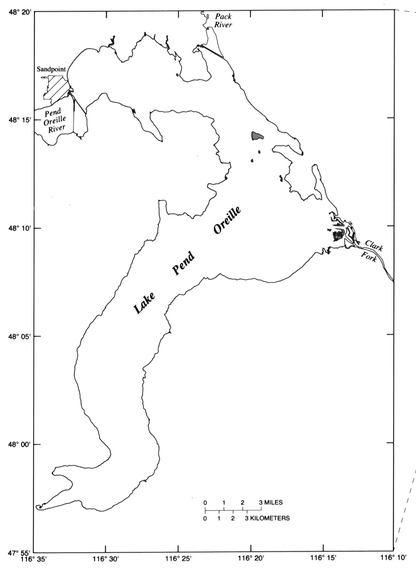
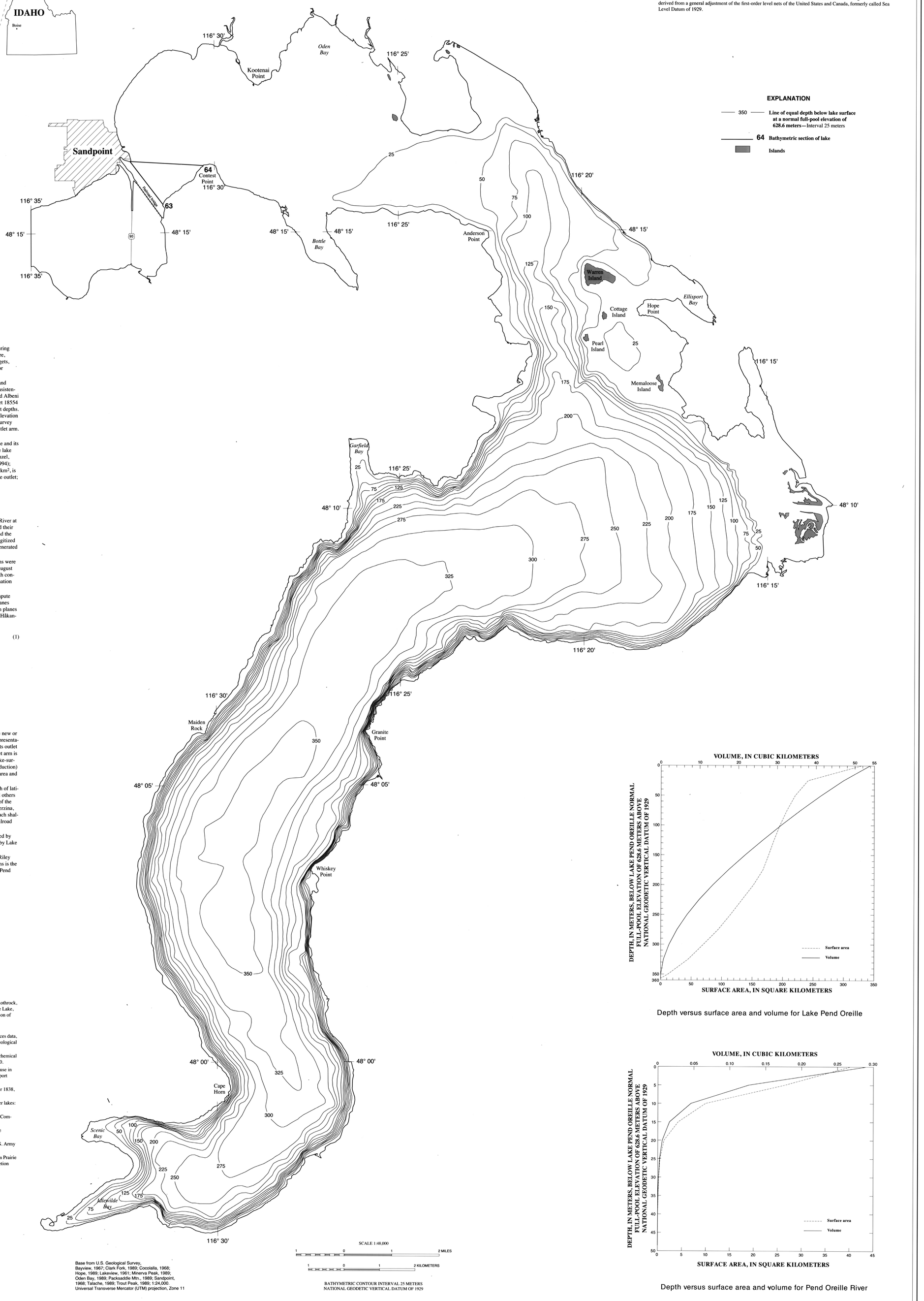
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
IDAHO DEPARTMENT OF HEALTH AND WELFARE, DIVISION OF ENVIRONMENTAL QUALITY

WATER-RESOURCES INVESTIGATIONS REPORT 96–4189
Bathymetric map, Lake Pend Oreille, SHEET 1 of 2
Fields, R.L., and others, 1996, Bathymetric Map of Lake Pend Oreille and Pend Oreille River, Idaho








## CONVERSION FACTORS AND VERTICAL DATUM

| Multiply | By | To obtain |
|---|---|---|
| cubic kilometer ($km^3$) | 810,700 | acre-foot |
| kilometer (km) | 0.6214 | mile |
| meter (m) | 3.281 | foot |
| square kilometer ($km^2$) | 247.1 | acre |

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

## EXPLANATION

- 350 — **Line of equal depth below lake surface at a normal full-pool elevation of 628.6 meters**—Interval 25 meters
- 64 — **Bathymetric section of lake**
- **Islands**

## BACKGROUND

The U.S. Geological Survey investigated nutrient enrichment in Lake Pend Oreille, northern Idaho, during 1989–90. The objectives of the cooperative investigation with the Idaho Department of Health and Welfare, Division of Environmental Quality, were to characterize limnology, quantify hydrologic and nutrient budgets, and develop a computer-based nutrient load/lake response model. The model required bathymetric data for computation of mass balances of water and nutrients within numerous depth layers in the lake.

A review of bathymetric data for the lake (Stross, 1954; Bue, 1963; Martin and Hanson, 1966; Leidy and Jenkins, 1977; U.S. Army Corps of Engineers, 1981; Milligan and others, 1983) revealed numerous inconsistencies and a lack of bathymetric data for the lake's outlet arm, the Pend Oreille River between Sandpoint and Albeni Falls Dam (map on sheet 2). Additionally, the original (1982) bathymetric map of Lake Pend Oreille, chart 18554 published by National Oceanic and Atmospheric Administration (NOAA), was based on preimpoundment depths. Albeni Falls Dam began regulating Lake Pend Oreille in June 1952 and raised the lake's normal surface elevation from 624.3 to 628.6 m above NGVD of 1929. To obtain accurate bathymetric data, the U.S. Geological Survey recomputed the bathymetry shown on NOAA chart 18554 and collected bathymetric data for the lake's outlet arm. This report shows the updated bathymetric data generated by those two procedures.

Lake Pend Oreille lies in a glacially scoured graben within the Purcell Trench (Wyman, 1993). The lake and its outlet arm receive inflow from about 62,700 $km^2$ (Harenberg and others, 1994). The Clark Fork enters the lake from the east and supplies about 85 percent of the surface-water inflow to the lake and its outlet arm (Frenzel, 1991). Above its mouth at Sandpoint, the lake receives inflow from 59,300 $km^2$ (Harenberg and others, 1994); therefore, the outlet arm receives inflow from about 3,400 $km^2$. Of that 3,400 $km^2$, 68.8 percent, or 2,340 $km^2$, is drained by the Priest River (Harenberg and others, 1994). The Pend Oreille River is the lake's only surface outlet; it joins the Columbia River in northeastern Washington.

## METHODS

During August 1989, a calibrated video depth sounder was used to measure depth of the Pend Oreille River at 62 bathymetric sections between Albeni Falls Dam and the railroad bridge at Sandpoint. Those depths and their locations were digitized onto a base map that had been generated by digitizing the shoreline of the lake and the river from 7.5-minute U.S. Geological Survey topographic maps. The depth contours for the river were digitized because the regularly spaced lateral bathymetric sections created computational problems for computer-generated contouring.

Lake depths depicted on NOAA chart 18554 were digitized and transferred to a base map. Those depths were increased by 4.3 m to correspond with postimpoundment depths at a normal full-pool elevation. During August 1989, two bathymetric sections were measured on the lake near its outlet adjacent to Sandpoint. New depth contours for the lake were generated with the TIN module of ARC/INFO[1], a computerized geographic information system.

After depth contours for the lake and outlet arm had been completed, the TIN module was used to compute surface areas for numerous depth planes. Summation of the volumes contained between adjacent depth planes yielded the total volume for the lake and its outlet arm. For quality assurance, the surface area of the depth planes analyzed by TIN were digitized, and volumes of water were computed using the following equation from Håkanson (1981, p. 41):

$$V_p = \sum_{i=0}^{n} \frac{l_c}{3}\left(a_i + a_{i+1} + \sqrt{a_i \times a_{i+1}}\right) , \qquad (1)$$

where

$V_p$ is the parabolic approximation of the lake volume, in cubic kilometers;

$l_c$ is the contour line interval, in meters; and

$a_i$ is the total surface area within the limits of the contour line $l_c$, in square kilometers.

[1]Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

## BATHYMETRY

Selected morphometric characteristics of Lake Pend Oreille and its outlet arm were computed from the new or updated bathymetric data and are summarized in the table below. The morphometric characteristics are representative of a normal full-pool elevation of 628.6 m above NGVD. The combined surface area of the lake and its outlet arm is 369 $km^2$, and 10.9 percent of that total is the outlet arm. The combined volume of the lake and outlet arm is 54.2 $km^3$; the outlet arm composes only 0.5 percent of the total volume. Normal drawdown reduces the lake-surface elevation to 625.1 m above NGVD and reduces the combined surface area to 344 $km^2$ (6.8-percent reduction) and the combined volume to 53.2 $km^3$ (1.8-percent reduction). Relations between depth and lake-surface area and volume at normal full-pool elevation are shown in graphs at the bottom right.

The bathymetric map of the lake (sheet 1) indicates that lake-surface area and volume are greatest south of latitude 48°15'00". The maximum depth is 357 m southwest of Whiskey Point, near mid-lake. Kemmerer and others (1923) reported a maximum depth of 377 m; however, the U.S. Navy has conducted bathymetric surveys of the lake's deep part in support of its submarine research and has not located a depth greater than 357 m (D. Gerzina, David Taylor Research Center, oral commun., 1990). The part of the lake north of latitude 48°15'00" is much shallower and smaller in surface area and volume. Some of the shallowest areas in the lake are between the railroad bridge at Sandpoint and the Dover area.

Compared with surface areas and maximum depths of natural freshwater lakes in the United States listed by Bue (1963), Lake Pend Oreille is the 21st largest and the 5th deepest. Its maximum depth is exceeded only by Lake Superior, Lake Chelan (Washington), Lake Tahoe (California and Nevada), and Crater Lake (Oregon).

The bathymetric map of the outlet arm (sheet 2) shows that the river has several troughs; the one near Riley Creek is 48.5 m deep (see bathymetric section 26). A distinctive feature noted from the bathymetric sections is the submerged benches on both sides of the channel (see bathymetric sections 20, 32, and 59). They were the Pend Oreille River's original shoreline prior to inundation by impoundment in 1952.

Selected morphometric characteristics of Lake Pend Oreille and Pend Oreille River at a normal full-pool elevation of 628.6 meters

| Characteristic and units | Lake | River | Lake and river |
|---|---|---|---|
| Surface area, square kilometers | 329 | 40.1 | 369 |
| Volume, cubic kilometers | 53.9 | .29 | 54.2 |
| Maximum depth, meters | 357 | 48.5 | 357 |
| Mean depth, meters | 164 | 7.2 | 147 |

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Depth versus surface area and volume for Lake Pend Oreille




Depth versus surface area and volume for Pend Oreille River

# BATHYMETRIC MAP OF LAKE PEND OREILLE AND PEND OREILLE RIVER, IDAHO

By
R.L. Fields, P.F. Woods, and Charles Berenbrock

1996

Base from U.S. Geological Survey,
Bayview, 1967; Clark Fork, 1989; Cocolalla, 1968;
Hope, 1989; Lakeview, 1961; Minerva Peak, 1989;
Oden Bay, 1989; Packsaddle Mtn., 1989; Sandpoint,
1968; Talache, 1989; Trout Peak, 1989; 1:24,000.
Universal Transverse Mercator (UTM) projection, Zone 11

Copies of this map can be purchased from:

U.S. Geological Survey
Information Services
Box 25286
Denver Federal Center
Denver, CO 80225