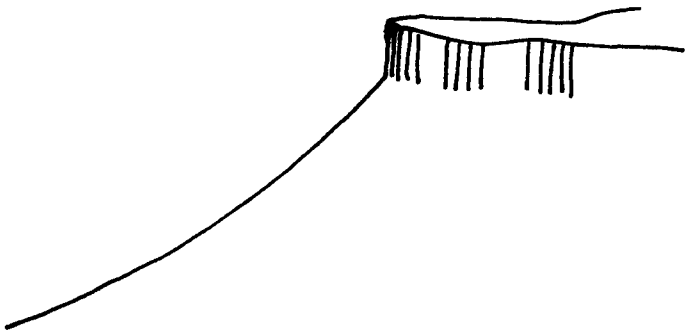

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FREMONT AND NEW FORK LAKES: SOME CHARACTERISTICS

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These glacial lakes lying within a few miles of one another on the west flank of the Wind River Mountains, appear to be typical of a large number of glacial lakes in the region, most of them smaller than these two. Fremont Lake has received considerably more study and therefore, it will be discussed first and later a comparison of the two lakes will be made.

FREMONT LAKE

Fremont Lake lies in a trough that was scoured by glacial ice into granitic rock and plugged at the downstream end by a terminal moraine. The lake basin is elongate and is pinched in width at about the halfway point to form a constriction called The Narrows. Upstream from this neck, the mountain slopes bordering the lake are nearly free of glacial till, bare rock surfaces predominating. Below The Narrows, the valley slopes are morainal, and there is virtually no bedrock at the surface. The outlet end of the lake is a terminal moraine made up of the till of both Bull Lake and Pinedale age. Since the ice retreat, the outlet stream, Pine Creek, has incised itself into the terminal moraine only 3 or 4 m.

The outstanding physical feature of Fremont Lake is its great depth (Figure 1). The maximum depth of 185.3 m makes Fremont the seventh deepest natural lake in the conterminous United States (excluding the Great Lakes) and the tenth deepest with Alaska included (Table 1).

Table 1. Natural lakes of the United States with depths exceeding 150 m

Name	State	Depth (m)
Crater	Oregon	589
Tahoe	California and Nevada	501
Chelan	Washington	489
Pend Oreille	Idaho	366
Nuyakuk	Alaska	284
Deer	Alaska	267
Chauekuktuli	Alaska	213
Crescent	Washington	190
Seneca	New York	188
Fremont	Wyoming	185
Clark	Alaska	184
Beverly	Alaska	152

As can be seen in Figure 1, the two parts of the lake are distinguished by differences in bottom morphology. In the southern part, the depth increases in regular pattern from the three shorelines and the traverse ridge, and the bottom is exceedingly flat. In the northern part the depth patterns are much more irregular, and, instead of one basin, there are several isolated pockets of deep water which have sloping bottoms.

The extreme flatness of the bottom in the southern part of the lake is well illustrated in Figure 1. The 180 m isobath covers a central area of 1.26 km^2 which includes, at 185.3 m, the maximum depth measured in the lake. The flat bottom is undoubtedly the result of the filling of a depression with sediment. The presence of a flat bottom only in the downstream and deepest part of the lake suggests that the sediment was deposited from density currents and consists of very fine grained material. However, no core samples have yet been taken.

Fremont River enters the north end of Fremont Lake and is the only influent stream other than a few minor rivulets. This river contributes 5 m^3/sec on the average. Annual precipitation directly on the water surface is judged to be about 35 cm. The total drainage area is 244.1 km^2. The slopes which surround the lake constitute a drainage area of 27.2 km^2 and they contribute practically no runoff to the lake. The ratio of total drainage area to the lake surface area is 11.9. A few pertinent quantities concerning Fremont Lake are listed in Table 2.

Table 2. Some aspects of the water balance of Fremont Lake

Area of lake surface	20.6 km^2
Drainage area at lake outlet	244.1 km^2
Average annual flow at gage	5 m^3/sec
Average annual depth of runoff	0.80 m/yr
Estimated runoff below gage	0.35 m/yr
Estimated precipitation on lake surface	0.35 m/yr
Estimated evaporation from lake	1.0 m/yr
Volume of water in the lake	1,690 x $10^6 m^3$

The ratio of lake volume to the mean annual inflow, expressed in the same terms, gives an indication of the renewal time, that is the amount of time it takes to replace the total lake volume by new inflow. For Fremont Lake this ratio is 11.1 years.

TEMPERATURE

The temperature of maximum density of water is 3.94° C. under ordinary atmospheric pressure. The temperature of maximum density, however, decreases with increasing pressure and thus with depth. At a maximum depth of Fremont Lake, 183 m, the temperature of maximum density is 3.73° C.

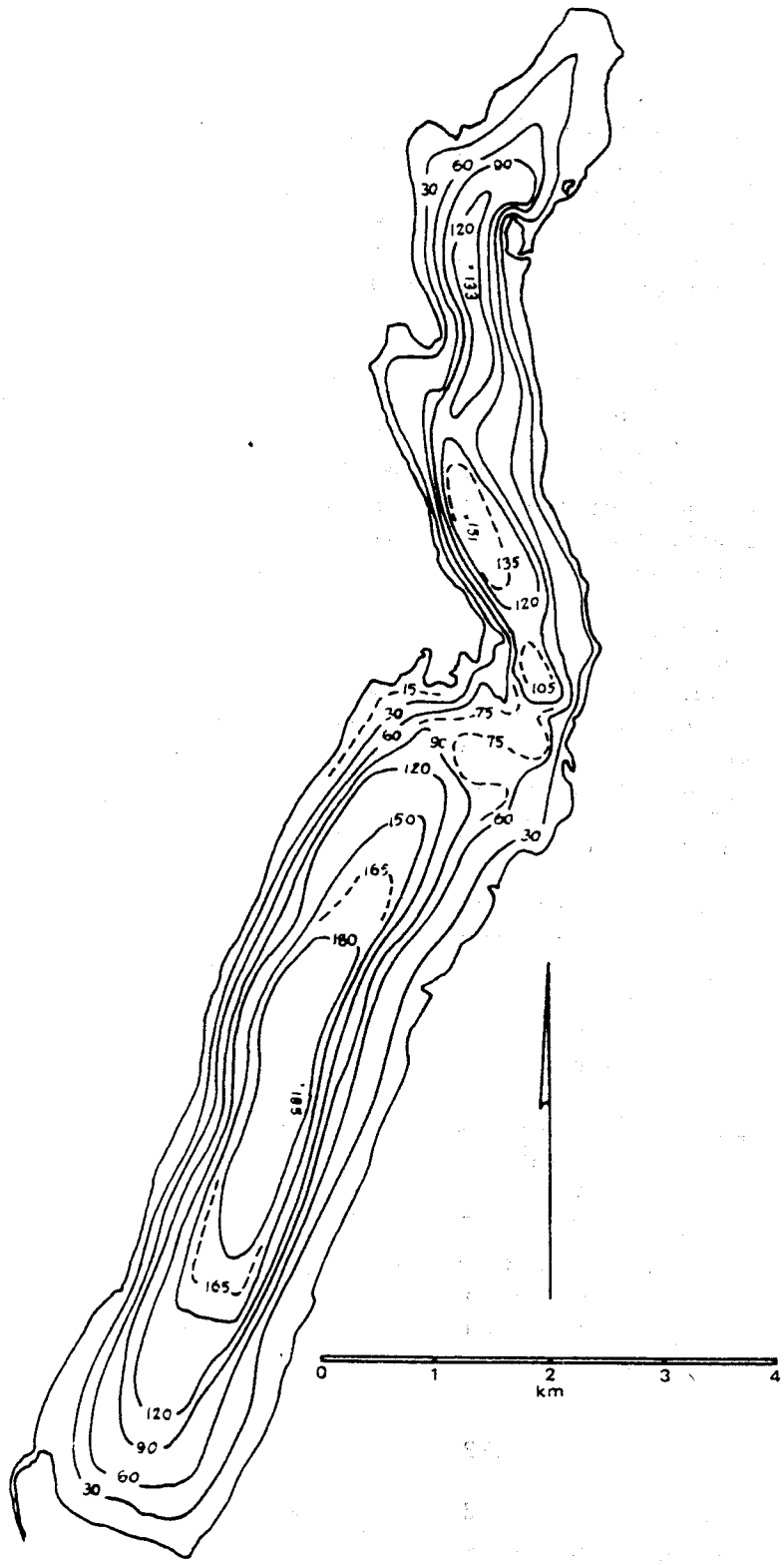


Figure 1. Bathymetric map of Fremont Lake. Mean water surface elevation and spillway elevation is 2179 m, mean sea level. Depth contour interval is 30 m; intermediate depths are given by broken lines.

Some temperature profiles of Fremont and New Fork Lakes are shown in Figure 2. Note that both lakes are nearly identical in their profiles except Fremont is much deeper.

In Fremont Lake on May 9, 1971, four days before ice breakup, temperatures above 60 m were colder than the maximum density temperature and those below 60 m were warmer. Thus the upper part of the profile was an unstable condition which changed by May 12 to one in which the temperature at most points were either similar to or warmer than the temperature at maximum density. The ice breakup occurred on May 13. These temperature data indicate that the turnover or mixing occurred about May 12 and extended down to probably 90 m, for by May 12 the profile between 30 and 90 m closely approximated the line of maximum density. Between May 9 and May 17, the temperatures remained virtually unchanged at 90 m and below. It is thus believed that mixing did not extend deeper than 90 m during this particular spring season.

CHEMISTRY

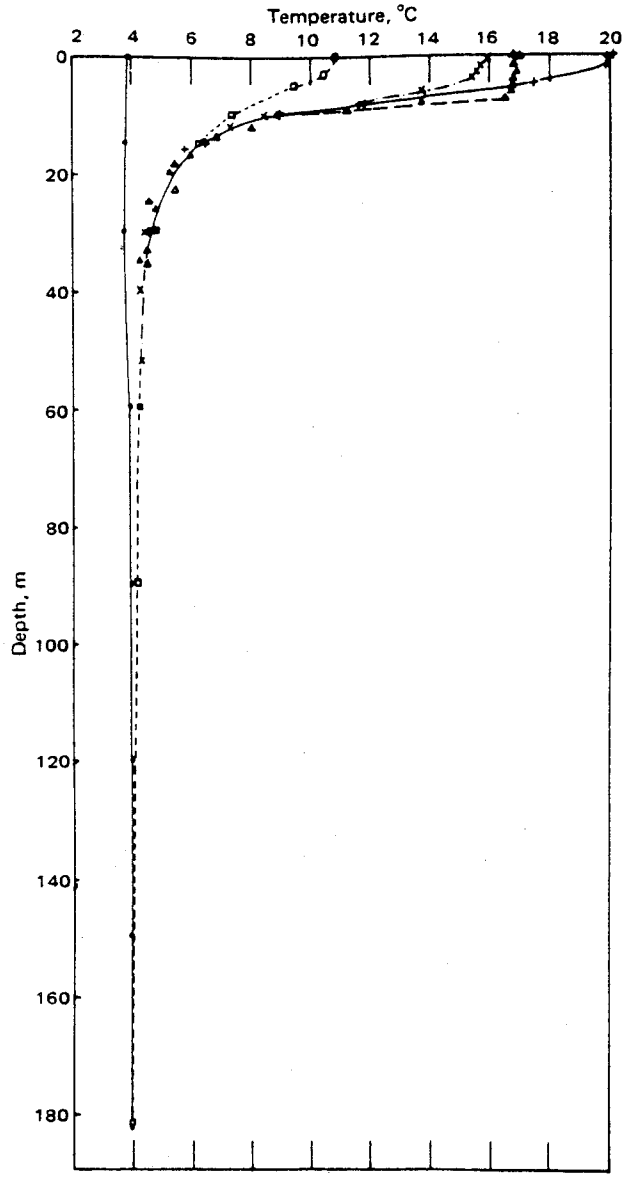
Dissolved oxygen content in Fremont Lake increases from about 7.7 mg/L at the surface to 9.8 mg/L at 10 m depth. At the maximum depth, the oxygen content represented a percentage saturation of 80%. This also indicates incomplete vernal circulation. The oxygen depletion at depth probably resulted from the oxidation of organic matter within the water column itself.

The other striking thing about Fremont Lake is the very low value of dissolved mineral content. The mean dissolved solids content of Fremont Lake is 12.8 mg/L, a value remarkably low for so large a lake. To give some idea of how this value compares with other dilute lakes of large size, Table 3 is presented.

Table 3. Dissolved solids in water of some large, dilute lakes in North America

	Dissolved Solids, mg/L
Waldo Lake, Ore.	2-5
Fremont Lake, Wyo.	13
Moosehead Lake, Maine	16
Lake Winnispeaukee, N. H.	18-21
Odell Lake, Ore.	25-28
Yellowstone Lake, Wyo.	55
Lake Athabasca, Alberta	58
Lake Tahoe, Calif.	60-80
Lake Superior, Minn.	82
Great Bear Lake, N.W. Terr.	98
Jackson Lake, Wyo.	104

It will be noted that only one lake in North America is known to have a dissolved solids mineral content lower than that of Fremont Lake.



Profiles of temperature as a function of depth. Fremont Lake: ●—●, May 9, 1971, where depth was 183 m; □---□, June 16, 1971, depth 183 m. New Fork Lake: +—+, July 31, 1979, where depth was 16 m; ▲—▲, Aug. 16, 1979, depth 38 m; x--x, Aug. 23, 1979, depth 56 m; △---△, Aug. 25–28, 1973, depth 38 m.

Figure 2.

The mineral content of the lake water is slightly higher than that of the inflowing Fremont River. On the basis of the data collected, it appears that the precipitation composition determines a considerable part of the major ion chemistry of Fremont Lake.

BIOLOGY

Net-plankton samples were collected at depths from 3 m to 45 m. The net-plankton included representatives of seven genera of phytoplankters and three genera of zooplankters. Diatoms made up 93% of the phytoplankton count.

Comparison of the mean distribution of organisms from one end of the lake to the other shows that the number of organisms in the net-plankton samples were markedly higher in the north end of the lake than in the south end. Also, a striking decrease in plankton count occurred with depth.

BACTERIOLOGICAL DETERMINATION

Samples of water tested for human contamination were taken in 1970 and on several occasions in more recent years. In practically all cases the coliform count was either zero or considerably lower than the public health standards usually accepted. Samples in the period from 1979 to 1981 taken at the far south end of the lake have shown at times some coliform count, a matter which is being studied by the local health officer. The levels, however, were still below permissible health standards.

NEW FORK LAKE

The dam on New Fork Lake was built by the New Fork Irrigation District. It is 5.2 m high, built in 1928 and causes a summer drawdown of 2.2 to 3 m. New Fork Lake as can be seen in Figure 3 is bounded by a lateral moraine for its full length. It is also partly cut by a moraine extending as a submerged barrier across the middle of the lake. The so-called Narrows of New Fork Lake, formed by such a moraine nearly cuts the lake in two and the water depth over the connecting shoal is a mere 1 m. New Fork Lake is only one-third the depth of Fremont Lake and the lower basin has a more dish-shaped cross section than the upper basin which has steeply sloping sides and a relatively flat bed in the lake center.

When temperatures are compared between Fremont and New Fork Lakes, the results are very comparable as can be seen in Figure 2. In both lakes, regardless of difference of depth, summer mixing achieves a depth of about 10 m. Below that, the lakes tend to maintain a nearly constant temperature close to that of maximum density. With the onset of summer, surface temperature increases and the depth of the mixed layer remains thin but when the surface water begins to cool in late summer, early fall, the depth of the mixed layer increases and its profile becomes isothermal to a depth of about 10 m.

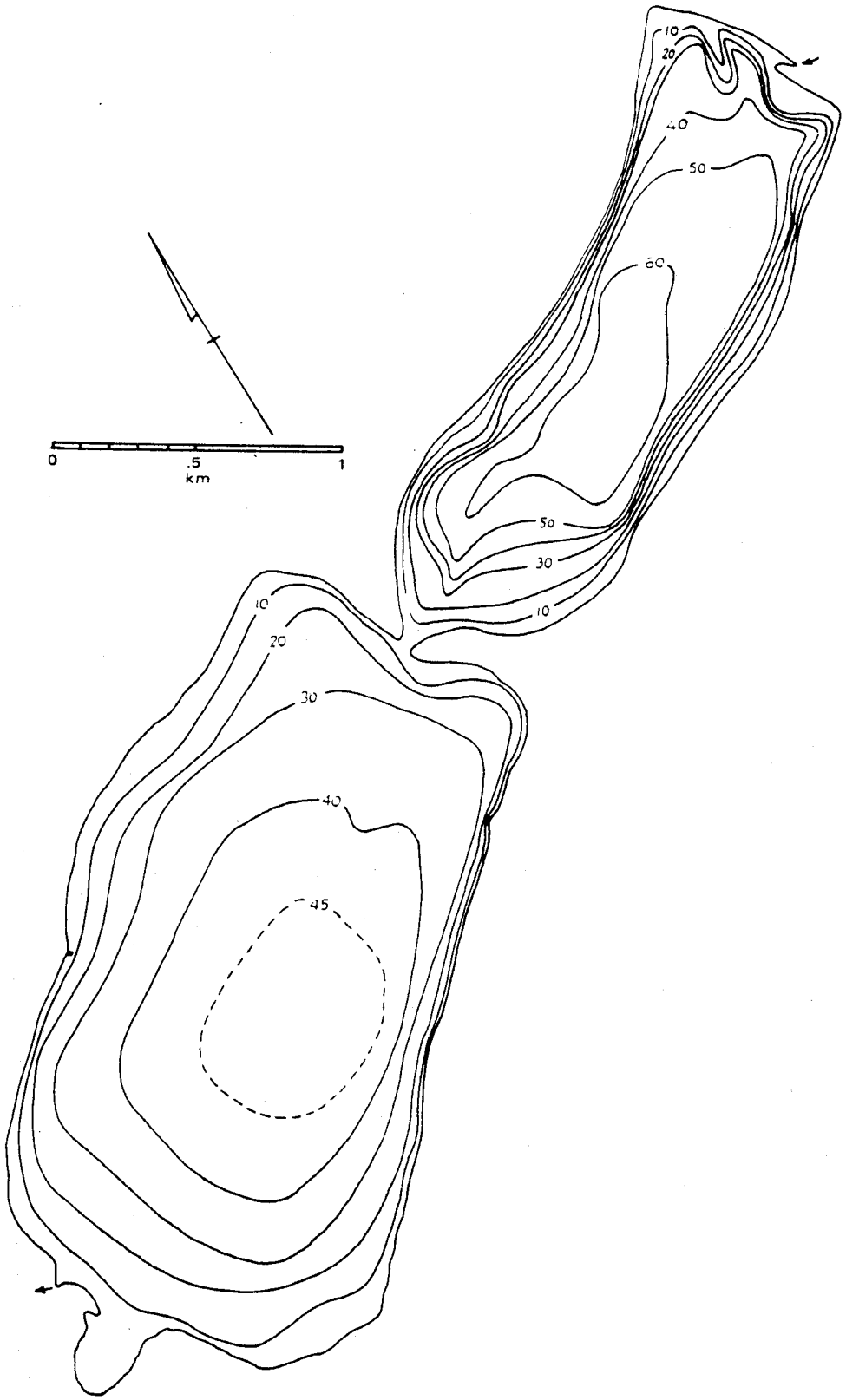


Figure 3. Bathymetric map of New Fork Lake. Spillway elevation at outlet is 2,383 m, mean sea level. Points of inflow and outflow are shown by arrows. Depth contour interval is 10 m; intermediate depths are given by broken lines.

CONCLUSION

Glacial lakes in the Wind River Mountains are of exceptional scientific and esthetic interest owing to their low content of dissolved solids, their depth and the absence of coliform contamination. On the basis of our measurements, Fremont Lake turns out to be the seventh deepest lake in conterminous United States and the second most dilute lake known in North America. These data clearly indicate that Fremont Lake should be preserved in its present condition as an ecological benchmark having national significance.

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