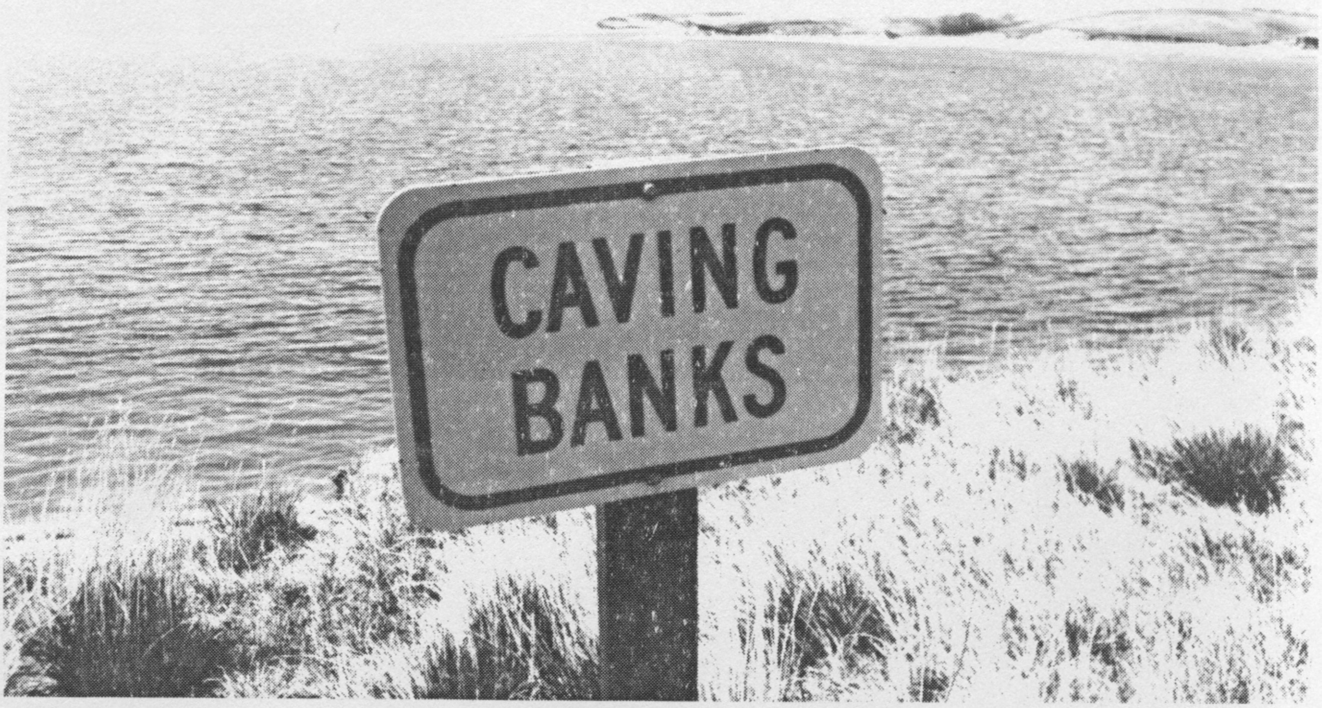
US Army Corps
of Engineers
Omaha District

BANK RECESSION

Causes, Measurement Techniques, Rates, and Predictions
Lake Sakakawea, North Dakota



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EXECUTIVE SUMMARY

Erosion of banks bordering lakes and reservoirs is a natural phenomenon that has caused immeasurable loss of land. Many attempts have been made to control this erosion and some attempts have been made to predict future erosion, for planning purposes. This project on Lake Sakakawea, ND began in 1983 to define erosion processes, quantify them, and design a procedure for predicting erosion rates and amounts.

Techniques have been developed to measure erosion processes and rates; these include the installation of bank surface erosion and bank top recession pin sets, the measurement of bank, beach and offshore slopes, and the integration of results with the factors of erosion.

Average bank recession at 20 stations along the east end of Lake Sakakawea between 1983 and 1990 was a little more than three feet a year, but some stations underwent as much as twelve feet of erosion in a single storm. The dominant erosion process is related to wave action, especially during summer storm events in those years when the pool level is high enough that waves break along the base of steep banks. But about 23% of total erosion occurs during the colder months (November through April), largely as a result of frost-thaw failure. But to understand why great variations in bank top recession occur it is necessary to understand passive factors of erosion, including bank and beach composition, stratigraphy and structure, antecedent moisture, bank geometry, and the type and amount of vegetation protecting the bank. For example, northerly-facing banks fail during frost thaw more than any other banks because they tend to retain more moisture. Southerly and southwesterly-facing banks undergo more wave erosion because of storm wind direction. Highly vertically-fractured tills that are underlain by loose sands tend to fail rapidly as large blocks. Highly fractured mudstones fail as numerous small blocks because vertical fractures are intersected by bedding plane fractures.

There are strong seasonal differences in bank recession along Lake Sakakawea, but the pool level is more significant. When the water reaches or exceeds a critical level of 1846 feet msl direct wave erosion can occur. Since 1983 there have been only three years when this occurred, 1983, 1984, and 1986. And in 1983 the water barely reached this level and only for a brief time. Despite this, 56% of the total bank recession at the 20 stations was during high pool levels even though this occurred only 16% of the time.

Prediction of future bank recession requires a knowledge of existing rates of recession and/or historical rates. Historical rates can be measured from Sediment Rangeline surveys, if available, and from low-altitude aerial photographs. Accurate measurements from photographs is difficult. Also, It is assumed that rates of recession will diminish over time as a result of eventual smoothing of shoreline irregularities, increased accumulation of natural riprap, and development of an offshore platform. Parabolic extension of measured rates can be used to estimate future recession.

Regression analysis of detailed measurements of bank recession and causative factors at Lake Sakakawea has led to the development of a series of predictive equations:

Eq.1a. $$Rw = 2.75 + 0.11\sqrt{A} - (0.11\sqrt{B} + 0.04\sqrt{C} + 0.44\sqrt{D} + 0.19\sqrt{E} + 0.12\sqrt{F}),$$

or

Eq.1b. $$Rw = 141.53 - (8.37\sqrt{B} + 25.08\sqrt{D} + 19.20\sqrt{E} + 10.44\sqrt{F}),$$

where Rw is the average recession of a given bank for each "warm" month of the year (May through October), A is the effective fetch, B is bank height, C is percentage of beach material finer than pebble size, D is angle of the offshore slope, E is the sine of the angle between the bank orientation and the direction of the dominant wind, and F is beach width. And,

Eq.2. $$Rc = 0.013 + 0.004B - 0.001G,$$

where Rc is the average bank recession over each "cold" month (November through April, B is bank height, and G is bank orientation with respect to the sun.

The total predicted annual bank recession at each station, therefore, is:

Eq.3. $$Rt = 6Rw + 6Rc$$

Subsequent analysis of additional measurements has led to the development of another set of predictive equations based on pool levels:

Eq.4. $$Rh = -0.46 + 1.20\sqrt{A} - 0.02\sqrt{B} + 0.10\sqrt{C} - 0.70\sqrt{D},$$

and

Eq.5. $$Rl = 0.142 + 0.004B - 0.001G,$$

where Rh is the average bank recession during each month the pool level exceeds the critical level (1846 ft msl), Rl is the average recession for each month of lower levels of the lake (most of the time), A is effective fetch, B is bank height, C is percentage of beach material finer than pebble size, D is beach slope, and G is the angle of the bank with respect to the sun. Inclusion of the results with historical data from Sediment Rangeline surveys can provide a trend which, if projected parabolically over time, can predict future recession with a greater validity than via a template method.