LAKE HERMAN DREDGING FEASIBILITY STUDY

for the

SOUTH DAKOTA DEPARTMENT OF WATER AND NATURAL RESOURCES

Dames & Moore
11236-001-05

January 4, 1980

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January 4, 1980

South Dakota Department of Water and Natural Resources
Joe Foss Building
Pierre, South Dakota 57501

Attention: Mr. James R. Seyfer
Lakes Specialist

Gentlemen:

This letter transmits six copies of our "Report of Lake Herman Dredging Feasibility Study for the South Dakota Department of Water and Natural Resources."

The scope of this study was planned in discussions between Mr. Miles Athey of Dames & Moore and Mr. Seyfer and was described in our proposal dated November 30, 1978. Authorization was provided by a contract which we signed on August 27, 1979. That contract attached our proposal as Appendix A and referred to it as providing a detailed description of the work.

During the course of the study, it became necessary to change project managers when Mr. Athey left Dames & Moore. Also, completion of the project was delayed because of the need to obtain futher information from the South Dakota DWNR. These matters were discussed by telephone on November 15, 1979. The discussions were confirmed by our letter of November 28, 1979.

Several other discussions were held between the team members and Mr. Seyfer to confirm points of information and to provide preliminary indications of our conclusions.

We appreciate the opportunity to serve you in conducting this interesting study. We will be pleased to answer any questions you may have and to assist you with any further investigation that may be desired.

Yours very truly,

DAMES & MOORE

By *Larry L. Morrison*

Larry L. Morrison
Associate

LLM:mb
11236-001-05

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LAKE HERMAN DREDGE FEASIBILITY STUDY TEAM

The Lake Herman dredge feasibility project was completed by the Seattle office of Dames & Moore (D&M). Technical assistance was provided by our Portland office and Hazleton Environmental Sciences (HES). The address and telephone number of the Dames & Moore office that controlled the study is:

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Function	Name
Project Manager	Larry L. Morrison (D&M)
Dredge Engineering	Dwight Hardin (D&M)
Fisheries	John Isakson (D&M)
Water Quality	Quentin Bliss (HES)

MAJOR CONCLUSIONS

Evaluation of the somewhat limited available data on Lake Herman has produced the following principle conclusions:

1. The lake is not filling with sediments as fast as some (Churchill et al. 1975) have estimated. The actual sedimentation rate is not precisely known. We have assumed a rate of approximately 22 acre-feet per year (USDA 1979) for purposes of this study.

2. Dredging is "feasible" in that easily dredgeable sediments are present to substantial depths.

3. Economically feasible dredging will not have a great long-term influence on lake water quality as a result of either the dredging itself or the deepened lake condition if the quality of the water entering the lake remains essentially the same.

4. Dredging is much more expensive than is generally realized by the public. For example, a project to dredge the entire lake 2 feet deeper is estimated to cost from $9 to $10 million, and it would require 700 acres of spoils area.

5. We believe that any dredging should be undertaken as a phased program and that careful monitoring should be accomplished to develop specific information on the effectiveness and life span of dredging activities.

6. Alternative methods of water quality improvement (other than dredging) should be further evaluated.

LAKE HERMAN DREDGING FEASIBILITY STUDY

for the

SOUTH DAKOTA DEPARTMENT OF WATER AND NATURAL RESOURCES

INTRODUCTION

PURPOSE

Dames & Moore has been retained to study the feasibility of improving the water quality and recreational potential of Lake Herman by dredging. Our study is a part of a model implementation project funded jointly by the Environmental Protection Agency (EPA), the South Dakota Department of Water and Natural Resources and other county, regional, and local entities. Both 208 Program and 314 Program monies are involved. A small amount of dredging was accomplished within the lake basin about 5 or 6 years ago, and we understand that there is now significant local interest in dredging as a possible means of lake improvement.

BACKGROUND AND NEED

Lake Herman is a shallow warm-water prairie lake located approximately 3 miles west of Madison, South Dakota. It is a "pothole" type lake, occupying a shallow basin formed by glacial action about 10 to 15 thousand years ago. The lake has a surface area of approximately 1,350 acres, with an average depth at full capacity of about 6 feet. Land use within the 56-square-mile watershed area of the lake is almost entirely agricultural.

A state park located on the eastern shore of Lake Herman is heavily used, with about 340,000 users in 1971 (Churchill et al. 1975). Several resorts and recreational facilities of various organizations are also located along the lake shoreline, as well as a number of year-round and "summer cottage" type residences. The major recreational uses of the lake are boating, fishing, water skiing, and swimming.

We understand that Lake Herman has become significantly shallower since this region was settled roughly 100 years ago. As extensive shoal areas have developed, the deterioration of water quality has apparently been accentuated by the stirring up of nutrient-rich bottom sediments by wind-induced wave action. In recent years, shallower than normal water depths have occurred because of drought conditions. The shallow water, in combination with heavy winter ice covers, has contributed to frequent fish kills.

As the deterioration of the lake became evident, a number of studies were undertaken to investigate the thickness and character of lake sediments, the composition and quality of the lake waters, the agricultural productivity of dredged lake sediments, and related topics. These studies, most of which have been conducted during the past 10 years, are cited in the bibliography included in this report. Data and conclusions from these previous efforts have provided the background information for our dredging feasibility study.

SCOPE OF WORK

The scope of our study is described in our proposal dated November 30, 1978. Authorization to proceed was provided by a contract between the South Dakota Department of Water and Natural Resources (DWNR) and Dames & Moore (D&M) signed on August 27, 1979. Because of delays in obtaining all necessary information, we requested an extension of our contract time to January 8, 1980 in our letter of November 28, 1979. We received verbal approval of that schedule change from Mr. James R. Seyfer during telephone conversations on November 15, 1979 and November 30, 1979.

The basic study objective is to develop the most efficient and cost-effective dredging plan that responds to the purpose of lake improvement. Our proposal defined five tasks that would be accomplished to meet this objective:

Task 1 - Review Existing Data

Task 2 - Evaluate Present Lake Condition

Task 3 - Develop Dredging Alternatives

Task 4 - Assess and Prioritize Alternatives

Task 5 - Prepare Plan for Preferred Alternative

Actually, in carrying out these tasks we have not found it possible to strictly limit ourselves to the question of dredging. Based on our experience, we feel that other methods are available that may be equally valuable and cost effective in enhancing the potential for certain types of recreation in Lake Herman. Therefore, brief descriptions of these methods and their projected effects are also included.

Unfortunately, the conclusions developed by our study do not permit us to be particularly optimistic with respect to significant improvement of Lake Herman by "economically feasible" dredging programs. We are mindful of the limits on currently available funding, but also recognize that additional monies may become available from various sources in the future. With these circumstances in mind, we have developed information on five specific dredging operations which, singly or in combination, will contribute to preserving the quality of Lake Herman and may allow some improvement. Information on the location, extent, cost, and general effects of each of these operations is provided in a later section of the report and is summarized in Table 1.

In addition, we have suggested how these various dredging operations might be incorporated into a four-phase dredging plan. The phases represent a logical progression from a rather limited dredging program responsive to currently available monies, to an extensive program that could possibly result in substantial long-term improvement in the lake.

EXISTING LAKE HERMAN ENVIRONMENT

PHYSICAL CHARACTERISTICS

As shown in Figure 1, Lake Herman consists of two somewhat separate areas of water. The larger and deeper northern portion of the lake is connected to the southern portion by a relatively narrow, shallow channel. Both the north and south portions of the lake become deeper toward their centers. According to the Lake County Conservation District (LCCD 1978), Lake Herman has the following physical characteristics:

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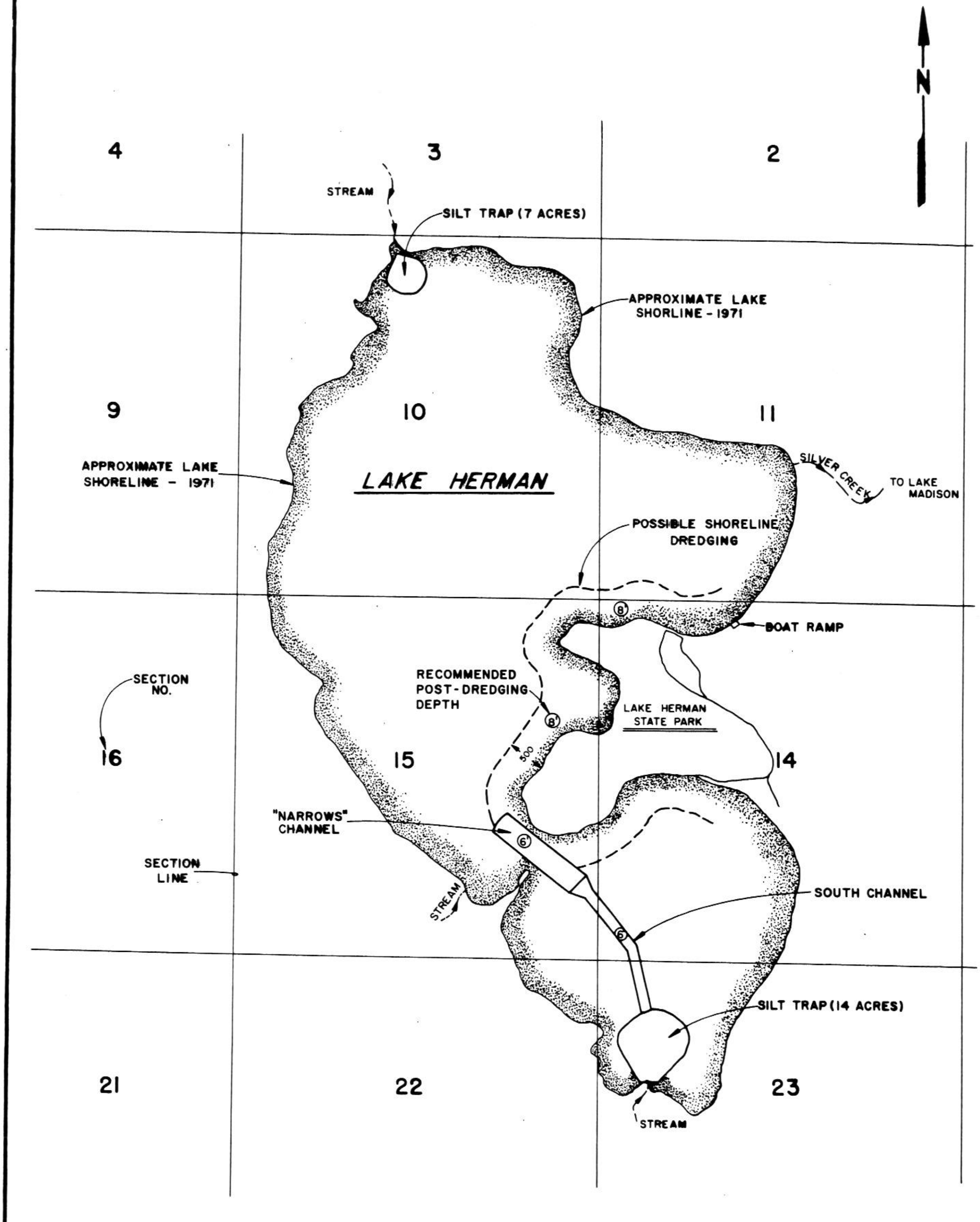
BY DL DATE 12-27-7_ CHECKED BY ________



MAP AND DREDGE ACTIVITY LOCATION PLAN

REFERENCE:
A COLLAGE OF 1971 AERIAL PHOTOGRAPHS PROVIDED BY SOUTH DAKOTA DEPARTMENT OF NATURAL RESOURCES.

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SCALE IN FEET

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FIGURE 1

Surface Area:	1,350 acres at Elevation 1,668 feet
Mean Depth:	5.6 feet
Maximum Depth:	8 feet
Volume:	7,525 acre-feet

There is some conflicting information on lake depth in the literature. A 1967 survey by South Dakota Game, Fish, and Parks Department personnel provided water and sediment depths using the spillway level of Lake Herman as the elevation benchmark. In 1975 Dakota State College personnel (Churchill et al. 1975) repeated most of the earlier stations and found generally shallower water depths throughout the lake, particularly in the more isolated southern portion. As discussed in a later section on lake sediments, much of the apparent change in lake sediment depths is probably due to variations in lake conditions at the time of measurement and investigative methods.

The 1975 water depth data (Churchill et al. 1975) were used in our evaluations. Based on the most recent assumptions regarding sedimentation rates (see later section), 1975 water depths can be corrected to 1980--the earliest year in which dredging might begin--by subtracting 1 or 2 inches. Applying this correction, the mean depth anticipated in 1980 is well below 5.6 feet, while the maximum depth is closer to 6.6 feet. These reduced depths would also reduce the 1980 lake water volume.

INFLOW/OUTFLOW

Inflow into Lake Herman is provided by three apparently unnamed tributaries, one entering the lake at the north end, one at the south, and one at the southwest (Figure 1). Outflow from the lake is via Silver Creek which flows from the northeast end of the lake over a spillway with fixed elevation. Silver Creek flows into a chain of lakes (Madison, Round, and Brandt), on to Skunk Creek and the Big Sioux River, and out of eastern South Dakota.

Average annual rainfall in the Lake Herman watershed is 23.8 inches (USDA 1973), and about 4,500 acre-feet per year of runoff reaches the lake from the watershed (EDCSD 1968). Based on hydraulic budget calculations (LCCD 1978), runoff into the lake, which is primarily from the three unnamed tributaries, averages about 40 inches per year. Average evaporation is about 33 inches per year. Annual outflow via Silver Creek was calculated at 47.5 inches (LCCD 1978) using data derived from Ellis and Adolphson (1965). Additional calculations to attain an inflow/outflow water balance indicate that about 16.7 inches per year, or 20 percent of the total inflow to the lake, comes from ground water at unknown locations (LCCD 1978).

Flows from the tributaries are intermittent with high flows during spring runoff from thawing snow and ice. After the spring thaw period, stream flows are low to zero, depending on local rainfall conditions. The heavy runoff period is brief, lasting around 30 days based on 1977 and 1978 data (LCCD 1978). During this period the fast flushing of the watershed brings heavy silt and nutrient loads to the lake.

Silver Creek flows out of Lake Herman in a similar pattern--intermittent flows with high flows in the spring thaw period and no flow during the dry summer/fall period. Again, local rainfall could significantly influence the flow of Silver Creek, assuming the Lake Herman water elevation is at the spillway level so that rainfall to the lake can flow out of it promptly. Churchill et al. (1971) describes Silver Creek as fed by Lake Herman during the spring and by the City of Madison sewage lagoon, located 1 mile above Lake Madison, during the entire year.

ICE COVER

Lake Herman is generally ice covered from mid-November to mid-May with ice depths of 24 to 30 inches and extremely variable snow depths. The ice cover places a "lid" on the lake that inhibits air-water interchange and contributes to water quality changes detrimental to fish (see later water quality and biology sections).

LAKE SEDIMENTS AND SILTATION

Lake Herman's large watershed is extensively farmed and grazed, but in the past much of it has lacked modern methods of erosion control. As a result, runoff from the watershed during the spring thaw period contributes very large silt loads to Lake Herman, where most of the material is deposited. Actually, Lake Herman is the first in a series of four lakes receiving runoff from the watershed, and thus acts as a sediment trap for the system. In addition to the major silt input from the tributaries, wind action on the lake acts on exposed shoreline areas to also contribute a small amount of silt.

Most of Lake Herman's bottom sediment is apparently silt with lesser amounts of clay and very small quantities of fine sand. The silt deposits, of depths possibly as great as 16.4 feet, overlie a clay zone mentioned in several reports (Churchill et al. 1975). Shorelines sampled by biologists of the South Dakota Game, Fish and Parks Department in 1976 and 1978, had bottom types of sand, gravel, and small rock (Brandt 1979). Brandt (1979) indicates that the amount of rock substrate suitable for walleye spawning is very limited in shoal areas of the lake.

Available information leads to conflicting conclusions with respect to the rate at which Lake Herman is filling with sediments. Based on steel probe measurement data from 1967 (South Dakota Game, Fish and Parks) and 1975 (Dakota State College), Churchill et al. (1975) concluded that during this period the volume of silt in the lake increased by 2,032 acre-feet, or 23.8 percent. At this rate, starting in 1975 the southern segment of Lake Herman would completely fill in 15 to 20 years and the remainder of the lake in 25 to 30 years. In a more recent study (USDA 1979), however, Cesium-137 was checked in core samples and related back to periods of atmospheric nuclear weapons testing. This method indicated a sedimentation rate of 4 to 9 inches in 25 years, or 0.16 to 0.37 inch per year (LCCD 1978). Based on the maximum rate, changes in silt depth of several inches would be expected between 1967 and 1975 rather than the several feet reported by Churchill et al. (1975).

Because of apparent discrepancies in the 1967 and 1975 data used by Churchill et al. (1975), we feel that the sedimentation rate indicated by the Cesium-137 studies is a more reasonable approximation of the actual rate. For example, a 1967 bathymetric chart prepared by the South Dakota Game, Fish and Parks Department shows that Station 40 at the south end of the lake had a water depth of about 4 feet and a silt depth of 7.75 feet, giving a total water and silt depth of 11.75 feet. On the other hand, measurements taken by Mr. Limmer (then with Dakota State College) in the winter of 1975 at the same station show a water depth of 2.9 feet and a silt depth of 14.43 feet, giving a total water and silt depth of 17.33 feet. Thus, there is more than a 5-foot discrepancy in the two totals. Differences in ice elevation between 1967 and 1975 probably explain the water depth difference.

We expect that the sedimentation rates were overestimated on the basis of the 1967 and 1975 studies because of differences in the depth to which the steel probe was forced into the bottom. This was no doubt dependent on the size and vigor of the probe operator, the time expended in advancing the probe, the specific grain size of the sediments at the probe points, and possibly other factors. It may be useful to repeat the 1975 water depth study during the winter of 1980, with special care to use the same reference for water depth measurements. It is likely, however, that the probe method of evaluating sediment depth is not of sufficient repeatability to warrant further effort of this type.

No doubt sedimentation rates in the lake are not uniform. The southern tributary contributes the major silt load to the lake (Seyfer, personal communication), and the narrow channel between the north and south portions of the lake has emergent vegetation which tends to inhibit sediment movement. It is anticipated that a significant portion of the sediment now entering the lake through the streams will be eliminated by implementation of Best Management Practices (BMPs) to a major portion of the watershed. Completion of the work which we understand is now in progress will result in placing more than 80 percent of the watershed area under BMPs. Also, we understand that construction of sediment traps on land is now in progress and should further reduce sediment input to the lake.

WATER QUALITY

Since Lake Herman is a shallow prairie lake, its water quality is readily influenced by seasonal and local climatic conditions. Because of its shallow depth and lack of stratification the water temperature of the lake is rapidly influenced by the air temperature. Recorded water temperatures have ranged from 0°C in the winter to 31°C in the summer (Churchill et al. 1972).

Alkalinity, pH, and nutrient levels in the lake are affected by the spring runoff and summer algae blooms (Churchill et al. 1971, 1972, and 1975). Water entering the lake during the spring runoff reduces the pH and alkalinity and raises the nutrient level (ortho and total phosphate, ammonia, nitrite, and nitrate). The pH and alkalinity levels increase as the algae population expands during late spring and summer, while nutrient levels decrease as phosphates and nitrogen become incorporated in the algal biomass. South Dakota water quality standards allow a pH range of 6.5 to 8.3. This is often exceeded during periods of excessive algae growth; measured pH values range from 6.9 to 10.1 (Churchill et al. 1972). Lake Herman was evaluated by EPA during their National Eutrophication Survey and was listed by them as the fifth most eutrophic lake in South Dakota (EPA 1977).

Since Lake Herman is used for water contact sports, fecal coliform levels are an important water quality parameter. From data available in 1979 (Seyfer 1979), the state water quality standard (< 200 per 100 ml) was not violated. The counts generally range from 10 to 40 per 100 ml, although in August 1979 counts of 130 and 200 per 100 ml were observed at two stations. The present connection between the southern portion and much larger northern portion of Lake Herman does not permit good circulation; consequently, the southern portion normally has poorer water quality than the northern portion.

The shallow depth of the lake does not allow it to stratify (LCCD 1978), and it has been reported that wave action during windy periods mixes the entire water volume (Churchill et al. 1972). The wave action is sufficient to keep many of the bottom sediments in suspension and results in the lake being quite turbid. Average secchi disk readings range from 30 to 50 cm (EPA 1977).

The level of nutrients, metals, and pesticides in lake sediments are also of interest in a dredging operation. Since high nutrient levels contribute to the eutrophic condition of the lake, the removal of nutrient-rich sediments by dredging can lead to improvement in water quality. Metal and pesticide content is important, because these materials can be released to the water during dredging and may be toxic.

Available information on the phosphate content of Lake Herman sediments indicates higher concentrations in the near-surface deposits (Churchill et al. 1975). Much less information is available on nitrogen content, a more important parameter since it has been found to be the limiting nutrient in the lake (see next section on biology). Data are available for iron, copper, and magnesium, but not for other heavy metals and pesticides. The level of iron is usually high during the spring runoff, and decreases as algal biomass increases during late spring and summer.

BIOLOGY AND FISHERIES

The high level of nutrients in Lake Herman results in high algal blooms during the summer (Churchill et al. 1971, 1972, and 1975; Hauber 1971). The dominant algae type is blue-green, which indicates that the lake is highly eutrophic. Hauber (1971) reported algae densities in Lake Herman in excess of 3,000,000 per liter of which over 98 percent were blue greens (Aphanizomenon and Anabaena). It has been reported that the consistency of the algal bloom at its worst is that of latex paint (LCCD 1978). Algal assay results and lake data collected by EPA in 1974 indicated that nitrogen was the limiting nutrient in the lake (EPA 1977). The addition of phosphate to the algal assays did not increase algal production.

In recent years extensive beds of submerged macrophytes have developed in Lake Herman during the summer (Churchill et al. 1975). Limmer (personal communication) has observed that in some years the entire southern portion of the lake is covered by emergent vegetation. In particular, significant growth occurs in the narrow channel that connects the southern and northern portions of the lake. The heavy growth of emergent vegetation in this channel, combined with shallow water levels during periods of low rainfall, can make boat passage between the northern and southern portions of the lake quite difficult. The varied appearance of emergent vegetation is somewhat influenced by variable lake levels due to local rainfall conditions.

In terms of fisheries, Lake Herman is classified by the South Dakota Department of Game, Fish and Parks as a "warm water marginal" lake, and is regarded as primarily a bullhead lake (Unkenholz 1974). The reason for the "marginal" classification is that the lake has a history of heavy winterkills approximately once every 3 years (Churchill et al. 1975).

The immediate cause of these winterkills is apparently cloudy ice or snow cover on the ice which prevents light penetration and leads to mortality of the phytoplankton. The decomposition of the dead algal biomass depletes the dissolved oxygen in the water and results in fish mortality. This condition occurs most frequently in the shallow southern portion of the lake, which is almost completely isolated from the northern portion during low water/thick ice periods. Fish tend to congregate in the deeper central area of the southern portion, and are stranded there when the ice develops. We believe that nearly all fish residing in the southern portion of the lake probably winterkill under low water and thick ice cover conditions.

In the years that winterkill is not a controlling factor, fish in Lake Herman reproduce and grow well (Brandt 1979). If 2 or more consecutive years occur without a fish kill, a popular sport fishery develops. Unkenholz (1974) reports that from July 1, 1972 to June 30, 1973 a total of 108,409 fishing hours were expended on Lake Herman, with a total catch of 81,988 fish (60,844 pounds). On the other hand, an extensive fish kill occurred during the 1977-78 winter and again in 1978-79. Except for bullheads, the sport fishery was essentially lost, and fishing pressure since then has been light (Brandt 1979). In 1978 and 1979 the State Department of Game, Fish and Parks stocked northern pike and walleye fry and adult yellow perch in an attempt to help the sport fishery recover.

ALTERNATIVE DREDGING PLANS

DISCUSSION

Based on our understanding of the Lake Herman environment and our past experience in lake rehabilitation and dredging projects, we have selected five specific dredging operations for consideration as a part of a feasible dredging program. We have evaluated the impact of each of these operations on the lake in the areas of water quality, recreational potential, and fisheries.

Any dredging operation in Lake Herman has the potential for creating short-term deterioration of water quality through the release of additional concentrations of nutrients, heavy metals and pesticides, as well as an immediate increase in turbidity. The degree of these effects would be dependent on the concentration of these materials in the sediment with depth, the area dredged, and the efficiency of the dredge operation. As discussed previously, data are not currently available on nitrogen, certain heavy metals, and pesticides. We recommend that this information be collected before dredging is initiated, so that impacts may be projected more accurately.

The five alternative dredging operations, together with our conclusions and cost estimates, are outlined in Table 1 and are discussed in more detail in the following paragraphs.

Narrows Channel

This dredging would involve the excavation of a channel at the approximate location shown in Figure 1 to connect the deeper water in the semi-isolated southern portion of the lake with the larger northerly portion. It appears that a channel having a minimum length of about 1,500 feet would be required. We believe that such a channel should have a minimum width of about 350 feet and an average final depth of about 6 feet.

Construction of the Narrows Channel would result in better water circulation which should improve the water quality in the southern portion of Lake Herman. This deeper channel between the north and south portions of the lake would also provide better access for boats and would enhance the fishery by reducing the chance of fish becoming isolated in the shallow southern portion of the lake, where they are subject to winterkill. In addition, the channel itself would provide an increase in fishing opportunities.

Sediment Traps

The impact on the lake of any stream-transported sediment can be lessened if the sediment is induced to settle in a rather small, defined area from which it can be removed periodically, if required. This can be accomplished by excavating basins of deep water at the locations where the tributaries enter the lake. As the sediment-laden streamflow enters the deep basin of relatively quiescent water, a major portion of the sediment will tend to settle in the trap.

Sediment traps would be expected to have a beneficial effect on the water quality of Lake Herman. Both sediment and sediment-associated nutrient loading in the lake would be reduced, resulting in a small improvement in overall water quality. This will improve the recreational potential of the lake by extending its life.

The sediment traps will provide deeper water adjacent to the shoreline which may increase fishing opportunities and productivity. On the other hand, such sediment traps could result in appreciable numbers of fish being isolated from the main portion of the lake, thereby increasing their chances of being winterkilled. It cannot be confidently predicted at this time whether the proposed sediment traps, by themselves, would be a benefit or detriment to the fishery of Lake Herman.

It should be noted that sediment traps will be required only if the application of BMPs to the watershed, and completion of the on-shore sediment traps, does not significantly reduce the quantity of stream-transported sediment entering the lake. In this regard, we recommend that streamflow into the lake be closely monitored following completion of the current construction to provide data for use in evaluating the postconstruction sediment contribution of the streams.

In our opinion, in-lake sediment traps, if utilized, should be designed for a minimum service life of 5 years. Based on the estimated present sedimentation rate of 22 acre-feet per year, criteria for sediment traps designed for effective 5- and 10-year life spans are summarized in Table 1. Possible sediment trap configurations are shown on Figure 1.

South Channel

Following dredging of the Narrows Channel, much of the southern portion of the lake will still become inaccessible during the summer due to shallow depths and dense emergent vegetation. The South Channel dredging operation would excavate a channel extending from the Narrows Channel to near the point where the unnamed tributary enters the lake at the south end. The length of this channel may vary depending on the actual existing water depth and the size and configuration of the southern sediment trap, if constructed. As shown in Table 1, we have assumed a channel length of 2,600 feet. We recommend the South Channel have a width of at least 150 feet and provide a final water depth of about 6 feet.

The most favorable timing of South Channel dredging would be to complete it in conjunction with dredging of the Narrows Channel in the same year. If both activities could be completed within 1 year, the South Channel dredging should precede the Narrows Channel dredging. This would reduce dredging impacts on overall lake water quality (turbidity, nutrient addition, etc.). However, if these operations are to be completed at different times, the Narrows Channel dredging must be done first. South Channel dredging alone could lead to increased "stranding" of fish species in a relatively small area in the lake's southern portion. Fish would be attracted to the deeper water during high-water periods, and could be stranded there as the lake level fell and an ice cover developed.

South Channel dredging would further enhance the water quality benefits expected as a result of the Narrows Channel dredging, provided the Narrows Channel is in place. The major influence of this dredging would be to increase circulation in and out of the presently "confined" southern portion of the lake.

Recreational benefits of the South Channel dredging would include creating additional access in this part of the lake for boating, fishing, and possibly swimming. Fishermen in particular would have increased access by boat to the southern portion of the lake compared with that now available when lake levels are low and attached macrophytes are abundant. The other benefit of the South Channel (in conjunction with the Narrows Channel) is that fish could more freely move in and out of the southern portion of the lake to feed and reproduce, and to escape the southern portion of the lake in the winter.

Shoreline/Lake Dredging

Obviously, dredging can be utilized to remove sediments and thereby increase water depth at essentially any area along the shoreline or within the lake. We understand that selective dredging of portions of the shoreline and nearshore areas has previously been considered to enhance recreational use, particularly within Lake Herman State Park and other developed recreation areas. If this type of dredging is performed, we recommend that it be designed to provide a water depth of about 8 feet. More complete and specific criteria for shoreline dredging is provided in a following section of the report.

Shoreline and/or lake dredging in selected areas is expected to have little effect on the overall water quality of Lake Herman. It is possible, however, that deepened areas will experience less wave action on the bottom sediments, resulting in slightly reduced turbidity levels.

Properly coordinated shoreline and lake dredging could increase the quantity and quality of recreational usage. Shoreline dredging could be carried out in areas where it would improve bathing beaches or reduce or eliminate beds of rooted aquatic vegetation. Coordinated on-land improvements in adjacent areas would increase the overall aesthetic value of the lake. Shoreline development would also improve the movement of boats from the shoreline to deeper water and provide better access for shore fishermen.

Lake dredging would also create deeper water that would be beneficial to fish during the winter. An aeration system has recently been installed in Lake Herman (Limmer, personal communication), and if the area of air input was made deeper it would provide some additional protection against winterkills. However, even with the aeration system and lake deepening, winterkills will probably continue to occur under adverse winter conditions (low water, thick ice, snow cover, high algae biomass, etc.).

Dredge Entire Lake

Based in part on a review of the limited dredging performed during the early 1970s in Lake Herman, Churchill et al. (1975) recommended that the upper 1 to 2 feet of bottom sediment within the entire lake be removed by dredging. It was concluded that removal of this nutrient-rich layer of sediment would improve water quality by: (1) reducing the amount of nutrients available for reintroduction into the water column by wind-induced wave turbulence and (2) reducing to some degree the effect of wave turbulence on the bottom because of the deeper water.

As indicated on Table 1, this action would involve the removal of 2.2 and 4.4 million cubic yards of sediment to excavate 1 and 2 feet, respectively, below the mudline. This would be a very major undertaking with a proportionally high cost. Consider, for example, that a spoil area or areas totaling about 700 acres would be required to dispose of the dredged material.

Confident predictions of the water quality impacts resulting from dredging of the entire lake basin are not possible because of limitations in the existing data base. Overall lake deepening would probably reduce the eutrophic condition of Lake Herman to some degree. The deepened lake would have increased water storage capacity which may or may not directly influence water quality. It is possible to argue that lesser storage requires greater outflows which "flush" nutrients from the lake. Conversely, it can be argued that a deeper lake with greater storage capacity may allow for increased dilution of nutrients by rainfall directly into the lake and by ground water inflow.

A lake with increased storage and no other changes in water inputs and losses should be deeper throughout much of the year (following the spring thaw). A deeper lake would probably be somewhat less affected by wind-induced turbidity. However, the lake would still not stratify with these small increases in depth, so some wind-induced turbidity would still occur.

As discussed previously, phosphate levels in Lake Herman sediments are much lower in the deeper materials than in the near-surface deposits (Churchill 1975). If this pattern holds for the entire lake bottom, much of the phosphate-rich material would be removed by uniform dredging of 1 or 2 feet. However, depending on the efficiency of the dredging and dredge spoils handling, phosphates may either be substantially removed and trapped on land or largely returned to the lake in waters flowing back from spoils areas. The most likely expectation is that some phosphates would remain tied up in the spoils area on land, but some would return to (or will remain in) the lake. No accurate estimate can be made as to the degree of phosphate removal, but phosphates in the lake would probably be reduced to some extent.

The recreational impacts of dredging the entire lake 1 or 2 feet deeper would seem to be generally beneficial. A basic benefit to the lake would come from increased water storage capacity. Increased access would be realized for boating, fishing, and swimming because of increased water depths and reduced areas of attached aquatic vegetation. The frequency and severity of fish winterkills should also be reduced.

Increased depths and probable small improvements in water quality (e.g. lower phosphates, cooler temperatures in deeper waters, even though not stratified) could increase the diversity of available fish habitat for presently occurring and additional game fish species. If rocky areas are exposed by dredging, natural spawning may be enhanced for species such as walleye. Reductions in attached vegetation may decrease available fish nursery areas temporarily, but this is not expected to have a long-term impact on the fish-rearing capacity of the lake. Fish planting could compensate for the temporary loss of rearing area. The amount of reduction in rooted aquatic vegetation is dependent on the reduction in nutrient levels and postdredging light penetration, which in turn is dependent on depth and turbidity. Therefore, the reduction cannot be quantified with any accuracy.

The reduction in rooted and emergent vegetation and possibly phytoplankton production, less turbid water, and other changes would improve the overall visual quality of Lake Herman. Such an improvement in the general aesthetic value of the lake would probably result in increased recreational usage.

COST ESTIMATES

Approximate cost estimates for the five alternative dredging operations are summarized in the two right-hand columns on Table 1. The estimates were based on the following assumptions:

TABLE 1

DREDGING PARAMETERS, INFLUENCES, AND COSTS FOR LAKE HERMAN, SOUTH DAKOTA

Dredging Activity	Area (acres)	Assumed Existing Depth (feet)[a]	Final Depth (feet)	Average Cut Depth (feet)	Volume (cu. ft)	Disposal Volume (cu. ft)[b]	Required Disposal Area (acres)[c]	Influence on Water Quality	Influence on Recreation	Dredging Costs[d]	Disposal Costs[e]
1. Narrows Channel (1,500' x 350')	12	4.5	6	1.5	29,000	38,000	5	1. Improved water circulation pattern	1. Increased access to South Bay for boating and fishing 2. Reduced potential of winterkills in South Bay	$58,000	$21,400
2. Sediment Traps[f] - 5-year life - 10-year life	 14 27	 2 2	 10 10	 8 8	 175,000 355,000	 230,000 460,000	 30 60	1. Reduced sediment loading in lake 2. Reduced sediment-associated nutrient loading	1. Creation of deeper fishing areas near mouth of inflowing streams 2. Creation of potential winterkill area 3. Prolonged physical life of lake	 $350,000 $700,000	 $61,000 $95,000
3. South Channel[g] (2,600' x 150')	10	4.5	6	1.5	25,000	33,000	4	1. Improved water circulation pattern	1. Creation of additional access to South Bay for boating and fishing 2. Reduced potential of winterkills in South Bay	$50,000	$19,000
4. Shoreline and/or Lake Dredging (500' x 500') (1,000' x 1,000')	 5.8 23	 4 5	 8 8	 4 3	 37,000 111,000	 48,000 144,000	 6 18	1. Slight decrease in wind-influenced turbidity	1. Increased shore usage 2. Increased aesthetic value 3. Enhanced fish overwintering capacity 4. Reduced quantity of rooted aquatic vegetation	 $74,000 $222,000	 $23,600 $44,600
5. Dredge Entire Lake (or equivalent volume)	1,350	--	--	2	4,350,000	5,655,000	700	1. Reduced eutrophic condition 2. Reduced wind-induced turbidity 3. Possible reduction in buffering capacity of lake bottom 4. Increased lake storage 5. Possible reduction in amount of phosphate in lake basin	1. Increased access for boating, swimming, and fishing 2. Reduction in frequency and severity of fish winterkills 3. Increased diversity of sport fish species 4. Reduced quantity of sport fish species 5. Increased aesthetic value	$8.7 million	$572,000

(a) The existing bathymetric information is incomplete and somewhat inconsistent. The assumed average depth is based upon review and evaluation of the 1967 sediment study performed by the South Dakota Department of Game, Fish, and Parks, and the 1975 survey by Dakota State University.
(b) A bulking factor of about 1.3 was applied to the dredged in-lake volume to estimate the required disposal area volume.
(c) Plan area of dredging areas determined in accordance with sketches shown on Figure 1.
(d) Dredging costs assumed are $2.00 per cubic yard. Mobilization to the site is not included.
(e) Disposal costs assumed are $1.50 per cubic yard of earthwork and $500 per acre of land area required.
(f) The estimated usable life of the sediment traps was determined based on a total lake sedimentation rate of 22 acre-feet per year. See text for additional discussion.
(g) Activity No. 3 cannot be implemented without Activity No. 1.

Dredging Costs	-	$2.00/cubic yard
Land Acquisition Costs (Disposal Site)	-	$500/acre
Dike Construction Costs (Stripping and Earthwork)	-	$1.50/cubic yard
Disposal Area Configuration	-	Square (most efficient shape for a given volume)

The costs in Table 1 do not include transporting dredging or other construction equipment to the site. In addition, the costs do not include necessary engineering services, environmental monitoring, administration, or contingencies. The estimates are based on costs prevailing at the time of this report. There are no allowances for inflation.

RECOMMENDED DREDGING PROGRAM

The data in Table 1 clearly indicate that dredging is a relatively costly activity, so we believe that a dredging program in Lake Herman should be approached cautiously. We recommend that some of the questions with regard to actual sedimentation rate and chemical composition of the sediments be resolved before final decisions are made. We also believe that the effects on the lake environment of the watershed works should be evaluated and that some of the alternatives to dredging, such as those discussed in the concluding section of this report, be considered before a dredging program is put into operation.

If dredging is still considered an appropriate action following these evaluations, we suggest that it be approached in a phased manner. Both the positive and negative effects of the initial phases of dredging should be evaluated so that subsequent phases can be designed for maximum benefit. The phases of dredging that we believe should be considered are described in the following paragraphs. We understand that the currently available funds for dredging are approximately $300,000 to $500,000 (Seyfer, personal communication 1979). We have formulated the initial phases of dredging with that budget limitation in mind.

Phase I

The initial phase of dredging should consist of the Narrows Channel alone or in combination with the South Channel (Figure 1). This would provide some benefits to water quality by improving water exchange through the narrows and greater inflow into the entire lake from the southern tributary. If the South Channel and Narrows Channel can be completed in one season we strongly recommend that the South Channel be completed first. This would allow the narrows "sill" to assist in retaining dredging impacts within the southern portion of the lake.

Estimated costs for Phase I are as follows:

	Dredging	Disposal
Phase Ia (Narrows Channel only)	$ 58,000	$21,400
Phase Ib (both channels)	102,000	40,400

Phase II

If only the Narrows Channel is completed in Phase I, then the South Channel should be planned as a part of the Phase II dredging. The choice of additional Phase II dredging activities should await an evaluation of the results of Phase Ia and/or Ib, as well as the results of watershed works in reducing silt and nutrient inflow. If Phase Ia or Ib appear to be successful, and if drainage basin works and on-land sediment traps still allow a substantial amount (say 30 to 50 percent) of the existing sediment load to reach the lake, some consideration should be given to in-lake sediment traps as a part of Phase II (Figure 1). The life span of such sediment traps is dependent on wind/water turbulence and redistribution of sediments, as well as the quantities of material contributed by the tributaries. Close monitoring of channels dredged during Phase I would provide some insight into the effects of sediment redistribution.

If in-lake sediment traps are found to be appropriate on the basis of these considerations, the estimated cost would be:

	Dredging	Disposal
Phase II (sediment traps on north and south tributaries)		
5-year life	$350,000	$61,000
10-year life	700,000	95,000

Phase III

This phase includes shoreline dredging, hence the magnitude of effort is highly variable, depending on the size of the area dredged. Actually, it would be desirable to stage any shoreline dredging so that one or two initially dredged areas could be monitored to determine the success of this type of dredging operation in improving water quality and recreational potential. It would be logical that areas initially selected for shoreline dredging be located along the state park shoreline, where usage levels have historically been very high. This would allow maximum potential recreational enhancement for any level of expenditure. It should be remembered that improving shoreline areas for swimming would probably require additional activities as well. For example, sand may need to be imported to provide attractive beach areas. In addition, silt and algae screens and/or clean water injection may be desirable in these areas (see final section of report).

If the initial stages of shoreline dredging appear to be successful, the dredged areas could be expanded to include more of the park shoreline and other areas adjacent to public recreation facilities. This activity could also be carried out adjacent to private property if appropriate funding is available. Cost estimates for incremental shoreline dredging are provided below. However, these estimates must be considered quite approximate because of variable near-shore bottom configurations:

	Dredging	Disposal
Phase III		
(500 lineal feet of shoreline dredging with 500-foot width)	$74,000	$23,600
(1,000 lineal feet of shoreline dredging with 1,000-foot width)	$222,000	$44,600

Phase IV

This phase would consist of a very extensive dredging operation. It has been suggested that deepening the lake by 1 to 2 feet would improve water quality (Churchill et al. 1975). In our opinion, however, this volume of dredging would be more valuable to water quality and fisheries enhancement if it were used selectively to deepen major portions of the lake as much as 5 to 10 feet more than their 1975 depth. Also, these deeper areas should all be interconnected so that isolated deep areas are less likely to contribute to winterkills of fish. The program we envision would concentrate on deepening the already relatively deep northern part of the lake from the center to the park area with additional deepened areas extending into this basin from more heavily used shoreline areas. The deep area in the northern part of the lake can be viewed as the "hub of the wheel" and the deeper areas extending from shore as the "spokes." These "spokes" would provide avenues for fishermen and fish movement as well as open-water areas for boating and swimming.

Selectively dredging several areas to relatively great depth would allow the use of fewer disposal areas, although the volume requirement would remain the same. Also, this approach would require relatively minimal dredge movement in comparison with general dredging to deepen the entire lake 1 to 2 feet. Greater dredge efficiency should result from this approach, too. Thus, this type of program should be somewhat less costly. In addition, a few relatively large and deep areas would provide more fish habitat for a wider variety of fish species than the program of overall lake dredging.

We strongly suggest that the effectiveness of Phase I, II, and III activities be reviewed, especially with regard to the movement of bottom sediments with time into artificially deepened areas, before this kind of major activity is seriously considered. If experience indicates that dredged areas fill in relatively quickly through contributions of sediment from surrounding areas, then a dredging program of this type may not be feasible.

The estimated cost for this phase of dredging is, of course, dependent on the quantity of materials removed and the locations of this removal. Because wide variations in the layout of the dredging program are possible, our cost estimates are very approximate. The volume estimate is based on dredging a 2-foot thickness of sediment over the entire lake. However, the cost estimate assumes that the dredging would be concentrated in smaller areas rather than encompassing the entire lake.

	Dredging	Disposal
Phase IV (Dredging of 4,350,000 cubic yards)	$8.7 million	$572,000

Monitoring Needs

All dredging programs must include monitoring of water quality in and around the dredge site, as well as the outflow from disposal areas as it returns to the lake. In addition, we believe it is extremely important that all dredging areas be monitored with respect to the change in depth with time, so that an accurate assessment of the longevity of such improvements can be made. As we have noted, the cost of such monitoring is not included in the cost estimates provided above.

DREDGING CONSIDERATIONS AND CRITERIA

A review of the available literature for Lake Herman indicates that the lake bottom sediments consist predominantly of silt and clay with lesser amounts of fine sand. As discussed previously, past efforts to measure the thickness of the soft sediments and the rate of sediment deposition have not been conclusive, apparently because of inconsistent field techniques. However, these studies do indicate that the sediments are very soft to depths of at least several feet. A limited dredging program was undertaken during the summers of 1970 and 1971 to remove about 62,000 cubic yards of lake bottom sediments in the northerly portion of the lake. A floating hydraulic suction dredge was utilized, and the slurry was pumped to a disposal area along the northeast shoreline of the lake.

In our opinion the soft bottom sediments can be removed most efficiently from Lake Herman by portable, floating hydraulic dredging equipment. We expect that dredges in the range of 8 to 12 inches in size would most likely be used for any dredging. The size designation of a hydraulic dredge refers to the diameter of the suction pipe. Most hydraulic dredges pump at approximately the same velocity; therefore, the pumping capacity of a 12-inch dredge is roughly twice the pumping capacity of an 8-inch dredge.

During the operation of a hydraulic suction dredge, a centrifugal pump creates a suction near the end of the suction pipe to remove the bottom materials. The excavated material, in the form of a soil-water slurry, is transported to a designated disposal area through a floating pipeline. The suction pipe is often equipped with a cutterhead to loosen the material and facilitate removal. However, the removal of very soft bottom sediments, such as those at Lake Herman, normally does not require the use of a cutterhead. The minimum depth of cut for a suction dredge in the 8- to 12-inch range is usually on the order of 1-1/2 feet. Cuts to lesser depths result in less efficient use of the equipment and are therefore more costly.

If dredging is carried out immediately adjacent to the shoreline to provide greater water depth for access and recreation, land-based equipment may be required. It is difficult for a floating dredge to produce the relatively uniform, gentle slopes that would be desired along the shore. However, a land-based dragline working on mud mats could probably excavate to about 75 feet (horizontally) from the edge of the lake. It is suggested that cuts along the shoreline be excavated on slopes no steeper than about 5 to 1 (horizontal to vertical). Dredge cuts deeper than 3 feet within the lake should be made in a "stair step" manner to produce average slopes not exceeding about 2 to 1 in steepness.

The dredged slurry generally consists of about 15 percent soil with the remainder water. Disposal of the dredged material is usually accomplished by pumping the slurry into a diked disposal area. At this time, specific disposal areas have not yet been identified. The selection of a potential disposal site should consider the following criteria:

1. Proximity of disposal area to dredge site. It is estimated that 10- to 12-inch dredges can efficiently pump the Lake Herman sediments a maximum horizontal distance of about 3,000 feet.

2. Irreversible commitment of resources due to filling, particularly the potential loss of currently productive agricultural land.

3. Suitability of on-site material for dike construction. Dikes can be constructed of essentially any nonorganic or nondeleterious soil.

4. Potential disturbance to fish or wildlife habitat.

5. Potential damage to existing structures.

6. Disposal areas should be of a shape that permits an efficient perimeter dike length to enclosed area ratio. Square sites are the most efficient in this regard.

The area needed for a disposal site depends upon the depth to which the dredged material is placed. We recommend that the maximum thickness be on the order of 5 feet.

The water portion of the slurry should be decanted over a weir and returned to the lake via a channel or pipe. Since the soils composing the bottom sediments are predominantly fine-grained silt and clay, the spoils slurry will remain turbid for a long period of time. To reduce the suspended solids in the effluent, the disposal areas should allow a sufficient detention time for the slurry. This is provided for in the design of disposal areas by allowing for the temporary storage of effluent water above the dredged soils. A minimum detention time on the order of 3 days is recommended. Retaining a minimum water depth of 3 feet above the maximum level of solids should provide for adequate detention time until the solids level approaches the maximum scheduled elevation. During the latter stages of filling, it may be necessary to pump on an intermittent basis to maintain an acceptable suspended solids content. The extra depth of water available during the earlier filling stages should be utilized to achieve longer detention, thus cleaner effluent.

Observations of previous dredging projects indicate the upper few inches of water in the disposal area are less turbid than the lower water. Based on these observations, it is recommended that decantation be limited to the upper 3 inches of water. This can be accomplished by adjusting the length of the weir according to the size of dredge. Recommended weir lengths for various dredge sizes are summarized in the following table.

RECOMMENDED LENGTH OF OVERFLOW WEIR VS DREDGE SIZE

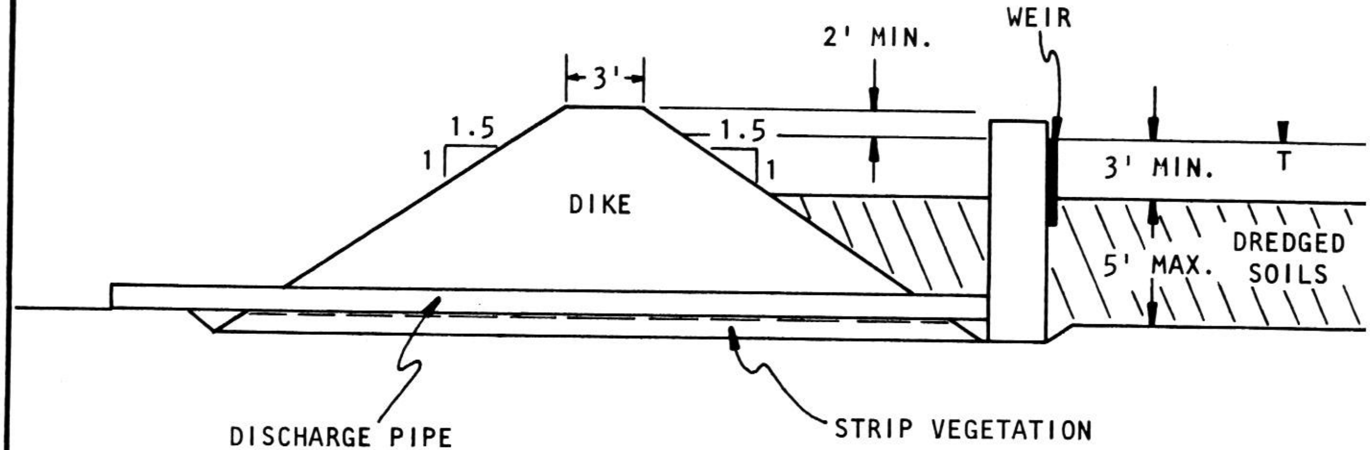
Hydraulic Pipeline Dredge Size in Inches	Recommended Weir Length in Feet
6	6
8	10
10	16
12	23

Effluent return channels to the lake should be located to avoid areas which are especially sensitive to sediment deposition such as beaches and fish spawning areas.

Recommendations for dike construction are summarized below and illustrated on Figure 2.

1. Construct dikes of nonorganic, nondeleterious soils. Strip borrow areas and areas beneath dikes to remove vegetation.

2. Construct dikes with interior and exterior slopes no steeper than 1.5 to 1 (horizontal to vertical) and a minimum crest (top) width of 3 feet.



NOTES:

1. STRIP SURFACE BELOW DIKE AND WEIR TO REMOVE VEGETATION.

2. CONSTRUCT DIKE THEN EXCAVATE TRENCH THROUGH DIKE TO INSTALL DISCHARGE PIPE. COMPACT BACKFILL AROUND AND OVER PIPE IN 6 TO 8 IN. LIFTS. THOUROUGHLY COMPACT WITH HAND OPERATED EQUIPMENT.

SKETCH-TYPICAL DIKE SECTION

DAMES & MOORE

FIGURE 2

REVISIONS BY ____ DATE ____
FILE ____/LAKE HERMAN
BY ____ DATE ____
CHECKED BY ____

3. Special compaction of dike fill is not generally necessary, since the construction equipment traffic will provide adequate compaction. However, the zone around the weir discharge pipe should be installed in thin lifts (6 to 8 inches) and thoroughly compacted with hand-operated equipment.

4. The dike should provide for a 2-foot freeboard above the maximum anticipated water level.

Table 2 summarizes the criteria for dredging and disposal.

TABLE 2

SUMMARY OF DREDGING AND DISPOSAL CRITERIA

DREDGING	
Dredge Type	Floating hydraulic suction dredge with or without cutterhead
Minimum Dredge Cut	1-1/2 feet
Maximum Dredge Cut Slope	Cuts deeper than 3 feet within the lake should be sloped or stepped to produce maximum 2 to 1 (horizontal to vertical) slope. Cuts along the shore should be sloped to produce maximum 5 to 1 (horizontal to vertical) slope. This may require use of land-based dragline equipment.
DISPOSAL	
Minimum Detention Time	3 days
Maximum Dredged Fill Depth	5 feet
Minimum Water Depth	3 feet
Dike Construction	
Interior and Exterior Slopes	1-1/2 to 1 (horizontal to vertical)
Crest Width	3 feet minimum
Freeboard	2 feet minimum
Weir Construction	Design for withdrawal of surface 3 inches (maximum) of water
Effluent Return	Open channel or pipe located to avoid sensitive in-lake areas

Following completion of filling and decantation of excess water within a disposal area, the fine-grained fill material will have the consistency of soft mud. The material will gradually dry and form a surface crust. The fill surface will probably support foot traffic after a few months of dry weather, and light vehicles after about a year. At this time the surface will be cracked and hard and will not be immediately suitable for tilling and planting.

The dredged fill soils will possess poor shear strength and consolidation properties and will not be suitable as structural fill. However, with proper treatment it is our opinion that the soils dredged from Lake Herman can be developed for productive agricultural use. A full evaluation of agricultural potential cannot be made without performing appropriate bioassays. This should include evaluation of the presence of potentially harmful or toxic substances (such as heavy metals and pesticides) that could be concentrated in plants and later consumed by humans or livestock.

A significant problem associated with agricultural use of the Lake Herman dredged sediments will be poor soil structure. The dredged material will form deltaic deposits in the disposal areas. The physical characteristics of the soil will vary with depth and with distance from the point of dredge discharge. Furthermore, the dredged material will dry and crust and will have poor internal drainage.

We believe that productive use of the soil will require a program of near-surface conditioning, crop management, and time. We recommend that the upper 1 to 1-1/2 feet of dredged material intended for agricultural use be homogenized prior to use by breaking clods and blending.

A minimum water depth of about 3 feet is required for access and operation of a small hydraulic dredge (8- to 12-inch size). According to the information available for our review, a minimum water depth of at least 3 feet is available within most of the lake, except during periods of severe drought. During periods of extremely low lake level, the dredge can move itself between locations by excavating a channel. However, this can be time consuming and will lead to higher costs.

Dredging will, of course, be limited to the annual period during which the lake is not icebound. For this reason, dredging should commence as early in the year as possible to facilitate completing the scheduled work during a single season. However, it may be necessary to postpone dredging until periods of dry weather necessary for completion of the disposal area dikes.

OTHER ACTIVITIES OF POTENTIAL VALUE

Our past research and experience in lake rehabilitation has suggested a number of activities other than dredging which may be of value in improving the quality of Lake Herman. Detailed evaluation of these activities and their incorporation into possible rehabilitation plans is beyond the scope of our contract. However, the following paragraphs provide brief descriptions of these actions and comments on their advantages and disadvantages for your consideration. Some of these actions would appear to have the capability of significantly improving water contact recreational potential at relatively modest cost. Obviously, a thorough evaluation of their applicability to Lake Herman would be needed before any plans for their use are formulated.

RAISE THE WATER SURFACE ELEVATION

It would be relatively easy to raise the spillway elevation at Silver Creek and increase the water surface elevation of the lake by 1 or 2 feet. In a sense, this would have the same effect as dredging the entire lake by the amount of the elevation increase. This activity would have the advantage of very low cost (unless property acquisition should be needed), and it would have essentially equal effect on all shoreline frontages. Possible disadvantages would include increased shoreline erosion, possible flooding of private property, no reduction of sediment or nutrient levels in the water, and, theoretically, increased potential for the lake to act as a sediment trap.

SWIMMING AREA IMPROVEMENTS

The attractiveness of Lake Herman for water contact recreation could be enhanced by improving beach areas and the quality of the adjacent water. For example, sand or sand and gravel could be imported to spread on the beach areas, fabric curtains could be placed to act as barriers to suspended sediment and algae, and small amounts of clean nutrient-free well water could be introduced within the swimming areas. Relatively small amounts of clean well water can have a significant effect in areas protected by these fabric screens.

INTRODUCTION OF LARGE QUANTITIES OF CLEAN WATER

Based on our brief review of the very limited ground water data available, it is not apparent that large quantities of clean nutrient-free ground water could be obtained in the vicinity of Lake Herman. Our impression in this regard does not constitute a definitive opinion, however. If enough water of good quality is available, so that quantities on the order of 1 to 2 percent of the lake volume could be introduced at critical times of the year, significant reductions in nutrient loading may be possible. This technique has had marked success in other lakes (University of Wisconsin and Wisconsin DNR 1974) and may be worthy of consideration for Lake Herman. We emphasize, however, that we have not evaluated this technique in detail, and are not recommending that it be pursued. If further data suggests that large quantities of good quality ground water are in fact available, we would suggest that this idea be explored.

CHEMICAL CONTROL OF ROOTED AQUATIC VEGETATION IN SELECTED AREAS

Most aquatic herbicides available on the market provide a short-term solution to the emergent vegetation problem. Two or three applications per year would probably be necessary. Herbicides may be a means of improving the attractiveness of limited areas for water contact recreation. However, it would probably be necessary to close those areas to swimming for a period of at least several days following herbicide use. In addition, the use of herbicides may not be acceptable to the public at large or to special interest environmental groups. A number of aquatic herbicides which could be considered for use are available commercially. Product labels provide specific instructions and related cautions to lake use after applications are made.

OTHER CHEMICAL TREATMENTS

In addition to herbicides, chemical treatment may also be used to reduce turbidity and nutrient levels by promoting flocculation and settling. We would interpret this to be of use only in isolated water contact recreation areas, rather than in the lake as a whole. The feasibility of this kind of treatment would appear to be very limited in view of the frequent wind-induced mixing of the water and bottom sediments.

We wish to emphasize again that the ideas presented in this section have not been studied with respect to their applicability to Lake Herman and are therefore not recommended. However, these techniques have been used in other lakes around the world and we have specific experience with the silt/algae screen and well-water injection techniques. If any of these activities appear to suit your needs and local preferences, further studies will be necessary to determine their feasibility at Lake Herman.

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