LAKE KAMPESKA SHORELINE PROTECTION PROJECT
FINAL REPORT

BY
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EPA CLEAN LAKES GRANT NO. S804713-01

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ABSTRACT

Lake Kampeska is one of the largest, high quality lakes in the Prairie lakes region of northeastern South Dakota. It was incorporated into the Watertown City limits in 1970. The proposal to riprap the most severely eroding shoreline areas was selected for a grant award under EPA's Clean Lakes Program in August, 1976. This effort to reduce lake sedimentation followed the development of a centralized wastewater collection system constructed around the lake perimeter during 1975-76 through an EPA grant.

The project utilized city, county, multi-county (Conservancy Sub-District), state and federal funding. Sites to be riprapped were selected by a multi-agency project task force during two boat inspection tours of the lake shoreline. Approximately 1152 m (3780 ft.) of shoreline were riprapped at a cost of $134,000. Most of the work was completed by late 1977.

In the spring of 1978 the lake level reached 48 cm (19 in.) above normal due to high surface inflow from the Big Sioux River which flows within one hundred meters of the lake inlet/outlet. During this period of abnormally high lake levels, waves from strong storm winds pounded the project works. Although vegetation was not yet established and fill areas had not settled properly, repair work was needed in only one project area. These repairs were made in 1981 utilizing $7,310 in supplemental grant funds. Visual observation of both project areas and non-protected areas afterward by the multi-agency project task force indicated that the stabilized areas had significantly reduced lake sedimentation.

Due to the problem inherent in working around the heavily developed shoreline of Lake Kampeska with expensive homes and landscaped yards, the cost per foot of shoreline stabilized was higher than for the Oakwood Lakes Shoreline Protection Project, a Clean Lakes project on an undeveloped lake in the same general area.

CONTENTS

FIGURES AND TABLES

FIGURES

TABLES

SECTION 1

INTRODUCTION

THE LAKE KAMPESKA RESOURCE

Lake Kampeska is a picturesque 1950 hectare lake located on the northwest side of Watertown, South Dakota. It has been incorporated into the city for the purpose of developing a centralized waste collection system to serve the 600 dwellings located around the lake. The city obtains about 65% of its water for municipal use from the lake.

Due to its size, depth, relatively good water quality, heavy use, and proximity to a population area, the lake was ranked in the first priority grouping by the State Lakes Preservation Committee (1977) and was ranked second in the state on a Lake Significance Ranking List prepared by the State Department of Environmental Protection (later called State Department of Water & Natural Resources - Division of Water Quality) under State Lakes Protection Grant Procedures (1978). In early 1978, the lake was selected as a State Water Quality Study area under the Section "208" Area Water Quality Management Program of PL92-500. Figure 1 is a map of the Lake Kampeska area showing the location of the bank shoreline protection areas financed through this project.

PROBLEMS AFFECTING THE LAKE

Total direct drainage area is small at about 55 sq. km (17 sq. mi.). Due to the very close proximity of the Big Sioux River to the lake outlet and the relative elevations of these two hydrologic resources, river flood flows from about 4662 sq. km. (1,800 sq. mi.) of uplands cause occasional high water levels and bring sediments and nutrients into the lake. Consequently, it would be desirable to restrict Big Sioux River inflows. A hydrologic study of the lake by the South Dakota Geological Survey (1971) stated, however:

> "During flooding a large quantity of water reaches Lake Kampeska through the inlet-outlet channel. The flood of 1969 caused the lake level to rise 5.2 feet indicating that 26,000 acre-feet of water was recharged into the lake.

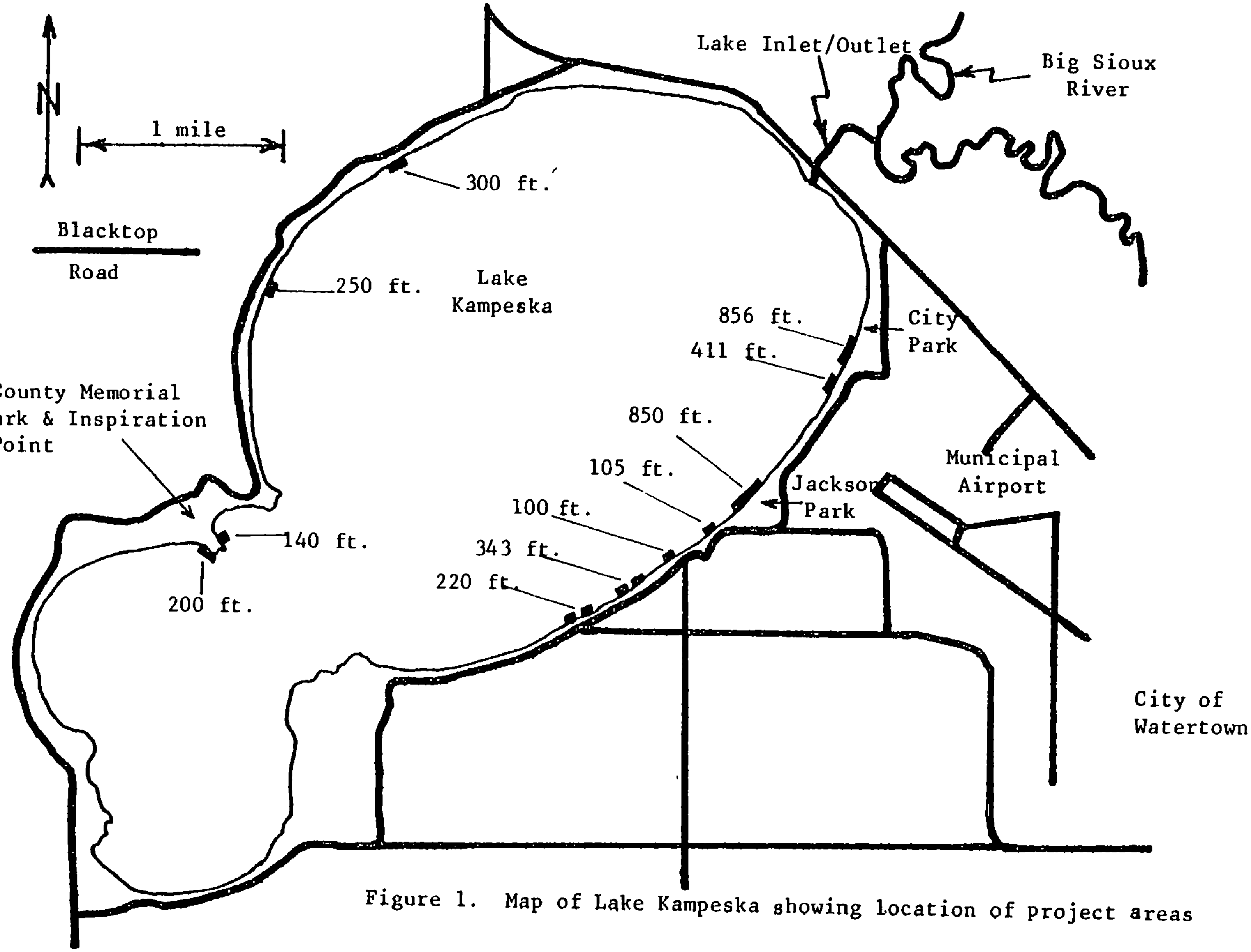

Figure 1. Map of Lake Kampeska showing location of project areas

"The rate of flow through the inlet-outlet channel was approximately 3 times greater than the rate of flow through Watertown.

"A construction on the inlet-outlet channel to block the flow of floodwaters to the lake without controlling the quantity of water reaching the study area will not function during flooding. Either the sand and gravel deposits on the sides of such a construction will be eroded and the structure destroyed or the water will flow over the construction. Even if the floodwater could be diverted from the lake during flooding, without construction of a deep wide channel through Watertown, flood damges in Watertown would increase substantially."

Another main source of inorganic sediments has been erosion of the lake shoreline during high lake levels and/or strong winds.

A report of the turbidity of the lake by Schmulbach (1968) indicated that the turbidity problem was to a large extent caused by eutrophication of the lake. This conclusion was based on observations of the water mass which revealed moderate turbidity levels but relatively large numbers of plankton, particularly blue green algae.

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

Visual inspection of the lake shoreline during the spring of 1978 by the EPA Project Officer and a multi-agency task force showed that the project works had done an excellent job of reducing bank erosion. Combined high lake levels and strong winds caused extensive erosion on non-treated shoreline areas. Thus, lake sedimentation has been reduced and severely damaged shoreline erosion areas have been restored, improving the aesthetic beauty of the lake and protecting shoreline property.

It is recommended for proposed publicly financed shoreline protection projects that a reliable sediment budget for the lake be developed in advance to determine whether shoreline erosion is a major source of lake sediments. It is also recommended that the selection of areas to be stabilized be made by a non-biased technical task force to minimize enhancement of private property.

Two aspects of project design should be evaluated carefully in future projects. First, the benefit of adding a thin gravel filter bed beneath the riprap should be considered. This is commonly done when gabien structures are installed. Some sediment apparently entered the lake when waves first washed over the completed riprap and exposed sediments below the rock. Secondly, if a lake is subject to extreme high levels periodically from surface runoff and if the fetch is long enough that strong winds could cause severe wind action, the value of placing rock riprap one foot higher vertically than in project design should be considered.

Consideration should also be given to adding the following requirements to construction specifications for lake shoreline riprap: (1) the contractor shall use a method of sloping the lake bank that does not allow any appreciable sediments to enter the lake. (2) rock riprap shall be stockpiled on the lake bank beforehand so that it can be placed as soon as the sloping work is completed, and (3) the area above the riprap shall be mulched and seeded as soon as the riprap has been completed and inspected. Careless construction methods can allow appreciable bank sediments to spill into the lake, heavy rains could cause considerable sheet erosion on recently exposed slope banks, and the toe of the new slope could easily be washed into the lake if the lake was at a high level and/or a windstorm occurred before the riprap was placed.

SECTION 3

DEVELOPMENT OF LAKE RESTORATION PROJECT

DEVELOPMENT OF PROJECT CONCEPT AND GRANT PROPOSAL

During 1971 the Watertown Parks and Recreation Department and the Codington County Conservation District, with technical assistance from the Soil Conservation Service, developed preliminary plans for protecting eroding banks at Jackson Park, a park developed and maintained by the City of Watertown.

Funds could not be secured at that time so the proposal became inactive. When local interests learned about the new federal Clean Lakes Program in 1975, interest was rekindled and the project was broadened to include shoreline erosion problems on the entire lake. The East Dakota Conservancy Sub-District, working with other local interests, developed and submitted a proposal to EPA for a $67,000, 50% cost-sharing grant on April 15, 1976.

OBJECTIVES OF THE DEMONSTRATION PROJECT

The objectives of the project were to prolong the life of Lake Kampeska through control of bank erosion sediment deposited in the lake, to help restore damaged shoreline, and, if possible, to improve the lake water quality.

MULTI-ENTITY PARTICIPATION IN PROJECT DEVELOPMENT

The Lake Kampeska Development Association, a private organization, assisted by raising $15,000 toward project construction. The Association assisted further by preparing and securing easements from private landowners, holding meetings to inform the public during project construction, and providing a pontoon boat for the multi-agency selection of sites for shoreline protection.

Nearly all levels of government participated in the project development. At the local level, the City of Watertown provided $16,000 toward project construction, while the City's Park and Recreation Department managed the construction contracts for the project. Codington County contributed $16,000 toward project construction. The Codington County Conservation District, as previously noted, was involved in early project planning.

At the multi-county level, the East Dakota Conservancy Sub-District, an 11½ county water resource planning and development agency, provided a $10,000 project grant, applied for and administered the EPA Clean Lakes program grant, collected water quality samples, and served as overall project coordinator. The First Planning and Development District assisted in preparing the EPA grant application and in setting up project meetings.

At the state level, the Department of Game, Fish and Parks provided a $10,000 grant, developed final engineering plans and specifications and supervised project construction. The Department also secured needed Section "404" permits from the Corps of Engineers and provided transportation for multi-agency inspection of completed project works.

At the federal level, the Soil Conservation Service developed some preliminary project plans and participated in the selection of project site areas. The Environmental Protection Agency provided $74,310 cost-sharing funds for project construction.

Prior to project construction the five non-federal entities involved with project funding and/or administration developed and signed a Memorandum of Agreement to reduce misunderstandings during installation of project works.

TECHNICAL ASPECTS OF PROJECT FEATURES

The project involved shaping existing slough banks to a flatter, stable slope by cut and/or fill, placing riprap on the new slope, and establishing grass on the exposed soil areas above the riprap. Where possible for stability, the bank was sloped shoreward from the toe of the existing slope. Since this practice would have eliminated much of the backyard of some shoreline residences, fill had to be used to bring the bank to the flatter slope.

General specifications for the project bank shoreline protection works are contained in Table 1. Figure 2 illustrates a typical cross section of project bank shoreline protection.

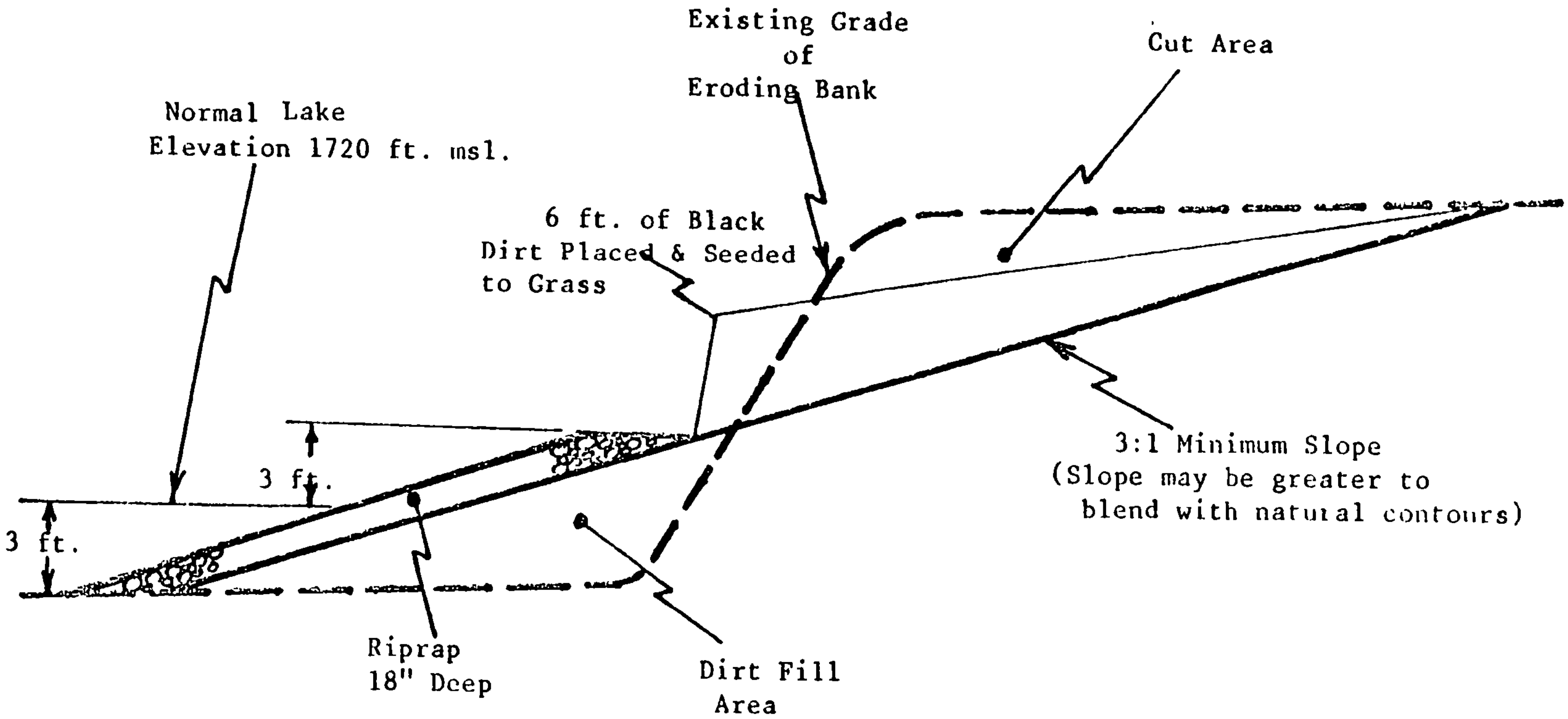

Figure 2. Typical cross section of bank shoreline protection work

TABLE 1. SPECIFICATIONS FOR PROJECT BANK SHORELINE PROTECTION WORKS

(1) Maximum Project Slope - 3:1 or as shown in the plans to blend into existing shoreline contours.

(2) Riprap Type - Fieldstone of the type that will not disintegrate upon contact with the element.

(3) Material Size - 60% in the 150 lb. class (15" diameter)
20% larger than 150 lb.
20% smaller than 150 lb.

(4) Depth of Rock - A minimum of 18".

(5) Placement of Rock - The rock to be placed by dumping or other mechanical means to keep the surface fairly level and to allow the rock to interlock. Riprap was placed three foot vertically both above and below normal pool elevation. On a 3:1 slope, the rock would thus be placed on about 18 feet of slope.

(6) Protection of Exposed Bank Areas Above Riprap - Six inches of black dirt placed, grass planted and guaranteed for one year.

These plans and specifications were checked by the EPA Project Officer with assistance from other federal technical experts in Denver and approved prior to bid letting.

PROJECT ACTIVITIES AFTER SUBMISSION OF GRANT APPLICATION

Selection of a project engineer and project areas was the chief activity until the grant was approved. The April 1976 grant proposal stated that the Soil Conservation Service would design and inspect the project works. On May 4, the Soil Conservation Service Area Conservationist provided notice that due to transfer of their area engineer, they could not provide further planning, design or supervisory assistance. John Brink, EPA-Denver Clean Lakes Coordinator, met with local interests on June 23 and noted that a grant award was imminent. Representatives of all the participating agencies toured the lake by boat and marked about 5,200 feet of severe, moderate-severe and moderate bank erosion areas on a large aerial photo. The Department of Game, Fish and Parks' Engineer agreed to seek approval to do the engineering. The Lake Kampeska Development Association agreed to work on needed easements. By August 24, the lake association had determined the land ownership of all severely eroding private lands identified on the boat tour and had secured signed statements of each landowner's willingness to grant project easements if their area was selected.

Action was taken to begin project construction as soon as the grant was approved. The Sub-District, on August 25, received notice of a $67,000 EPA grant award with the grant contract offer received September 14. Jerry Siegel, East Dakota Conservancy Sub-District Manager, was named Grantee Project Manager and Bruce Perry of Denver-EPA Project Officer. Watertown Parks and Recreation Department opened bids for work on the Jackson Park Area August 25. Plans and specifications were transmitted to John Brink for review. After touring the lake shoreline September 21, Mr. Brink concurred with selected project areas and the Jackson Park plans. Three days later a $18,400 contract was awarded to Brownlee Construction of Watertown, South Dakota for the Jackson Park area.

The requirement for a Corps of Engineers' permit for installation of riprap on a lake shoreline under Section "404" of PL92-500, which became effective October 1, and the Department of Game, Fish and Parks' loss of their chief engineering assistant delayed initiation of construction of the rest of the project.

Bids were opened for the remainder of the project on April 26, 1977. The low bid totalled $96,731.15. Shortly thereafter, the following documents were transmitted to the EPA to comply with grant conditions: (1) certification that the bids were properly advertised, (2) bid summary, (3) an explanation of why the particular bid was accepted, (4) copy of final plans and specifications, and (5) EPA Form 5700-41, a breakdown of bid prices by the contractor. After these documents received proper EPA review, a contract was awarded to Brownlee Construction for the work.

The first partial payment for completed project work was processed in July with nine EPA payments made over the course of the project.

The Project Manager contacted the EPA Project Officer on September 7 concerning the following: (1) a time extension request for the grant contract to 6/30/78, (2) advisement of an August 17 change order bringing the second construction contract total to $107,938.79, and (3) a request that the Department of Game, Fish and Parks' $4000 direct cost in preparing final plans and specifications and supervising construction be incorporated into the grant.

By April of 1978, the construction work had been essentially completed. On April 26, Debbie Patterson, new Denver-EPA Clean Lakes Coordinator (officially designated EPA Project Officer on May 19), along with the contractor and representatives of the non-federal project entities, made a joint inspection of the completed riprap work. Minor dress-up work was recommended on a few areas where the fill bank above the rock had eroded when waves from strong winds and a high lake level pounded and overtopped the recently completed works. Although minor problems were noted at a well-attended public meeting on the project that evening, the public expressed strong approval of the completed work. The contractor agreed to correct all noted problems. A subseqeunt May 26 telephone call from a lake association member concerned over the design stability of the riprap work was resolved with a May 21 boat tour of project areas.

The EPA Project Officer and local Project Manager jointly examined project works again June 21. The need to make repairs on a project stabilized area at Inspiration Point in Codington County's Memorial Park became apparent, however, after the lake level had receded to normal elevation.

During late 1978, the Project Manager developed tentative plans for adding rock to the Inspiration Point area, secured cost estimates, and attempted to put together enough funding and locate a contractor to do the needed repair work. Although the original contractor verbally indicated a willingness to undertake the repair work, heavy snows covered the area early in the winter and the work was delayed. Abnormally high lake levels occurred again in the spring of 1979 and caused further erosion damage at the Inspiration Point site. The need to secure supplemental EPA grant funds for the repair work and unavailability of Project Engineer's staff to supervise the work delayed a project completion to April, 1981. A supplemental EPA 50% cost-sharing grant of $7,310 was received on 7/31/80 and used to successfully complete the project.

SECTION 4

RESULTS AND DISCUSSION

SELECTION AND DESIGN OF PROJECT AREAS TO MAXIMIZE BENEFIT TO LAKE AND MINIMIZE BENEFIT TO PRIVATE LANDOWNERS

Lake Kampeska is a highly developed lake with about 600 dwellings. Residental land use occupies 75% of the shoreline area.

There are two problems inherent in developing shoreline protection on a highly developed lake. First, the work provides a direct benefit to certain private lakeshore property owners as sloughing banks are an eyesore and threaten the existence of portions of the property. This problem is compounded when other landowners have already expended several thousand dollars to do similar work. Second, it is very difficult to obtain inexpensive access through private property to selected sites on the lake because earth-moving equipment and trucks loaded with heavy rock materials can do extensive damage in moving across landscaped yards.

Areas to be stabilized were selected by a technically oriented multi-agency task force which ranked the severity of bank erosion problem areas during a boat inspection tour of the lake shoreline. Selected areas were the most severe vertical sloughing banks 10 to 20 feet in height. Rock was placed only high enough to protect the bank from erosive wave action. For most private riprap work, the entire height of the bank is riprapped for aesthetic purposes. In addition, landowners from selected site areas were required to grant free access to the lake prior to preparation of final project plans. Fortunately, the lake was at extremely low levels during the main 1977 construction period. This allowed the contractor to gain access to the lake at undeveloped locations and travel along the lakeshore to gain access to project sites with his heavy equipment.

ECONOMIC FEASIBILITY OF THE TECHNIQUE

The cost of developing shoreline protection on Lake Kampeska was affected by the uncertainties faced by the contractor in working in highly developed areas. This is apparent when comparing the cost per unit length of shoreline protection for Lake Kampeska to the unit cost for a similarly designed project on the Oakwood Lakes which are relatively undeveloped and located about thirty miles away. For Lake Kampeska, the final total cost for 1152 m. (3780 ft.)

of shoreline stabilization was $147,208.80 or a unit cost of $218 per m. ($39 per ft.) of shoreline while for the Oakwood Lakes the final total cost for 631 m. (2070 ft.) of shoreline was $69,310 or a unit cost of $100 per m. ($33.50 per linear ft.) of shoreline.

The other main factor affecting the cost of shoreline stabilization is the location and cost of suitable rock materials.

TECHNICAL EFFECTIVENESS

Concurrent Impact of Other Activities

Due to limited sampling it is very difficult to assess the impact of the shoreline protection works on water quality. As noted earlier, construction of and hookup to a centralized waste collection system was completed in 1976. The impact of this improvement would occur over the next several years. Also, 1976-1978 were very unusual hydrologic years. Due to a prolonged drought, the lake was about 163 cm. (64 in.) below full in January, 1977 and 91 cm. (36 in.) below full in January, 1978. Heavy Big Sioux River spring runoff in 1978 brought the level to 48 cm. (19 in.) above full (1720.0 ft. mean sea level) in April, 1978. Thus, 1978 spring inflow with its load of sediments and nutrients raised the lake 139 cm. (55 in.). The following intensive earth disturbing construction activities on or immediately adjacent to the lake shoreline also impacted the lake during the same period: (1) construction of the waste collection system and hookup to individual residences, (2) installation of both project and privately financed shoreline protection, and (3) construction of numerous shoreline residences.

Water Quality Evaluation

Although there were no project funds allocated for water quality monitoring, samples were generally collected and analyzed bimonthly during 1976-1978 through a cooperative East Dakota Conservancy Sub-District/South Dakota Department of Environmental Protection lake monitoring program. A composite of three grab samples collected at 0.5 m. depth was analyzed for each sampling date at the S.D. Health Lab in Pierre, South Dakota. Also, although none of the main water quality labs in the state were equipped to analyze chlorophyll a, the Sub-District financed the collection and analysis of some chlorophyll a samples by Randall Brich, a Department of Biology graduate student at South Dakota State University.

Some water quality data was collected during 1974-1977 to attempt to evaluate the impact of the centralized sewer system being installed. A tabulation and review of that data by Hansen (1978) is contained in Appendix A. He verifies the difficulty in detecting with any confidence changes in the lake due to any improvement works when limited data is available.

An evaluation by the South Dakota Department of Water & Natural Resources - Division of Water Quality of the water quality data collected during and since this project is contained in Appendix B.

Visual Observation of Project Effectiveness in Reducing Lake Sedimentation.

It is somewhat difficult to determine the volume of sediments that did not enter the lake due to the project works during the high lake levels and strong winds that prevailed during the spring of 1978. Visual observation, however, made by the EPA Project Officer, Project Manager and others indicated that two to eight feet of bank thickness were eroded into the lake from less severe eroding banks which did not receive erosion protection through the project.

By multiplying the observed average bank erosion of 1.5 m (5 ft.) in unprotected areas times the average bank height in project areas of approximately 3.6 m (12 ft.) times the 1152 m (3780 ft.) of shoreline stabilized through the project, it can be roughly estimated that the project prevented 6220 m^3 (8400 yd^3) of sediment entering the lake in 1978 alone. Assuming that the bank material volume would swell by 20% when it became lake bottom sediment and assuming a dredge removal cost of $1.95 per cubic meter ($1.80 per cubic yard) it would have cost a roughly estimated $18,144 to remove this bank material if it had been allowed to enter the lake.

REFERENCES

1. State Lakes Preservation Committee. 1977. A plan for the classification-preservation-restoration of the lakes in northeastern South Dakota. State of South Dakota and the Old West Regional Commission.

2. South Dakota Department of Environmental Protection. 1978. Unpublished lake significance ranking list.

3. Barari, Assad. June, 1971. Hydrology of Lake Kampeska. South Dakota Geological Survey for South Dakota Department of Game, Fish and Parks. Dengell-Johnson F-19-R completion report.

4. Schmulbach, James C. Final Report 1967-68. Study of the turbidity-production factors in Lake Kampeska, Codington County, South Dakota for South Dakota Department of Game, Fish and Parks. Dengell-Johnson Project No. F-20-R-2, Job 1.

5. Hansen, D. R. March 1, 1978. Personal correspondence to Watertown City Engineer John Babcock.

APPENDIX A. EVALUATION OF CENTRALIZED SEWER SYSTEM PROJECT

SOUTH DAKOTA DEPARTMENT OF GAME, FISH AND PARKS

Box 637
Webster, South Dakota 57274

March 1, 1978

John Babcock
City Engineer
Municipal Building
Watertown, South Dakota 57201

Dear John:

I've tabulated and reviewed the data for Lake Kampeska (see Tables 1 and 2). Using the nutrient concentrations as indicators of water quality, I could not detect any significant changes. As you can see from the graphs I've included, the concentrations of nutrients do not follow any distinct patterns that could be attributable to the sewer system around the lake. The nitrogen parameters would be most likely affected by the system and if you'll notice, concentrations of the three parameters vary considerably (except NO_3) and tended to be higher in July during 1976 and 1977. This is just opposite of what you would hope to see.

In my opinion, the data indicated that the baseline study as we are conducting it will not detect, with any degree of confidence, changes in the lake due to the sewer system. It appears that the uncontrollable variables affecting water quality of the lake have a much greater influence than probable or actual reductions of nutrient input to the lake by installing the sewer system. This is especially true in a dynamic, productive lake such as Kampeska. Some of these variables include the input of water and nutrients from the Big Sioux River, from other runoff sources, and from precipitation; changes in phytoplankton (algae), higher aquatic plant, and fish populations; and variations in weather conditions from one year to another. To account for all of these factors in relation to expected water quality benefits from the sewer system, would require a study of much greater detail, cost, and length of time than you are presently conducting or are probably willing to embark upon. I don't think that what you've done so far has been a waste of time or money. It has provided some baseline data which could be used for comparisons some time in the future.

Therefore, I recommend that, if possible, you terminate the baseline nutrient study that you are now conducting. I fully recognize the importance and value of documenting the results of projects that are designed for the benefit of our lakes. However, I also think that we have to be realistic about our capabilities to evaluate these projects.

There is a possibility of continuing to monitor water clarity by using a secchi disc. This is a simple method that could be done inexpensively with volunteer help, but would have to be done regularly. This parameter may be more relevant and useful to you than the chemical data. If you would like to talk about this some time and possibly get a program like this going, I would be happy to meet with you. It often helps to get the local people involved in something like this, too.

Give me a call if you have any questions or would like further information.

Sincerely yours,

Doug Hansen /s/

Douglas R. Hansen
Research Biologist

DRH/d
cc: Jack Opitz

Enclosure

Table 1. Mean concentrations (mg/l) of nutrients at three Lake Kampeska in-lake stations.

		1974	1976	1977
NO_3	March	0.23	0.03	0.15
	April	0	0	0
	July	0.03	0	0.08
NH_3	March	0.06	0	0.70
	April	0	0	0.47
	July	0	0.72	0.42
Org N	March	0.68	1.60	0.31
	April	0.72	0.65	1.56
	July	0.52	0.93	0.61
$O-PO_4$	March	0.69	0.67	0.58
	April	0.64	0.64	0.56
	July	0.36	0.17	0.68
$T-PO_4$	March	0.80	0.70	0.81
	April	0.73	1.28	1.48
	July	0.63	0.42	1.10

Table 2. Nutrient concentrations (mg/l) at inlet-outlet (Station 1) of Lake Kampeska.

		1974	1976	1977
NO_3	March	0.50	0	0.41
	April	0.08	0	0
	July	0.02	0	0.05
NH_3	March	0.30	0.42	1.00
	April	0	0	0.50
	July	0	1.10	0.45
Org N	March	1.03	2.40	0.59
	April	0.98	0.65	1.27
	July	0.70	1.68	0.11
$O-PO_4$	March	0.16	0.51	0.89
	April	0	0.04	0.07
	July	0.17	0.60	0.27
$T-PO_4$	March	0.21	0.90	1.10
	April	0.27	0.28	0.50
	July	0.54	1.56	0.58

APPENDIX B. WATER QUALITY ANALYSIS

Sampling was initiated in the fall of 1976 and continued through spring of 1978 to determine the effects of shoreline riprapping on in-lake water quality. Samples were collected near the Jackson Park area and near South Dakota Game, Fish & Parks access areas in the northwest and southwest quadrants. These three grab samples were collected and composited for analysis. Samples were collected with a Van Dorn bottle at approximately 0.5 m depth. Since samples were composited no valid statistical analysis could be performed on the results so the following analysis is based on observation of general trends within the data.

Seasonal trends as influenced by natural factors within the Lake Kampeska ecosystem were evident (Table 1) but trends or water quality changes affected by the project work were limited at best (Tables 2-4). Total solids, total suspended solids, total dissolved solids, and conductivity showed no definite trends through the sampling period. Frequency and intensity of sampling were probably inadequate to assess the subtle changes that would be expected from riprapping only a portion of a large windswept lake. Visual assessment of the benefits to a particular zone of the lake adjacent to, or in the prevailing wind pattern of the riprapped area would probably more accurately describe water quality improvements than the sampling regime that was conducted. During 1978 there was a slight decrease in TS, and conductivity perhaps indicating some measurable improvement related to project works. Samples collected during summer 1979 in conjunction with compilation of the South Dakota Lakes Classification Survey also show a reduction in TS values. These water quality changes could be expected as a result of shoreline erosion control but since construction activities did not end until late 1977 the changes observed may only reflect the cessation of heavy equipment operating on the project areas. Determinations of the impact of riprapping activities on water quality of Lake Kampeska are also limited by sheer size of the riprapped area in comparison to the entire shoreline. Only a small percentage of the shoreline was treated for erosion control so even if total control was achieved on those areas, windblown sediments from untreated areas would easily interfere with water quality monitoring of project areas (Figure 1).

Future projects of this type should perhaps have a somewhat modified monitoring and evaluation program. Monitoring of water quality in proposed riprap areas should commence at least one seasonal cycle before construction begins and continue through one seasonal cycle following completion of construction so to include the "control" seasonal time period in post construction monitoring. If this approach is followed a small sample of baseline data can be compared to post treatment data that has been collected in a similar manner from identical sites. Emphasis should be placed on physical parameter measurements such as secci depth, wind direction, speed, and prior duration (i.e. several days from the same direction prior to sampling), precipitation, TSS, TDS, TS, and conductivity. These parameters should more directly reflect the effects of sediment reduction structures or procedures. Further information regarding Lake Kampeska can be found in the South Dakota Lakes Classification Survey 1981 and in the South Dakota Department of Water & Natural Resources water quality study area report on Lake Kampeska currently being prepared.

Table 1. Lake Kampeska 1976-1978 - Selected Parameters Mean Seasonal Results.

		1976*	1977	1978
NH_3-N	Spring	-	.09	.035
	Summer	-	.075	.045
	Fall	.03	.11	-
	Winter	.19	.80	-
NO_3	Spring	-	<.10	.38
	Summer	-	<.10	<.1
	Fall	<1	.30	-
	Winter	<1	.42	-
NO_2	Spring	-	.01	<.01
	Summer	-	.01	.01
	Fall	NA	.01	-
	Winter	NA	.01	-
T-PO_4	Spring	-	.169	.254
	Summer	-	.229	.288
	Fall	.332	.380	-
	Winter	.257	.382	-
O-PO_4	Spring	-	.149	.256
	Summer	-	.187	.249
	Fall	.191	.316	-
	Winter	.220	.333	-
TSS	Spring	-	7.0	16
	Summer	-	23.5	11.5
	Fall	20	25	-
	Winter	3	6	-
TDS	Spring	-	443	328
	Summer	-	414	324
	Fall	410	408	-
	Winter	451	533	-
TS	Spring	-	450	344
	Summer	-	438	336
	Fall	430	433	-
	Winter	454	539	-
FECAL COL.	Spring	-	<3	4
	Summer	-	13	6.5
	Fall	<3	16.5	-
	Winter	3	<3	-
COND. μMHO	Spring	-	645/24°	-
	Summer	-	-	438/23°
	Fall	540/23°	-	-
	Winter	680/24°	-	-

*One Sample Only

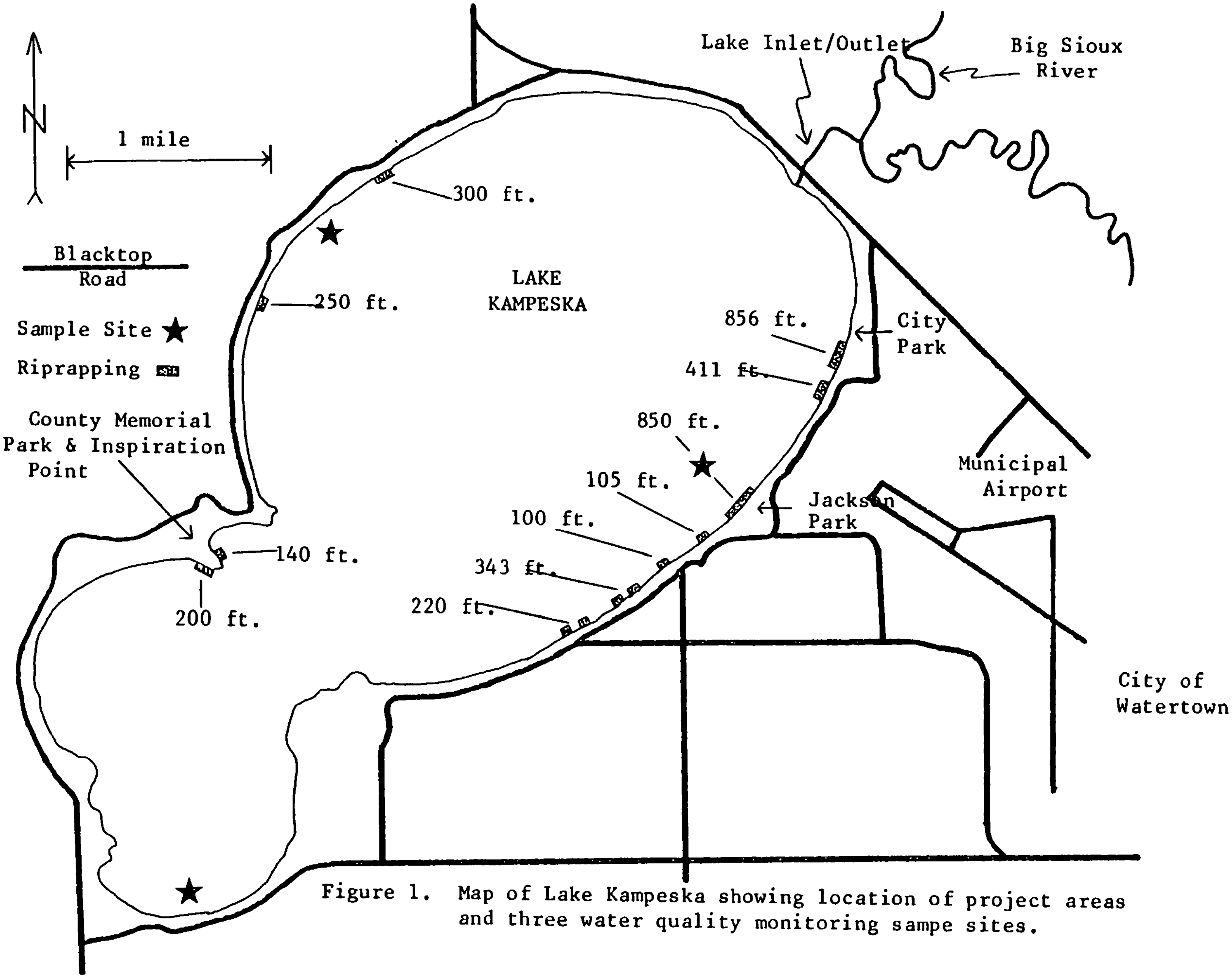

Figure 1. Map of Lake Kampeska showing location of project areas and three water quality monitoring sampe sites.

Table 2. Lake Kampeska 1976 - Selected Parameters.

Date	9-15-76	11-18-76
No. Samples	3	3
NH_3-N	.03	.19
NO_3	<1	<1
NO_2	NA	NA
T-PO_4	.332	.257
O-PO_4	.191	.220
TSS	20	3
TDS	410	451
TS	430	454
FECAL COL.	<3	<3
COND. μMHO	540/23°	680/24°

Table 3. Lake Kampeska 1977 - Selected Parameters.

Date	1-19-77	3-8-77	5-4-77	8-9-77
No. Samples	3	1	3	3
NH_3-N	1.45	.08	.10	.06
NO_3	.34	$\angle$.10	$<$.10	$\angle$.10
NO_2	0.00	.01	.01	.01
T-PO_4	.303	.198	.139	.318
O-PO_4	.294	.179	.119	.254
TSS	2.0	13.0	1.0	39.0
TDS	615	548	337	368
TS	617	561	338	407
FECAL COL.	3	3	3	NA
COND μMHO	860/23°	770/24°	520/24°	560/24°

Date	8-31-77	9-27-77	10-28-77	12-4-77
No. Samples	3	3	3	3
NH_3-N	.09	.08	.13	.14
NO_3	.10	.10	.5	.5
NO_2	.01	.01	.01	.01
T-PO_4	.285	NA	.380	.461
O-PO_4	.223	.282	.349	.379
TSS	8.0	33.0	17	10
TDS	460	396	420	450
TS	468	429	437	460
FECAL COL.	13	30	$\angle$ 3	$\angle$3
COND. μMHO	610/22°	550/33°	580/24°	650/24°

Table 4. Lake Kampeska 1978 - Selected Parameters.

Date	3-7-78	4-25-78	5-17-78	5-23-78	8-3-78	8-31-78
No. Samples	3	3	2	3	3	3
NH_3-N	.03	.07	<.02	.02	.07	.02
NO_3	.6	.7	<.1	<.1	<.1	<.1
NO_2	.01	.01	<.01	.01	.01	.01
T-PO_4	-	.345	.206	.210	.319	.256
O-PO_4	.478	-	.142	.148	.242	.256
TSS	23	6	11	24	4	19
TDS	494	282	286	251	347	301
TS	517	288	297	275	351	320
FECAL COL.	<3	7	<3	<3	<3	10
COND. μMHO	750/24°	385/22°	385/22°	400/24°	425/23°	450/23°

Table 5. Lake Kampeska Chlorophyll a Data secured by East Dakota Conservancy Sub-District for EPA Lake Restoration Project.

Date	Jackson Park Area Chl. a (mg/l)	Game, Fish & Parks Access Area Chl. a (mg/l)
7/25/77	11.6	20.9
8/30/77	28.4	34.8
9/26/77	51.1	27.8
10/27/77	6.5	6.2
4/24/78	12.7	14.4
5/22/78	5.4	3.6
7/24/78	9.1	13.2