FINAL REPORT

RICHMOND LAKE WATER QUALITY DEMONSTRATION PROJECT

PROJECT PERIOD
3/12/90 THROUGH 3/11/94

PROJECT SPONSOR

SOUTH BROWN CONSERVATION DISTRICT

Report Prepared By

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I. EXECUTIVE SUMMARY

Richmond Lake is located in southwestern Brown County approximately 14.5 kilometers (nine miles) northwest of Aberdeen, South Dakota. The lake is used extensively by the community of Aberdeen and surrounding area residents for recreational purposes. In recent decades, however, the lake has experienced high nutrient levels, poor water clarity, and high fecal coliform bacteria counts. Toxic algae blooms have also threatened the safety of the lake users.

These problems prompted the local citizens to begin efforts to improve the water quality of the lake. After considerable local discussion, the South Brown Conservation District agreed to sponsor a Water Quality Demonstration Project.

This project evolved into a collaborative effort between the local citizens and the South Brown Conservation District. Technical and financial assistance was requested from a number of governmental agencies. Funding was provided by the U.S. Environmental Protection Agency (EPA), the USDA Soil Conservation Service (SCS), the USDA Agricultural Stabilization and Conservation Service (ASCS), the South Dakota Department of Environment and Natural Resources (DENR), the South Dakota Department of Agriculture (DOA), the South Dakota Department of Game, Fish & Parks (GF&P), and the James River Water Development District. Local landowners also provided cost-share or in-kind services towards the project. Technical assistance was provided by DENR, SCS, and the Cooperative Extension Service (CES).

This project was based upon the voluntary efforts of the local landowners to implement various Best Management Practices (BMPs) in the watershed to control nonpoint source pollution. The major accomplishments of the project are listed below.

1. Six Animal Waste Management Systems (AWMS) were constructed for high priority areas.

2. 4,877 meters (16,000 feet) of livestock exclusion fencing was placed along the lake shoreline to control lake access from 221 hectares (545 acres) of lake-side pasture.

3. Three alternative watering facilities were established to compliment livestock management activities.

4. Sloughing banks along the lake shoreline were stabilized with 697 meters (2,288 feet) of rock rip-rap.

5. Approximately 2,412 meters (7,912 feet) of fragile shoreline areas were protected with 1,206 hand-planted trees.

6. Approximately 1,214 hectares (3,000 acres) of cropland were converted to grasslands through the Conservation Reserve Program.

An information/education program was also initiated as part of the project. This program included:

- installation of three informational signs at high traffic areas at the lake;

- publication of a general informational brochure about the Richmond Lake Water Quality Demonstration Project.

- publication of a quarterly newsletter throughout the project to keep the public informed;

- informational meetings to keep all local citizens and governmental agencies up to date about the project and to discuss problems;

- publication of annual progress reports;

- completion and use of an informational videotape of the project;

- documentation of the project with photographs and slides, which were also used in presentations; and

- public education through annual project tours.

The project was assessed with three techniques. One consisted of a general comparison of accomplishments versus original tasks. A second method used the Agricultural Nonpoint Source (AGNPS) model to predict changes in sediment and nutrient yields from areas before and after BMP implementation. A third method was based on water quality monitoring.

Based on these assessments the project was considered a success. The project generated a cooperative effort between the farmers and the lakeside dwellers where past efforts had been confrontational. Although this project primarily assisted the farmers in controlling pollution sources, it did cause the lakeside dwellers to assess their own pollution potential and take steps to make sure that their dwellings were not pollutant sources. The project implementation activities varied from the activities in the original workplan but it is not unusual for projects of a voluntary nature to vary from preconceived plans. The best projects are often those that are flexible enough to adapt to changing conditions without deviating from the original project goals.

Of ten planned AWMS, six were constructed, one other ceased operation and one was determined not to need an AWMS. Much more shoreline was stabilized (697 meters of rip-rap compared to 213 meters planned, plus 2,412 meters of "soft" shoreline protection with tree plantings). The livestock exclusion by fencing was not as successful as planned; 4,877 meters of shoreline was excluded out of 13,106 planned. The cropland BMPs were widely acceptable, especially the Conservation Reserve Program. Approximately 1214 hectares of cropland were converted to grasslands.

The AGNPS model was used to assess the relative success of the cropland conversions and the AWMS in reducing sediment and nutrients yields. The cropland conversions plus the AWMs appeared to reduce sediment loadings to the lake by 162,386 kilograms/year (179 tons/year), a 5.5% reduction in annual load. The nitrogen loadings were reduced by 1,089 kilograms/year (a 5.5% reduction) and the phosphorus loadings by 635 kilograms/year (a 14.6% reduction).

These reductions showed the effectiveness of the CRP and the AWMS but the other project activities were not included in the AGNPS evaluation. Shoreline rip-rap is a well-known, effective erosion control technique and livestock exclusion undoubtedly has a positive impact on reducing fecal coliform bacteria as well as reducing livestock induced shoreline erosion. The tree plantings and the information/education effort were also not included in the AGNPS assessment. These project elements most likely contributed to reduced nutrient and sediment loading to the lake and it is not unreasonable to believe that the sediment and nutrient loading reductions were even greater than what AGNPS predicted.

The water quality monitoring did not show any appreciable improvements in nutrient concentrations but the lack of beach closures due to high fecal bacteria counts indicated a significant level of fecal coliform bacteria control. This was presumably due to the construction of AWMS for those operations adjacent to the lake and to the livestock exclusion activity. Improvements in nutrient levels may not be realized for a few years and it is critical that all of the BMPs remain in place and are given adequate oversight and maintenance.

The Richmond Lake Water Quality Demonstration Project dealt with various problems which arose prior to and during the project. One major problem typical for this type of project was the initial confrontational attitude of the many project participants (and non-participants). The farmers thought that most of the lake problems were due to the lakeside dwelling septic tanks whereas the lakeside dwellers thought that the livestock operations and farming in general were the problem. This produced some overheated debates and some bad feelings but in the long run, the good nature of the local people and basic common sense prevailed. The farmers implemented NPS pollution control activities and the lakeside dwellers took steps to implement their own set of control measures.

In spite of this initial problem, the project proved to be an outstanding example of cooperation between landowners and governmental agencies as well as an effective nonpoint source pollution control project. It is recommended that other projects learn from this one and consider the following project insights and recommendations.

- Clearly identify and document a water quality problem prior to starting implementation activities.

- Hold pre-project and project meetings to give everyone a chance to comment and provide input.
- Identify attainable project goals.
- Promote cooperation among project participants.
- Be opportunistic when creating a project funding package.
- Use dedicated and trained personnel to ensure project success.
- Be flexible with project elements but retain project goals.

II. INTRODUCTION

Richmond Lake is located in southwestern Brown County approximately 14.5 kilometers (nine miles) northwest of Aberdeen, South Dakota. The lake is used extensively by the community of Aberdeen for recreational purposes. In recent decades, however, Richmond Lake has experienced high nutrient levels and poor water clarity. Toxic algae blooms also occurred and threatened the safety of the lake users.

These problems prompted the local citizens to begin efforts to improve the water quality of the lake. After considerable local discussion, the South Brown Conservation District agreed to sponsor a Water Quality Demonstration Project.

This project evolved into a collaborative effort between the local citizens, South Brown Conservation District, and various regional, state, and federal agencies to control nonpoint source pollution in the Richmond Lake watershed. This report describes in detail the operation of the Richmond Lake Water Quality Demonstration Project. The information contained within this report will be used to benefit other projects with similar restoration goals.

III. GENERAL DESCRIPTION OF RICHMOND LAKE

Richmond Lake is a man-made "T" shaped lake located approximately 14.5 kilometers northwest of Aberdeen, South Dakota (Figure 1). The dam and spillway were completed in 1938 under a special WPA work project. The structure is situated about two kilometers east of the former confluence of Foote Creek and an un-named tributary. Lake overflow is directed southeast through Foote Creek into Mocassin Creek and eventually into the James River.

Richmond Lake covers an area of 340 surface hectares with an average depth of 3.35 meters and a maximum depth of 8.23 meters. The lake floor contains sand and gravel in the shallows to silt and muck in the deeper areas. Thermal stratification is not present during the seasonal lake cycle. Climatic conditions consist of warm summers and cold winters with much seasonal variation. Winter cold spells may plummet the temperature down to -37 degrees C and in summer extremes of 43 C have occurred. Average precipitation is about 48 centimeters with most falling during thunderstorms. Average snowfall is 86 centimeters and is normally accompanied by strong winds. The average pan evaporation is 119 centimeters. Less than 5% of the lake shoreline is covered with aquatic plants (cattail and bulrush). The most abundant fishes in the lake are crappie and bullhead.

The State of South Dakota has assigned the following beneficial uses to Richmond Lake:

1. Warmwater permanent fish life propagation;
2. Immersion recreation;
3. Limited contact recreation; and
4. Wildlife propagation and stock watering.

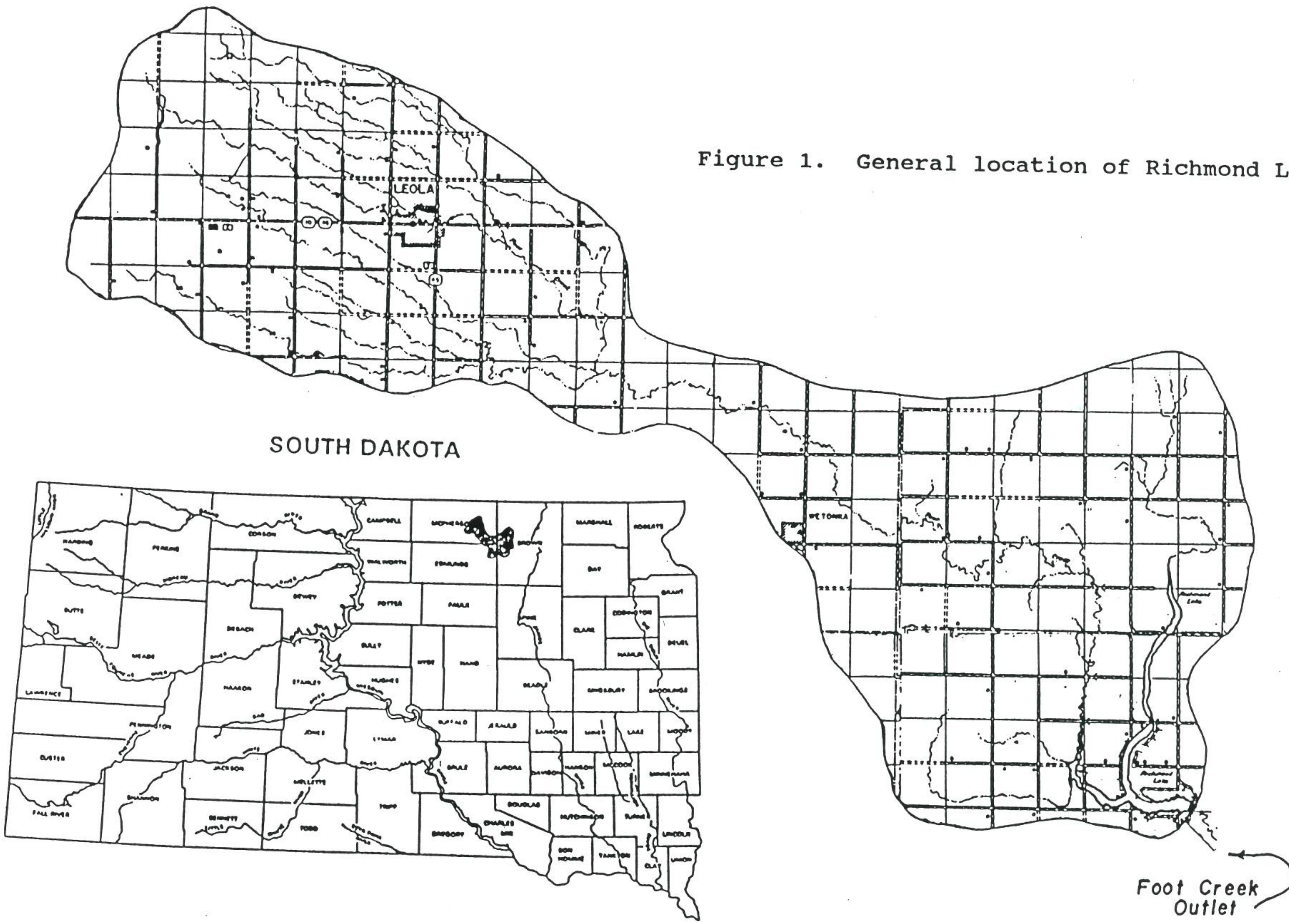
The inflowing tributaries have the beneficial uses of:

1. Irrigation; and
2. Wildlife propagation and stock watering.

The Richmond Lake watershed area is approximately 37,232 hectares. This area occurs in portions of Brown, Edmunds and McPherson counties. Foote Creek and three un-named tributaries account for the intermittant inflows to the lake. The land consists of slightly undulating uplands on the Drift Prairie of the James River Lowland. Soils are generally loamy and moderately well drained (55% Niobell/Noonan, 29% Williams/Barnes, 14% Barnes/Williams, and 2% Bryant). Land use is estimated at 70-80% grassland and 20-30% cropland.

Agriculture is the main enterprise in the watershed. Small grains such as wheat, barley and oats are raised for cash crops and beef cattle make up the predominant livestock operation. Estimated population within a 65-mile radius of the lake is 81,406, of which

Figure 1. General location of Richmond Lake.



approximately 137 are permanent residents around the lake. The lake includes two recreational sites that feature a public boat landing, swimming beach and camping facilities. One private business is located at the lake and features a cafe and lounge.

IV. PROJECT DEVELOPMENT

Concern over Richmond Lake's general water quality heightened in the mid 1980's. The decline was evidenced by high in-lake nutrient levels, occasional blue-green algal blooms, low oxygen levels, poor water clarity and sporadic fecal coliform problems. The incidence of algal toxicity during the summer of 1985 increased public awareness of lake water quality problems. A toxic strain of the common planktonic blue-green alga, Anabaena flos-aquae and high fecal coliform bacteria counts attributed to periodic beach closures during 1985 and 1986.

The Richmond Lake Association (RLA) held meetings to discuss the worsening condition of the lake and decide what should be done. At the informational meetings the group discussed prior lake studies and the need for current water quality data. During the fall of 1986, the RLA contacted the DENR for assistance. In 1987, the RLA entered into a contract with DENR to complete a two-year Diagnostic/Feasibility Study on Richmond Lake. This study provided current data on the lake's trophic condition and associated use impairment. The study was used to develop restoration alternatives to benefit water quality and enhance lake use. The RLA was primarily responsible for the water monitoring program and watershed data collection. The RLA received field work assistance from the GF&P, Northern State College, Brown County and the City of Aberdeen. As the information was collected, DENR evaluated the water samples. The AGNPS model was also used to prioritize areas in need of NPS pollution controls.

As the D/F Study neared completion, DENR contacted the SCS and the South Brown Conservation District (SBCD) to assist with the development of a water quality project. The "Hydrologic Unit" (HU) planning process was used to gather local input. The SCS and CES (Cooperative Extension Service) helped conduct the HU meetings. The first meeting included lake area residents and the second meeting was held for landowners and operators. Public concern over the lake's increasingly poor water quality was held in high regard at both meetings. To channel the diverse views on water quality and establish a plan of action, the two groups needed to be brought together. The Richmond Lake Planning Committee (RLPC) was formed to unify the various groups. The committee included: lake area residents, landowners and operators, local interest groups, and various state and federal agencies. A roughed out workplan was written and a steering committee was selected. The workplan was developed from the D/F Study and consideration of available funding sources. The South Brown Conservation District accepted the responsibility as local project sponsor. A Final workplan was soon approved and the Richmond Lake Water Quality Demonstration Project was submitted for funding from a number of funding sources.

During December of 1989 the Richmond Lake Project was declared a USDA HU Demonstration Project. This made cost-share programs available for the installation of agricultural practices such as animal waste management systems and Best Management Practices. Technical assistance from the SCS and CES provided professional guidance for project implementation. During January of 1990, the project was approved as a EPA 319 Project. This grant provided funds for NPS pollution control activities, water quality monitoring, and personnel. During June of 1990 the DENR approved a grant from the Consolidated Water Facilities Construction Fund to assist with the implementation activities. Other support for the project was secured through grants from the SD Conservation Commission, the James River Water Development District, and the GF&P. In-kind donations of cash, materials, equipment use and working hours were used to match state and federal grant money. This in-kind match was provided by local farmers and ranchers, the Richmond Lake Association, SBCD, the Brown-Marshall Conservation District, GF&P, Brown County, and other local interest groups. Funding for the project ended up with a breakout of 57% federal, 17% state and 26% local.

During the spring of 1990 the Richmond Lake Planning Committee met and reviewed the project budget and selected a committee to interview candidates for a project coordinator position. The five member committee consisted of representatives from SCS, SBCD, GF&P, the Richmond Lake Association, and area landowners. A coordinator, Kim Schneider, was selected in May 1990 and began work in June 1990. The duties of the project coordinator was to manage and coordinate the project activities such that the four major project objectives are completed. These objectives included: management of an information/education program within the watershed and outside of project boundaries; implementation of various conservation practices; resolution of the lakeside septic system issue and project assessment.

V. OBJECTIVE 1 - INFORMATION/EDUCATION PROGRAM

Informing and educating the public about NPS pollution, its causes and its solutions is one of the most important aspects of NPS pollution control. It is not enough to simply go into an area, solve its problems and then leave. Given the voluntary nature of this project, landowners in the area must be informed about NPS pollution problems and the possible solutions to those problems. This is the only way that they can understand the important role they play in NPS pollution control.

Projects like this offer an excellent opportunity to showcase BMPs and other solutions to NPS pollution. Landowners outside of a project area must be made aware of NPS pollution and that many of the solutions require their active participation. The knowledge and experience gained from this project can be very useful to other NPS projects as well.

One major objective of the Richmond Lake Water Quality Demonstration Project was to inform and educate the public about the project. An Information/Education Program was developed that used a variety of ways to accomplish its goals. The project coordinator, CES, SCS and the South Brown Conservation District were all involved with the I&E effort. A brief narrative about each task is given below.

Task 1 - Publish Richmond Lake Brochure.

A two-color brochure about the project was published during 1993. This brochure detailed a short history of Richmond Lake and outlined the findings of water quality testing that was done prior to the project. Details of the planned activities to improve lake stability and water quality were outlined in the brochure.

Task 2 - Publish Quarterly Newsletter.

During 1990, the first project newsletter was published and sent to lake area residents and others after a 250 name mailing list was developed. Each subsequent year, a quarterly project newsletter was sent to project participants, watershed residents, landowners and the media. Current topics of interest from the project were occasionally included in the Brown County ASCS newsletter as well. The project's quarterly newsletter contained articles about the project progress, range management, erosion control, chemical usage, well testing and other topics which have a positive effect on the efforts of the project.

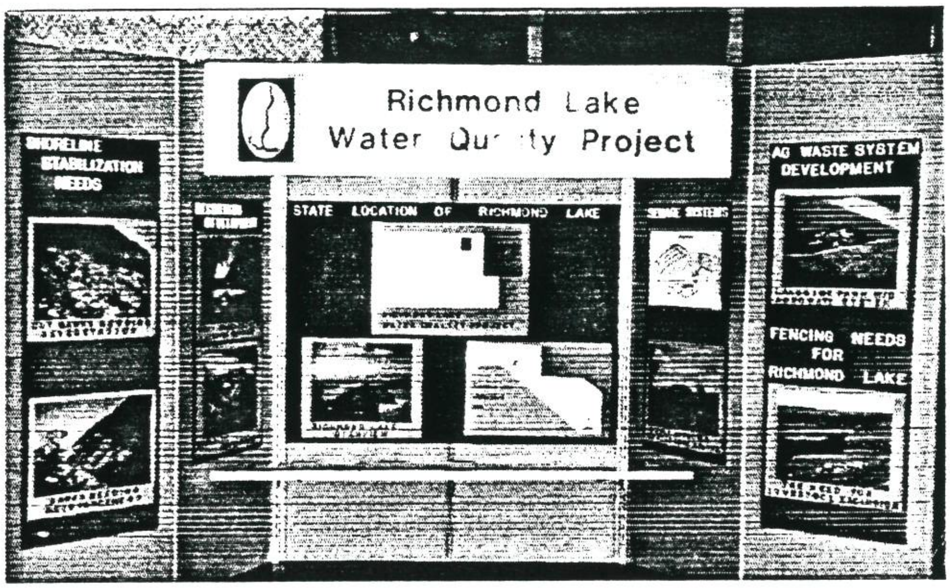
Task 3 - Local Meetings.

During 1990, one public meeting was targeted for farmer/ranchers and another for lakeside homeowners. The main purpose of these meetings was to identify water quality problems and, once identified, suggest solutions to those problems. The two groups identified the same basic problems but the source identification was quite different. The landowners felt that the cause of lake contamination was due to faulty and out-dated septic/sewer systems at the lakeside homes and the homeowners were convinced that the contamination was due to livestock and crop operations around the lake. Subsequently, a Richmond Lake Task Force was created that represented all concerned parties. The public meetings then became more cooperative and productive. Up to six public meetings were held each year for the project. Minutes of these meetings were mailed to all those on the established mailing list to keep them informed.

In addition to local meetings, a number of other gatherings were attended. The Project Coordinator displayed the project at the South Dakota Nonpoint Conference held in Sioux Falls, South Dakota during 1991 (Photograph 1). The Cooperative Extension Service manned a booth at the Ag Expo show in Aberdeen during 1992 and 1993. Booths were also attended at an Environmental Fair in Aberdeen and at two SD Association of Conservation District conventions. Information about the project was disseminated through one-on-one discussions and group presentations and through the use of the Richmond Lake Project video.

Task 4 - Keep Local Media Informed.

Efforts were made to keep those involved and the public informed of project progress through local media outlets including: television, radio, and newspapers. During 1990, three news releases, two television spots and two radio spots were used. During 1992, a local television station produced three news spots on project activities. These were broadcast statewide. Several radio spots were also developed and aired locally. In addition, there were four formal news releases. During 1992 and 1993 a news article was provided to the TRI-STATE NEIGHBOR publication for a special water quality issue they were producing. The project was included in a water segment of the Extension Service television program "Todays Ag". The results of studies on waste management and the accomplishments of the project were included in three additional "Todays Ag" programs and lawn care fertilizer run-off information was included in another program. Media efforts were continued during 1993 with the project information included in five articles released to the statewide media by Ag Communications at South Dakota State University.



Photograph 1. Display poster for the Richmond Lake Water Quality Project.

Task 5 - Erect Cooperative Agency Project Signs.

During 1990 it was felt there was a need to publicize and educate the public about the widespread support and involvement in the project. One way this was accomplished was through the installation of signs at key locations around the lake. The signs gave visibility to the project, listed all of the many project participants, and invited the general public to join in the effort. The three signs were erected at key locations: at the boat ramp/dock/handicapped fishing pier area; at the north bridge area; and at the west bridge area.

Task 6 - Take Photographs.

Photo-points were established during 1990 to document project progress. The many slides and photos were invaluable when assembling newsletters, display booths for farm show and service club presentations, news releases, project brochures, self-guided tour brochures and slide presentations. During July 1992, SCS arranged for aerial photos of completed conservation practices and livestock waste management systems. These were also used for booth displays and slide presentations.

Task 7 - Conduct Annual Tours of Project Area.

Project participants and the general public were invited to a tour each fall. Traveling by pontoon boat and van, tour participants were able to get a close-up view of completed shoreline stabilization activities, livestock exclusion, alternative grazing practices, best management practices, and animal waste management systems.

A self-guided tour brochure and signs were prepared by the CES. The brochure was made available at the Brown County Extension Office and at the Richmond Lake Park Office. Interested persons can follow the map and read about the lake improvement practices in place.

Task 8 - Provide Technical Assistance.

During the summer of 1992, the Brown County Extension Service and the CES began an effort to determine two things: 1) if current lakeside lawn fertilizing practices contributed nutrients to the lake and 2) if the lake water contained high enough concentrations of nitrogen and phosphorus, to exclude the use of supplemental fertilizer for those residents using lake water to water their lawns.

A lakeside lawn with proper slope towards the lake was identified. The homeowner was cooperative and allowed some experimentation. The entire lawn was fertilized according to SDSU recommendations.

The lawn was divided into three equal parts and varying amounts of "rainfall" water were applied to each section in an effort to see if run-off could be generated. Slightly more than ten inches of water over an eleven day period could not generate run-off. It was concluded that the soil types in the test plot and around the lake were such that nutrient inputs from lakeside lawn run-off were not a contributing factor in the eutrophication of the lake.

Samples of the lake water were also analyzed for nitrogen, phosphorus, and potassium. Given a typical lawn watering rate and the relative nutrient needs of a lawn, it was concluded that lake water alone may not provide enough nutrients for a healthy lawn. Commercial lawn fertilizers or other nutrient supplements may be needed to provide the necessary amounts of nutrients.

Task 9 - Project Video.

During September 1993, CES personnel completed a video detailing the project and the work that had been done to improve or maintain water quality. This 14-minute video contained interviews with the project participants as well as views of the implemented project activities. The video has been used at meetings and at farm shows statewide as an educational tool about water quality.

Task 10 - Develop Animal Waste Management Handbook.

Informing operators about animal waste management and the regulatory, technical and financial assistance programs available to them is an important activity geared towards the operators. An informational handbook was developed by CES personnel during the first two years of the project and printed during August 1993. The document was subsequently made available to interested agencies and the public. To date, 230 copies of the manual have been distributed.

VI. OBJECTIVE 2 - IMPLEMENT CONSERVATION PRACTICES

The Lake Study concluded that much of the NPS pollution in the lake watershed was due to agriculture. DENR used the AGNPS computer model to evaluate various land use data with regard to nutrient and sediment loading. The AGNPS model ranked ten concentrated livestock feeding areas in the lower watershed as having high NPS pollution potential (Photograph 2). The project workplan prescribed conservation practices to restrict NPS pollution run-off from identified areas. The majority of the restoration activities were concentrated in the lower part of the watershed. This was due to the close proximity to the lake and the higher potential for nutrient delivery as compared to the upper watershed area.

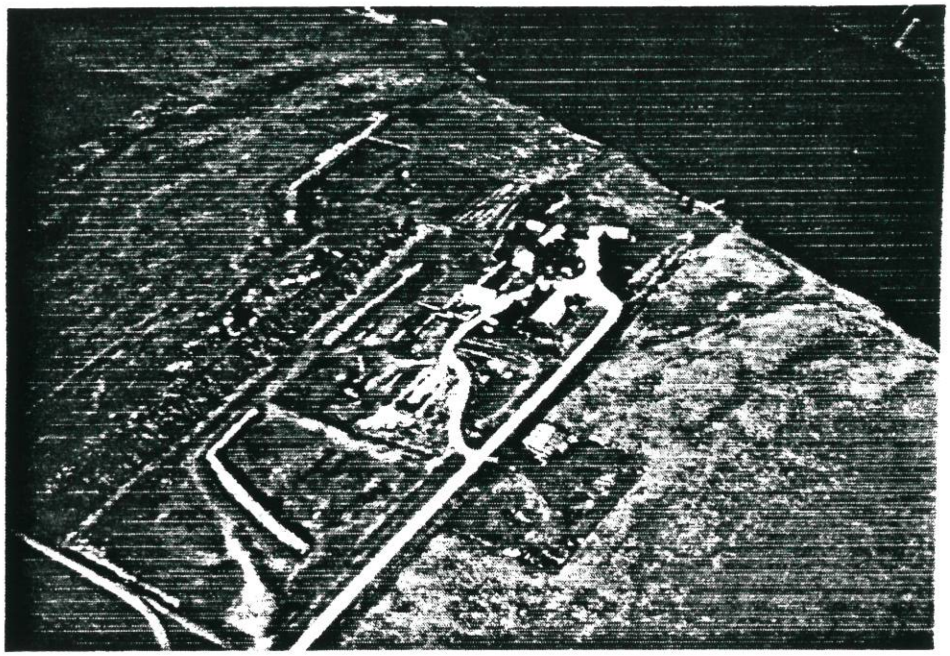
Conservation practices scheduled for application included the establishment of animal waste management systems, exclusion fencing of lakeside pastures, shoreline stabilization, and treatment of crop and rangeland with Best Management Practices (BMPs). All of the activities offered through this project were voluntary. Technical assistance in the form of engineering and design work was supplied by the SCS and SBCD. The ASCS supplied special cost-share assistance for the application of AWMs and BMPs. The EPA 319 grant and the DENR Consolidated Water Facilities Construction Fund provided the remaining funding for the project activities.

Task 11 - Installation of Animal Waste Management Systems.

The workplan identified 10 high priority feeding areas for possible livestock waste management systems. These areas, located in the lower watershed area, were prioritized according to the size and pollution problem exhibited (Figure 2). Installation of individual AWMS would eliminate NPS runoff from each site and reduce lake nutrient and sediment loadings as well as bacterial contamination.

To promote project participation, an appealing cost-share package was assembled for the AWMS. The package provided an ASCS-Long Term Agreement payment for AWMS construction which was limited at $10,500 per operator not to exceed 75% of the total cost. The remaining cost was then applied as 60% 319 funds, 20% State grant funds, and 20% landowner cost as cash (see Table 1 for final budgets for each AWMS). The James River Water Development District (JRWDD) assisted the operators with extra funding for fence establishment. In-kind contributions from each operator covered costs associated with site preparation prior to construction.

Technical assistance was supplied by the SCS in the form of survey and design. The project coordinator was responsible for coordinating and scheduling all activities pertinent to AWMS installation. Operation and maintenance agreements were made between the project sponsor and the individual operators. These agreements established criteria for maintaining proper system operation for a period of ten years. Failure to comply with the



Photograph 2. Feedlot adjacent to Richmond Lake.

Table 1. Budget summary of animal waste management systems.

Operator	Total cost	ASCS-ACP	EPA-319	State	Local
#3	$69,327	$10,416	$33,805	$11,268	$13,838
#1	32,979	10,500	11,933	3,978	6,568
#4	27,815	10,500	5,981	1,994	9,340
#6	38,758	9,176	16,967	5,656	6,959
#5	31,328	10,500	11,847	3,949	5,032
#2	43,438	10,500	19,529	6,510	6,899
Totals	$243,645	$61,592	$100,062	$33,355	$48,636
Percentages	100%	25%	41%	14%	20%

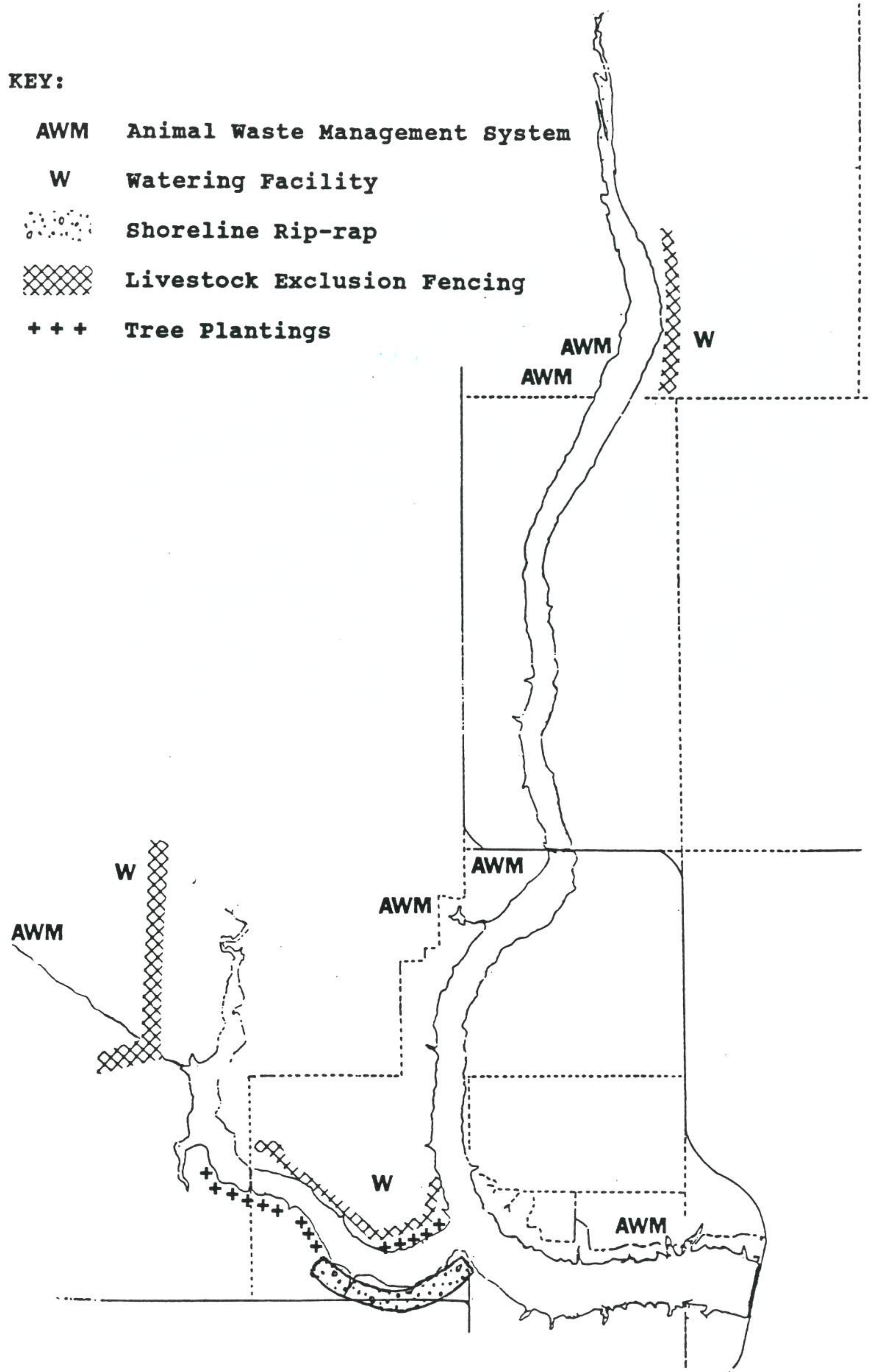


Figure 2. Location of selected implementation activities.

agreement would result in reimbursement of project cost-share funding.

Six AWMS were installed during the project's first two years (Figure 2, Photograph 3). The systems were done according to priority ranking determined by the AGNPS computer model. The list below reflects AWMS ranking and construction date.

System	AGNPS Rank	Construction Date
AWM #1	66	12/30/91
AWM #2	66	11/12/91
AWM #3	50	11/16/92
AWM #4	40	11/19/91
AWM #5	32	11/16/92
AWM #6	28	11/02/92

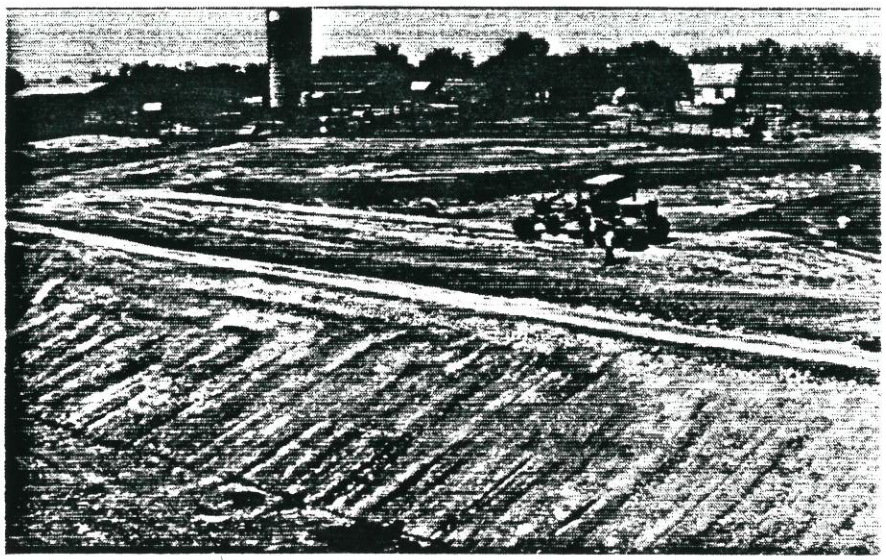
Four additional feeding areas received high AGNPS rankings and were offered project assistance. These systems were not installed because of a variety of reasons. Two operators declined assistance, one operation no longer feeds cattle, and the last area did not appear to have any significant potential for run-off.

One other feeding area in the upper watershed area requested assistance. The area was surveyed and an AWMS designed. The proposed system was let for bid on three separate occasions but construction did not occur. Once the bids were declared too high relative to the design estimate. On the second occasion, the lowest bid was rejected by the operator due to misinterpretation of the bid advertisement. In the final attempt, the operator cancelled the advertisement and expressed he had no further interest in constructing an AWMS.

The AWMS installation process proved instrumental in completing a good share of our projected workplan goals. Six out of the ten planned AWMS were constructed. These systems helped limit the amount off nutrients entering the lake and especially decreased fecal coliform bacteria counts. Refer to Section VIII for a detailed discussion of AWMS effectiveness.

The cost-share programs were effective during the construction phase and helped attract interest. Most of the AWMS final costs exceeded initial project estimates and future projects should plan for inflation and increased costs.

During the project's initial year (1990), activity was slower than expected. This was partially due to the time lapse between securing project funding and hiring adequate trained personnel. Engineering design work also accounted for some initial delays but by the end of the second year the project made large strides towards completing project activities. A chronological summary of the construction activities is given below.



Photograph 3. Construction of an Animal Waste Management System.

-1990-

June - Operator contact regarding AWMS.

Aug. - Completed topographical survey of AWMS #3.

Oct. - Completed soil borings for AWMS #3 and #7.

Nov. - Completed topographical survey for AWMS #7.

Dec. - Completed topographical surveys for AWMS #1, #4, and #6.

-1991-

Jan. - Completed soil borings for AWMS #1 and #4.

Feb. - Completed topographical survey for AWMS #5.
- Reviewed AWMS #1 and #4 designs with landowners.

Mar. - Completed soil borings for AWMS #2 and #5.
- Completed topographical survey for AWMS #2.

Apr. - Completed soil borings for AWMS #6.
- DENR approved designs of AWMS #1 and #3.

May - DENR approved design for AWMS #6.

June - Advertised bids for AWMS #1, #3, and #4.
- Held site tours for potential bidders.

July - DENR approved designs for AWMS #2, #5, and #7.
- Completed archeological survey for AWMS #1, #3, and #4.
- Bid opening and approval of contracts for AWMS #1, #3, and #4.
- Staked AWMS #4 area for construction.
- Issued notice to proceed for AWMS #4.

Aug. - Staked AWMS #1 area for construction.
- Advertised for bids for AWMS #2, #5, and #7.

Sep. - Held site tour for potential bidders for AWMS #2, #5, and #7.
- Accepted bids for AWMS #2 and #5.
- Rejected bid for AWMS #7, bid too high.
- Ran advertisement for 2nd bid for AWMS #7.
- Staked AWMS #2 and AWMS #3 areas for construction.

Oct. - Bid for AWMS #7 rejected by owner.
- Re-advertised for AWMS #7 bids.
- Operator cancelled bid advertisement for AWMS #7.

- Began construction for AWMS #2 and AWMS #3.

Nov. - Construction complete for AWMS #1, #2, and #4.

-1992-

Jan. - Contacted additional operators about AWMS.

Apr. - Staked AWMS #5 area for construction.

May - DENR approved design for AWMS #6.
- Advertised for AWMS #6.

June - Construction complete for AWMS #3.
- Began construction for AWMS #5.
- Staked AWMS #6 area for construction.
- Construction complete for AWMS #5.

July - Began construction for AWMS #6.

Aug. - Construction complete for AWMS #6.

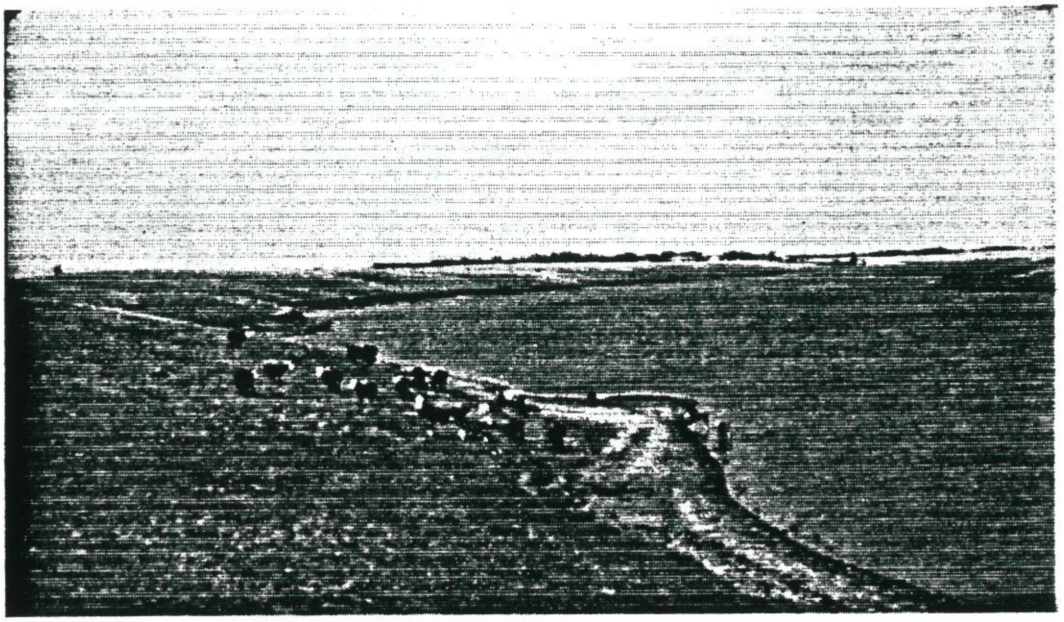
Task 12 - Develop Livestock Exclusion

Fourteen pastures were identified as target areas for livestock exclusion (Photograph 4). To reduce the amount of nutrient loading and shoreline erosion as well as bacterial contamination due to livestock, three activities were promoted: establishment of exclusion fencing, cool season grazing plans, and alternative watering sources.

Initially all pastures were inventoried and field inspections were performed. The project coordinator contacted pasture owners and operators to notify them of cost-share availability. All practices were offered on a voluntary basis. The costs were offered as 60% 319 grant, 20% state grant, and 20% landowner input (Table 2).

Seven pastures were treated through livestock exclusion, five in the form of fencing and two through a seasonal grazing plan. The SBCD and SCS supplied technical assistance for these practices. Approximately 4,877 meters (16,000 feet) of fence was built on 217 hectares (535 acres) of lakeside pastures (Figure 2, Photograph 5). The two seasonal grazing plans protect over 1,829 meters (6,000 feet) of shoreline and cover 101 hectares (250 acres) of pasture. The fencing activities provided for an improved vegetative cover on denuded banks and acted as a buffer for nutrient run-off.

Alternative water sources were made available to project participants involved with lake exclusion. This enabled operators to install water facilities rather than using the lake for watering. A variety of facilities were installed and they included; two WEB water system pipelines, one small dam and one small dugout. All received project funding through cost-share programs. The WEB pipelines were funded through 60% federal Section 319 funds, 20% state money, and 20% landowner inputs. A special US Fish & Wildlife Service grant and ASCS-ACP funding helped support construction of the small dam. Project funding was



Photograph 4. Livestock along the shoreline of Richmond Lake.

Photograph 5. Fencing to limit livestock access to the lake.

Table 2. Budget summary for livestock exclusion fencing and alternative watering sources.

EXCLUSION FENCING

Operator	Fence length (meters)	Hectares effected	Total cost	cost-share	Local
#1	945	24.3	$6,198	none	$6,198
#2	1,006	36.4	452	$ 327	125
#3	1,707	91.1	2,787	2,230	557
#4	533	24.3	2,506	1,316	1,190
#5	645	40.5	1,728	1,320	408
Totals	4,836	216.6	$13,671	$5,193	$8,478

Remarks: Operator #1 was Brown County and they did not receive any financial assistance. All of their input was counted as local input.

ALTERNATIVE WATERING SOURCES

Operator	Total cost	USFWS	ASCS-ACP	Project	Local
#1	$ 734	none	none	none	$ 734
#2	6,238	$1,000	$2,675	$2,050	513
#3	2,161	none	none	1,729	432
#4	1,765	none	1,324	none	441
Totals	$10,898	$1,000	$3,999	$3,779	$2,120

FUNDING SOURCES

ACTIVITY	Total cost	ASCS-ACP	USFWS	319	State	Local
Exclu. fence	$13,671	none	none	$3,116	$2,077	$8,478
Alt. water	10,898	$3,999	$1,000	2,267	1,512	2,120
Totals	$24,569	$3,999	$1,000	$5,383	$3,589	$10,598

also used to assist with the remaining costs of the dam. The small dugout used 75% ASCS-ACP cost-share with the other 25% coming from the landowner (Table 2). Cost-share was not provided to Brown County for their exclusion fencing and watering facility. Their activities, however, did provide match towards the project. A chronological summary of these activities is given below.

-1991-

Nov. - Completed alternative watering system at one location.

-1992-

June - Surveyed areas for small dam construction as an alternative watering facility.

July - Livestock exclusion fence erected on County land.
- Alternative watering facility built on County land.

Sep. - Completed construction of one small dam.

Nov. - Installed one livestock exclusion fence for one area.

-1993-

Nov. - Installed one livestock exclusion fence in one area.
- Installed one alternative watering facility in one area.

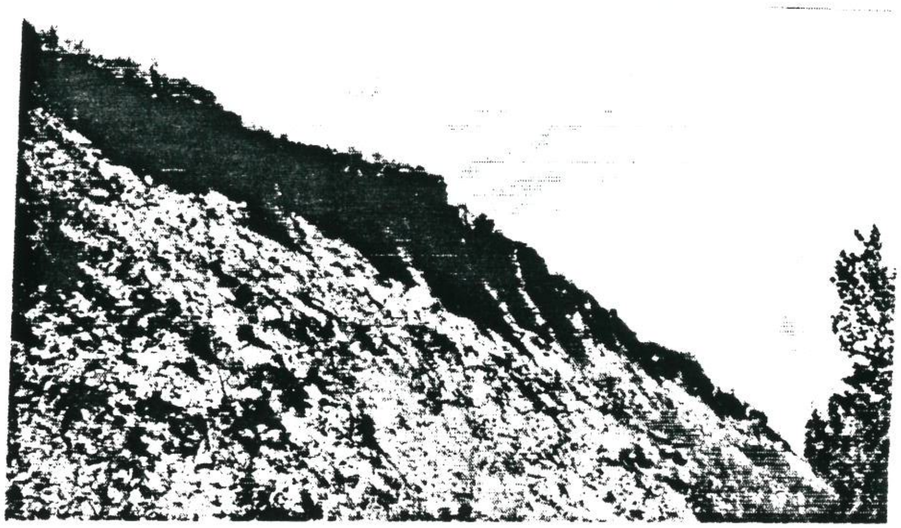
-1994-

Mar. - Installed livestock exclusion fencing in two areas.

Task 13 - Stabilize Eroding Shoreline.

Water clarity at Richmond Lake had declined by more than fifty percent in the last ten years preceeding the project. Most of the turbidity was caused by suspended particles of silt and clay. The D/F Study concluded that much of the problem comes from in-lake sediment deposits and shoreline erosion (Photograph 6). Field investigations noted that sloughing banks and denuded shorelines were extensive on the south side of the lake. This was due in large part to prevailing winds and wave action. Originally 313 meters (700 linear feet) of shoreline treatment was scheduled in the workplan. The lake study and SCS engineers recommended sloping of banks, placement of rock rip-rap, and revegetation in selected areas (Figure 2).

The area indicated for intense stabilization was located on the south side of the lake's west arm. All high priority areas were located on State owned land, which is maintained by the GF&P. An advisory group of SCS, SBCD and GF&P revisited the problem sites and evaluated them during the summer of 1990. It was determined that more shoreline stabilization was needed than what was



Photograph 6. Bank erosion along Richmond Lake.

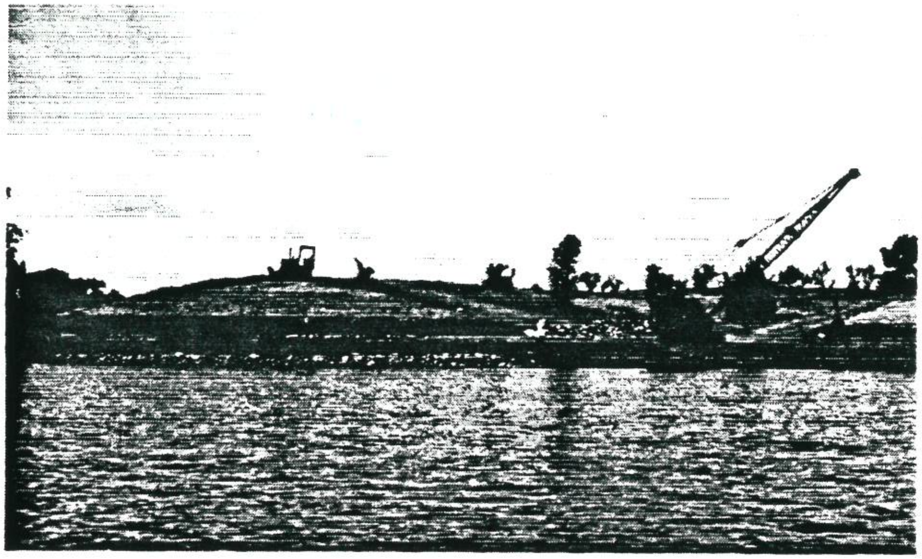
originally planned. Engineering assistance from the SCS and GF&P was sought but they could not provide immediate service. Private consultants were interviewed for obtaining project estimates but the increased cost prohibited using these consultants. The SCS eventually agreed to provide engineering survey and design assistance. During January 1992 the SCS completed the engineering design for the shoreline stabilization. A detailed construction quantities list was prepared for bank sloping, rip-rap placement and grass seeding. The planned area covered 671 meters (2,200 feet) of critical shoreline in five separate sections. The project was let out for bids during the summer of 1992 and staked for construction shortly thereafter.

Construction began during the fall of 1992 with excavation of top soil and rough shaping of the banks. Weather conditions halted progress in early November and activity did not resume until May 1993. Construction was continuously delayed by wet weather that summer. The lake rose above the spillway in July and remained at that level until late fall. This slowed construction considerably and made rock placement difficult. An over-run in rock material cost was attributed to actual underwater placement in the keyway. The general construction activities were completed during September 1993 and grass seeding was completed in late October.

Approximately 13,763 cubic meters (18,000 cubic yards) of dirt were moved and over 671 cubic meters (2,200 cubic yards) of rock used to complete the shoreline stabilization (Photograph 7). A large amount of local funding was sought for project support. Many groups were involved throughout the operation. The Brown County Highway Department transported field rock to the job site for rip-rap placement. Many area farmers and ranchers donated field rock and equipment for use. The GF&P supplied grass seeding operations with grant money. The SBCD received a Conservation Commission state grant for use on the shoreline stabilization. The combined effort insured completion of the project in its entirety.

Shoreline areas in need of moderate erosion protection were identified during further field investigations. These areas were not scoured severely but needed treatment. The workplan recommended vegetative plantings on these secondary sites.

Trees were planted on 2,438 meters (8,000 feet) of shoreline during 1990, 1991 and 1992 (Figure 2). The SBCD and the Brown-Marshall Conservation District supplied a large variety of trees including; golden willow, buffaloberry, chokecherry, cottonwood, juneberry, native plum, dogwood and northwest poplar. An experimental sandbar willow planting was provided by the SCS during 1991. Technical assistance was provided by the SCS and the CES for the plantings. Labor and equipment was supplied by the Richmond Lake Association, Telephone Pioneers group and the GF&P. Over $2,000 in local support was accumulated during tree planting efforts.



Photograph 7. Shoreline stabilization at Richmond Lake.

A chronological summary of the shoreline stabilization effort is given below.

-1990-

June - Interviewed potential engineers for shoreline stabilization.

-1991-

May - Planted trees on eroding shoreline.

July - SCS took responsibility for shoreline survey and design.

Aug. - Completed topographical survey for shoreline stabilization.

Nov. - Completed design for shoreline stabilization.

-1992-

Jan. - Made contacts to secure field rock for rip-rap.
- Made contacts to transport field rock.

Apr. - Completed archeological survey for shoreline stabilization.

June - Planted trees on eroding shoreline areas.
- Received US Army Corps of Engineers 404 permit for shoreline stabilization.

July - EPA approval of shoreline stabilization design.
- Advertised bids for shoreline stabilization.

Aug. - Held site tour for shoreline stabilization.
- Opened bids for shoreline stabilization.
- Staked area for shoreline stabilization.

Oct. - Began shoreline stabilization construction.

Nov. - Shoreline stabilization construction halted.

Dec. - Transportation of field rock to shoreline area.

-1993-

May - Resumed construction for shoreline stabilization.

June - Frequent rains delayed construction activities.

July - Frequent rains delayed construction activities.

Aug. - Completed shoreline stabilization rip-rap.

Nov. - Completed seeding of shoreline stabilization sites.

Funding for shoreline stabilization came from five sources with a breakdown as follows:

Section 319 grant	$72,900.00
DENR - Board of Water and Natural Resources	23,694.00
Local input - mostly in-kind	11,378.00
SD Dept. Agric. - Conservation Commission	5,500.00
SD Dept Game, Fish & Parks	5,000.00
Total	$118,472.00

Task 14 - Implement Best Management Practices.

The implementation of Best Management Practices (BMPs) on pasture and cropland was recommended by the D/F Study. The AGNPS computer model was used to analyze erosion problems in the watershed. Several areas in the lower watershed region were identified as problem areas and the workplan recommended the following variations of conservation tillage and grass seedings.

1. Pasture and hayland plantings.
2. Grass waterways.
3. Stream channel erosion control.
4. Residue management and conservation tillage.
5. Wind stripcropping.
6. Conservation Reserve Program.
7. Nutrient and pesticide management.

The project coordinator was responsible for identifying individual areas in need of immediate treatment. Operators were contacted and made aware of the available cost-share programs. Grass seedings were installed through the ASCS Agricultural Conservation Program (ACP) and the Conservation Reserve Program (CRP). Grass stand establishment was cost-shared at a 75% level for ACP seedings and 50% for the CRP. SCS provided valuable technical assistance during program sign-up and in developing seeding plans.

Nearly 1,335 hectares (3,300 acres) were seeded with new grass; over 1,214 hectares (3,000 acres) as CRP and the rest as hayland (Figure 3). The CRP contracts provided yearly payments for the establishment of permanent grass. These areas are taken out of production for at least ten years. Three separate sign-up periods were held during the project. A special water quality provision was included into the CRP that focused on water quality projects. All land operated within the watershed boundaries was eligible for CRP if it met the proper cropping requirements. Many of the cells identified as problem areas were protected with grass seedings. These areas were mainly located on the adjoining tributaries of Foote Creek.

All operators were made aware of the project's erosion control practices through public meetings and publications. Many operators took advantage of the no-till and minimum tillage programs.

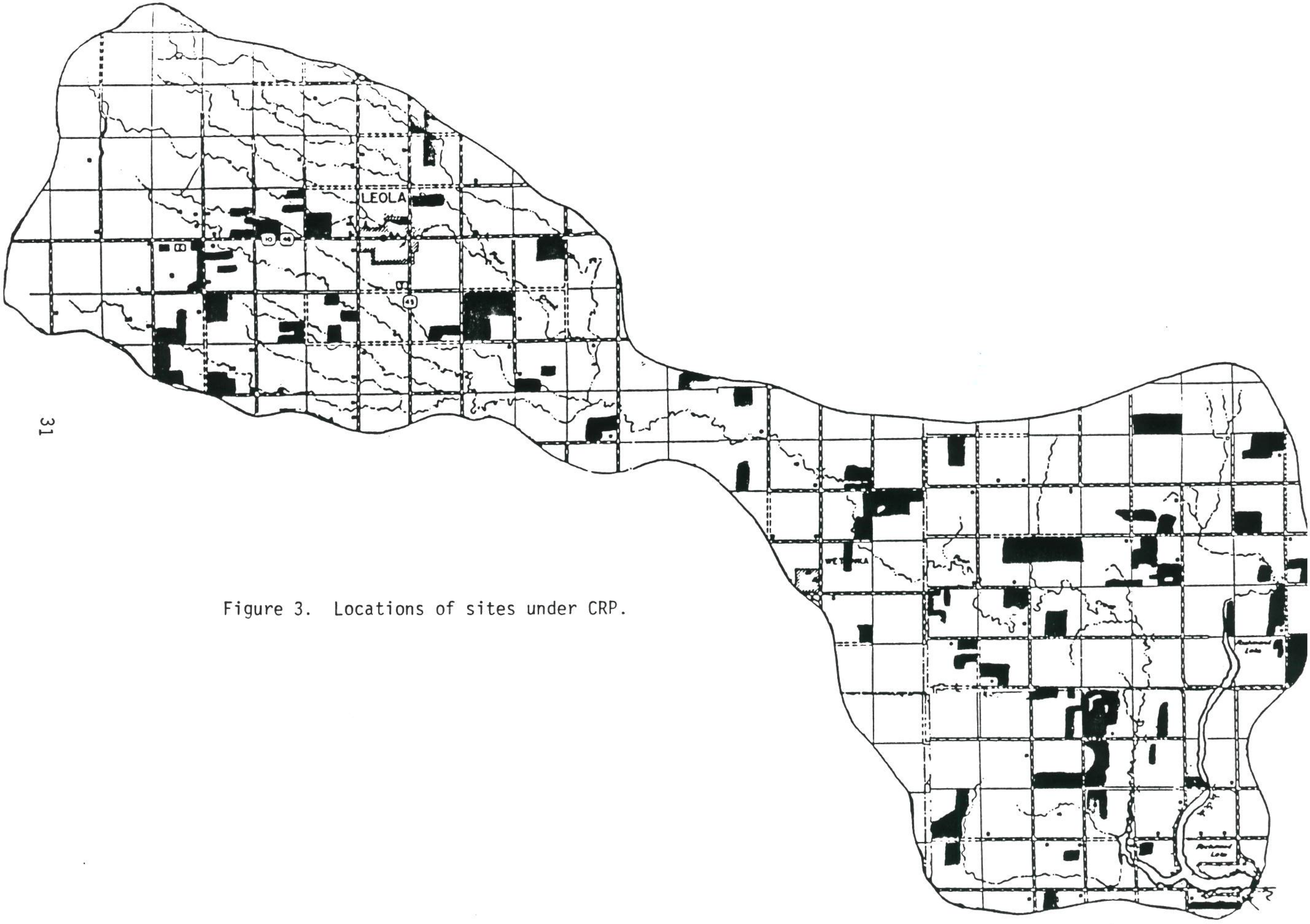


Figure 3. Locations of sites under CRP.

Approximately 186 hectares (460 acres) were controlled through the use of conservation tillage practices. Some operators, however, decided to continue with conventional tillage systems.

VII. OBJECTIVE 3 - SEPTIC SYSTEM SURVEY AND SANITARY DISTRICT

During a number of the Richmond Lake Planning Committee meetings it was evident that there was much concern over the impact of lakeside septic systems on lake water quality (Photograph 8). Septic systems were not studied during the D/F Study and it was decided by the Committee that a survey of the septic systems around the lake should be conducted as part of the project.

Task 15 - Complete Septic System Survey.

During the summer of 1989, the Richmond Lake Association distributed a septic system survey to the lakeshore homeowners and a second survey was conducted by the DENR during June of 1990 using a similar form. During this June survey, DENR could not contact many residents because most people were presumably at work. Consequently, a third survey was conducted during August 1990. The forms from all three surveys were analyzed by DENR by comparing the information given in the survey forms to the South Dakota regulations on Individual and Small On-site Wastewater Systems under ARSD Chapter 74:03:01.

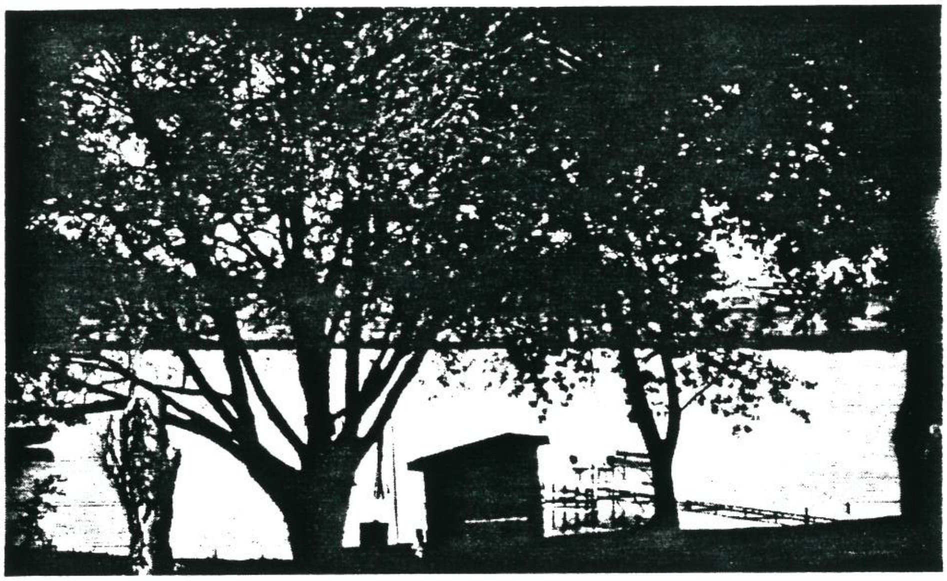
Ninety-five out of approximately 137 residents around Richmond Lake responded to the survey. Few of the survey forms were completely filled out but it was decided to generalize about each system as well as the information allowed. Some forms contained so little information that no attempt was made to generalize about the system.

An analysis of the survey forms revealed nonconformance with the South Dakota criteria pertaining to individual and small on-site wastewater systems. The most common problems were:
- absorption area too close to a well or cistern (5 systems);
- absorption area too close to the lake (2 systems);
- absorption area too close to buildings (2 systems);
- septic tank too close to a well or cistern (3 systems); and
- septic tank too close to the lake (2 systems).

Other problems included; drainfield being too deep, absorption area having only one drain line, lot size requirements, and the presence of privys or cesspools.

Task 16 - Sanitary District Formation.

A number of approaches to this issue were discussed, including the formation of a sanitary district and eventual construction of a sewer system. During the September, 1991 meeting of the Richmond Lake Association, a steering committee was established. The committee was to determine sanitary district boundaries, administer a petition for district formation and schedule an election to form the district.



Photograph 8. Outhouse near lake shoreline.

The establishment of a sanitary district would enable the lake area residents to complete the lake restoration activities not funded through Section 319 or USDA programs. A sanitary district is eligible to apply for assistance from other State and federal funding sources to construct a sewer system. During September of 1992, trustees were elected for the newly formed Richmond Lake Sanitary District. The District then hired an engineering firm to complete a feasibility study. This study will determine an estimated cost for the construction of a sewer system for the Richmond Lake area. The District is now investigating different financing options and funding sources to help with project costs. This effort will compliment the work done under the Richmond Lake Water Quality Demonstration Project and help ensure a clean lake.

VIII. OBJECTIVE 4 - PROJECT ASSESSMENT

Project assessment is a critical element of any project. The assessment not only provides a measure of project success or failure, it also provides guidance for other projects in the developmental stage. The Richmond Lake Water Quality Demonstration Project used three methods of project assessment.

Assessment Methods.

The first method consisted of quantifying the actual accomplishments of the project tasks. Measurements such as acres of BMPs implemented, number of animal waste management systems installed, length of shoreline stabilized, etc. can provide a general measure of project success.

The second method of assessment was based upon the Agricultural Nonpoint Source (AGNPS) computer model (Young 1986). This relatively complex model predicts sediment and nutrient yields from 16.2 hectare (40-acre) cells within a watershed. The watershed is divided into 16.2 hectare cells and a number of different physical and environmental factors are determined for each cell. The widely accepted Universal Soil Loss Equation is used in the model to estimate sediment and nutrient yield from each cell. The model also has the capability to take into account drainage patterns and estimate sediment and nutrient yields of cells draining to the lake. Two model runs were executed, one prior to BMP implementation and one after BMP implementation. In this way, the relative effect of BMP implementation on sediment and nutrient yields was assessed. A detailed report of this analysis was written by DENR, May, 1994 and titled "Agricultural Nonpoint Source (AGNPS) Analysis of the Richmond Lake Watershed, Brown County, South Dakota".

The third assessment method was based on water quality monitoring. The purpose of this monitoring was to document changes in the water quality of Richmond Lake due to project implementation.

Four sampling sites were established in the lake (Figure 4). Water samples were collected from the lake surface each month during the project (Photograph 9). Parameters collected or measured in the field included: water and air temperature, pH, Secchi disk transparency, water depth and color, and ice cover. Unusual circumstances were noted by the personnel and visual observations included: wind, odor, precipitation, septic conditions, dead fish, surface water film, and turbidity.

Water samples were analyzed by the EPA certified South Dakota State Health Laboratory and used accepted methodologies. The following parameters and methods were used during the analyses.

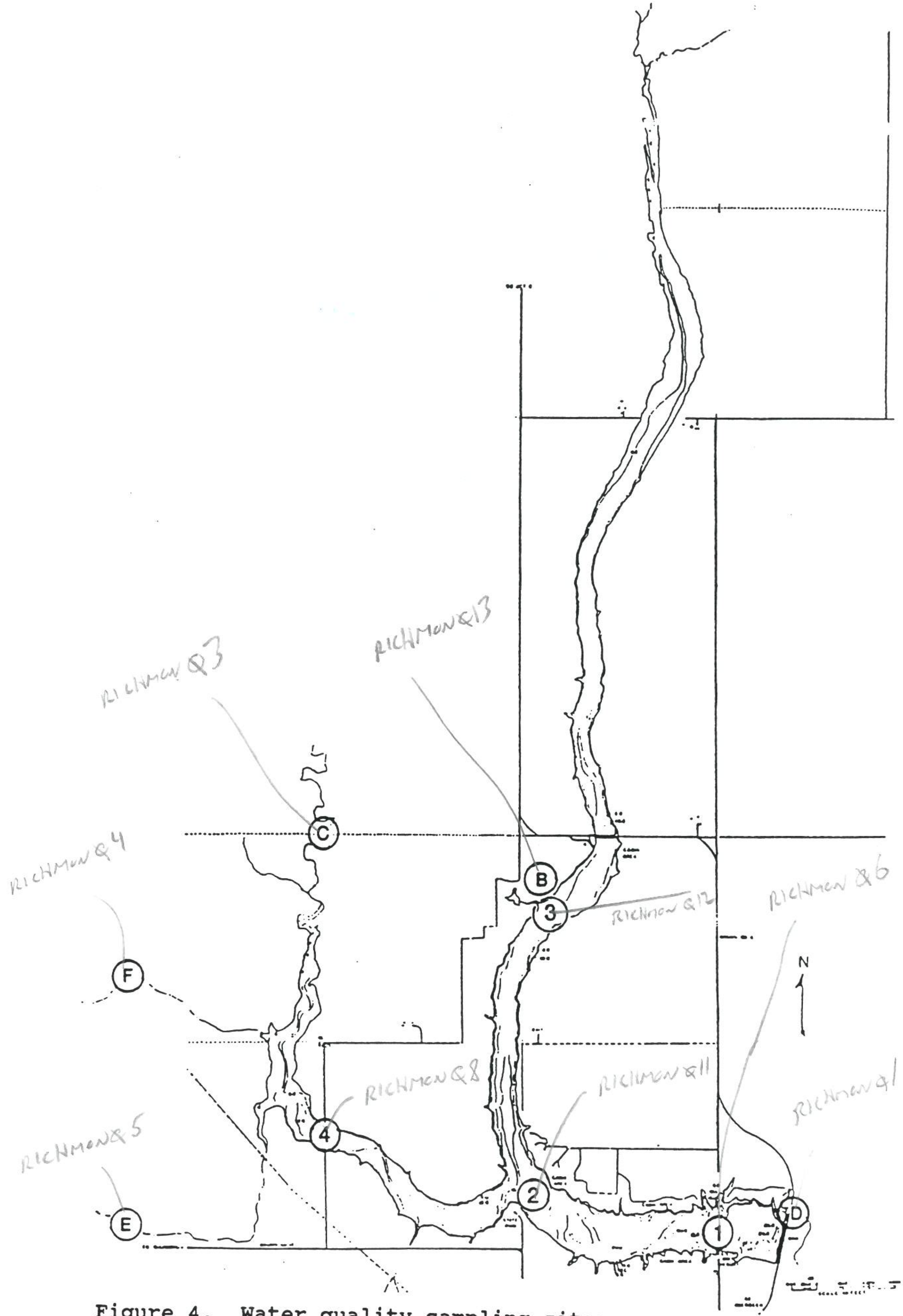


Figure 4. Water quality sampling sites.

Photograph 9. Water quality sampling at Richmond Lake.

Parameter	Method	Reference
Total phosphorus	Persulfate digestion	EPA (1983)
Total Dissolved Phosphorus	Filtered persulfate	EPA (1983)
Nitrate-N	Automated Cd reduction	APHA (1980)
Nitrite-N	Automated Cd reduction	APHA (1980)
Ammonia-N	Automated phenolate	APHA (1980)
Kjeldahl Nitrogen	Semi-automated block	EPA (1983)
Total Suspended Solids	Evaporation @ 180 C	APHA (1980)
Total Dissolved Solids	Evaporation	APHA (1980)
Fecal Coliform Bacteria	Membrane filter	APHA (1985)

To determine the effectiveness of AWMS for improving water quality, four systems were initially chosen as sampling areas. At each area, water samples were to be collected upstream and downstream from the AWMS and nutrient loadings calculated from flow and water quality data. However, the AWMS that were constructed were mostly located adjacent to the lake rather than adjacent to inflowing streams and they did not lend themselves to "upstream/downstream" sampling. These areas often did not have well defined channels that could be monitored for water flows. Consequently, only one site was located at these AWMS to monitor water quality (Figure 4). Sites B and F were located on tributaries where AWMS were implemented and sites C and E were located on tributaries still having untreated feeding operations. Additional grab samples were collected if deemed appropriate. Field parameters included: water and air temperature, pH, and water color. Other worthy observations were noted. The water samples were analyzed by the South Dakota State Health Laboratory for the following parameters (the previously mentioned analytical methods and references are the same for these parameters).

Total Phosphorus
Nitrate-N
Ammonia-N
Total Suspended Solids
Fecal Coliform Bacteria
Total Dissolved Phosphorus
Nitrite-N
Kjeldahl Nitrogen
Total Dissolved Solids

Quality assurance procedures were performed by personnel from DENR in accordance with the South Dakota Nonpoint Source Management Program Quality Assurance Plan.

Task 17 - General Assessment.

The first assessment method was to compare the project accomplishments to the original project goals. The original goals included:

- construction of 10 AWMS;
- placement of 12,802 meters (42,000 feet) of fencing for livestock exclusion;
- development of 14 alternative watering facilities;
- stabilization of 213 meters (700 feet) of shoreline;

- treatment of 1,012 hectares (2,500 acres) of cropland; and
- the resolution of the septic system issue.

At the conclusion of the project the following results were obtained.

- 6 out of 10 AWMS were constructed, one was determined not to need an AWMS, and one ceased operation;
- 4,877 meters of exclusion fencing out of 13,106 planned;
- 3 out of 14 alternative watering facilities installed;
- 697 meters of rip-rap placed out of 213 meters planned, 2,412 meters were also treated with tree plantings;
- 1,214 hectares of cropland treated out of 1,012 hectares planned; and
- a sanitary district was formed and consulting firm hired to estimate costs for a sewer system.

The above accomplishments must be considered a success. The BMP implementation was a voluntary effort and although the project goals were fairly realistic, changes in landowner attitudes can cause a project to fail or succeed. In this project, all of the project participants were willing to adapt to changing conditions and attitudes. The livestock exclusion fencing was not very acceptable to local landowners because of maintenance concerns but the CRP Program proved to be widely popular. Construction of AWMS were relatively successful and much more shoreline was treated than was planned. Such is the nature of this kind of project and it shows how flexibility with a project's tasks can still result in an effective nonpoint source pollution control project.

Task 18 - Agricultural Nonpoint Source (AGNPS) Computer Model.

The Agricultural Nonpoint Source (AGNPS) computer model was used to assess the effectiveness of selected BMPs in having an impact on sediment and nutrient loads from the watershed. This model was first used during the Lake Study to prioritize areas in need of treatment. The model was used a second time to assess the implementation effort. A more detailed report of the second effort can be found in a DENR report prepared after the BMPs were implemented (DENR 1994).

AGNPS uses a watershed that is separated into a 16.2 hectare cell grid (Figures 5 and 6). The model predicts runoff volume and peak rate, eroded and delivered sediment, nitrogen, phosphorus and chemical oxygen demand for a single storm event for all 16.2 hectare cells. The model is cumulative in that the pollutants are routed in a cell-wise fashion that mimics the direction that the runoff would have. A number of computer "runs" were conducted to determine sediment and nutrient loads to Richmond Lake as well as to determine the effect of CRP and AWMS on sediment and nutrient loads. This project made no attempt to verify the model's results with measured "field" data because of the difficulty in getting reliable water flow data from the tributaries. However, it was

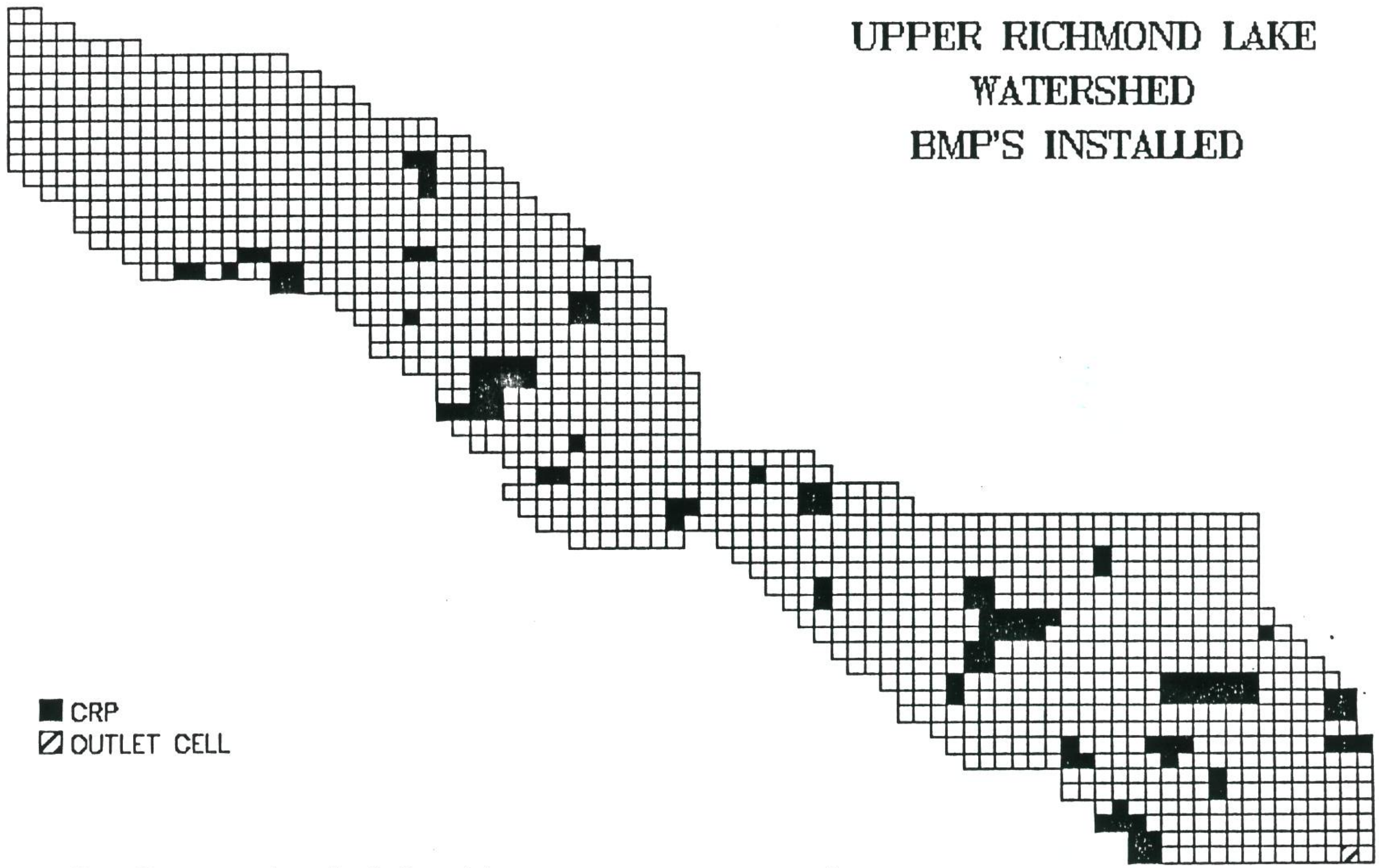


Figure 5. Upper watershed locations of acres placed into CRP for the AGNPS computer model.

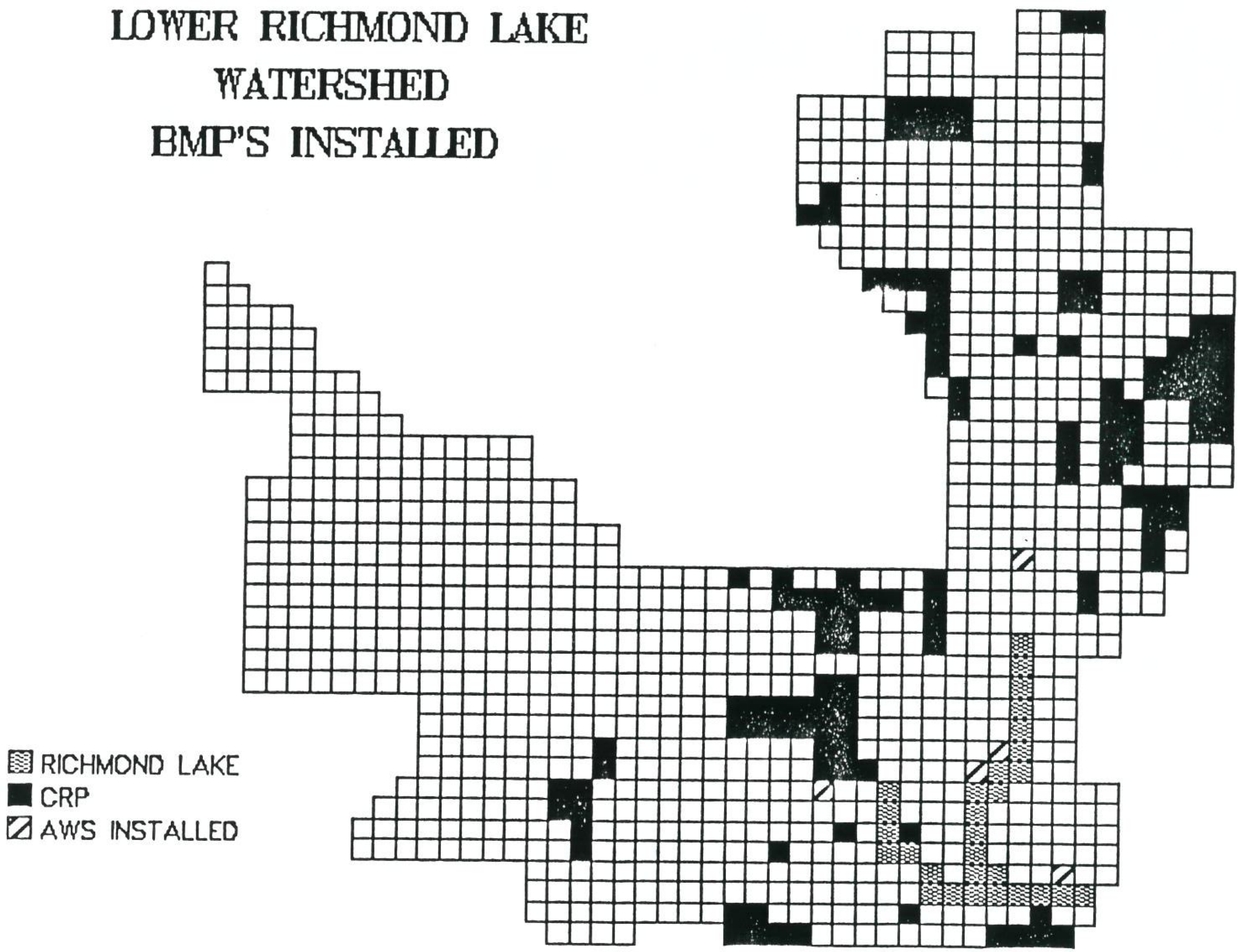


Figure 6. Lower watershed locations of CRP and AWMS for the AGNPS computer model.

felt that the model's results could still provide a reasonable approximation of the effects of BMP implementation on nutrient and sediment loads.

The results indicated that most of the sediment and about 20% of the nutrient loading to the lake originated in cells that were about 2.4 kilometers (1.5 miles) or less from the lake. This is due to the flatter terrain in the upper portions of the watershed and the fact that most of this area is grassland or managed pasture land. The feedlots close to the lake also had a significant impact on nutrient loads. Sediment loading from the feedlots appeared to be negligible. The number of critical cells within 2.4 kilometers of the lake compared to the total number of critical cells in the watershed are indicated below.

pollutant type	near lake critical vs. total critical
critical erosion rates	31 out of 34 cells (91%)
critical nitrogen load	4 out of 20 cells (20%)
critical phosphorus load	4 out of 21 cells (19%)
feedlots	8 out of 9 cells (89%)*

* one feedlot near the lake was inadvertently omitted from analysis.

AGNPS runs were also made to estimate the reduction in sediment and nutrient loads as a result of the CRP and AWMS implemented during the project. A total of 234 cells were converted to CRP, 128 in the upper watershed (12%) and 106 in the lower watershed (8.5%). Six of the ten critical feedlots in the lower watershed had AWMS installed (one was inadvertently omitted from the AGNPS analysis).

The BMPs (CRP plus AWMS) appeared to reduce sediment loads to the lake by 162,386 kilograms/year (179 tons/year), a 5.5% reduction for annual loading. Reductions of 5.7% and 6.5% were obtained for 5-year and 25-year storm events as well. Nitrogen loadings to the lake were reduced by 1,087 kilograms/year (1.2 tons/year) (5.5% reduction) for annual loading, by 6.0% for a 5-year storm event and by 5.9% for a 25-year storm event. Phosphorus loadings to the lake were reduced by 1,087 kilograms/year (1.2 tons/year) (14.6% reduction) for annual loading, by 6.6% for a 5-year storm event and by 6.4% for a 25-year storm event.

These results are positive but probably not great enough to have a large impact on the algal populations in the lake. The Lake Study indicated that at least a 50% reduction in phosphorus loading is needed to get the loading down to what Vollenweider (1968) considers "dangerous", the level at which a lake may become eutrophic. The AGNPS model predicted about a 15% reduction after BMP installation.

Nitrogen loadings were not considered a problem during the Lake Study and so any reductions as a result of BMP implementation become more of a "protective" reduction rather than a "restorative" reduction.

The AGNPS model predicted a 5-6% reduction in sediment loading after BMP implementation. This is a positive result but it is not known how much of an impact this will have on the lake. In the long term, the reduction should be significant since the sediment is cumulative in the lake.

One factor that the AGNPS model did not account for was fecal coliform bacteria. The beach at the State Park was often closed because of high bacteria counts. After BMP installation, it was noted that the number of beach closures were eliminated. This was presumably due to the installation of AWMS at those feedlots close to the lake.

The AGNPS model did not take into account the effects of shoreline stabilization, livestock exclusion, and other conservation practices. These undoubtedly had an impact on sediment and nutrient loading to the lake but no attempt was made to quantify their impacts.

Task 19 - Water Quality Monitoring.

The results from the water quality monitoring are presented and summarized in the Appendix.

Although no nutrient or sediment loads were determined for the lake tributaries, there were enough in-lake water quality data to assess the lake throughout the project and to compare these data to "pre-implementation" data from previous studies.

Table 3 presents mean values for selected parameters during the summer months prior to and during project implementation. Care should be taken when comparing these data because slight variations in sample collection times and numbers but it was felt that this comparison may still provide useful information. These data, however, suggest that no significant changes have occurred relative to total phosphorus, total nitrogen, and Secchi transparency because of the Lake Restoration Project. The data did show some differences between the 1970's and 1980's but these decades were both during pre-implementation project times and no explanation was attempted.

Although historical data for beach closures are no longer available, the lake was closed for most direct contact activities for a number of days during 1985 because of a toxic algae bloom. In addition, the beach at the State Park was closed for approximately 90 days during 1986 because of high fecal coliform bacteria counts. These closures directly led to the Richmond Lake Diagnostic/Feasibility Study and subsequently the 319 Lake

TABLE 3. MEAN SUMMER CONCENTRATIONS OF SELECTED PARAMETERS FOR RICHMOND LAKE.

	1974	1979	1987	1988	1989	1991	1992	1993
SECCHI TRANSPARENCY (M)	1.8	1.6	0.6	0.4	0.5	0.5	0.8	0.5
TOTAL PHOSPHORUS (Mg/L)	0.22	0.22	0.15	0.09	0.16	0.26	0.17	0.15
TOTAL NITROGEN (Mg/L)	2.1	1.55	1.62		1.44	2.36	1.26	1.62

Data from 1974 taken from USEPA (1977)
Data from 1977 taken from Koth (1981)
Data from 1987-1989 taken from DWNR (1990)
Data from 1991-1993 taken during implementation project

TABLE 4. SELECTED TROPHIC STATE VALUES FOR LAKES IN THE JAMES RIVER BASIN.

TOTAL PHOSPHORUS	1989	1991	1992	1993
HIGHEST ATTAINED TSI VALUE	110.2	112.1	103	106
RICHMOND LAKE TSI VALUE	77.4	81.9	72	81.5
MEAN TSI VALUE JAMES RIVER BASIN LAKES	87.7	90	90	91.5
LOWEST ATTAINED TSI VALUE	67	67	70.8	69

SECCHI TRANSPARENCY	1989	1991	1992	1993
HIGHEST ATTAINED TSI VALUE	82.8	83.9	70.9	69.4
RICHMOND LAKE TSI VALUE	69.8	63.6	56.8	51.9
MEAN TSI VALUE JAMES RIVER BASIN LAKES	64.6	63.5	59.8	51.8
LOWEST ATTAINED TSI VALUE	54.5	55.1	48.3	37.2

Restoration Project. It should be noted that no beach closures have occurred since the Restoration Project began. Fecal coliform bacteria counts have remained at low levels (10/100 ml) throughout the Restoration Project. It is thought that the new animal waste management systems adjacent to the lake are the cause of the decreased fecal coliform bacteria counts. However, there is still much local interest about the source of the bacteria and the lakeside residents are looking into means to more effectively treat wastes from their homes and summer cottages.

A comparison of Richmond Lake trophic state index data to those from lakes within the same river basin (the James River Basin) is given in Table 4. Richmond Lake appears to be about average for lakes in this river basin. Although only one "pre-implementation" year was available for this comparison, it is interesting to note that the rank of Richmond Lake compared to the other lakes has remained about the same prior to and after implementation activities begun; the lake has about average water quality conditions for lakes in the basin.

Given the general lack of tributary flows during the project (except during 1993), few samples were taken (see the Appendix). No water quality criteria exceedences for ammonia, nitrates, dissolved solids, or suspended solids were detected at the tributary sites during 1992 and 1993. However, sites C, F, and A continued to have relatively high phosphorus concentrations. In addition, relatively high numbers of fecal coliform bacteria were present at sites B, F, and A during 1993 (over 1000/100 ml). There is no fecal coliform bacteria criterion for these tributaries but these results indicate that there is still a potential source for fecal coliform bacteria and/or nutrients in the watersheds of these tributaries. If the low in-lake levels obtained during the project continue over the next few years, it is likely that no further work needs to be done with the remaining feedlots in the watershed even though some high bacteria counts are noted in the tributaries.

IX. PROJECT INSIGHTS, CONCLUSIONS AND RECOMMENDATIONS

The Richmond Lake Water Quality Demonstration Project produced many insights into how to develop and implement a successful project. The following points were were probably the most important for the success of the project.

1. CLEARLY IDENTIFIED WATER QUALITY PROBLEM.

The Diagnostic/Feasibility Study completed for Richmond Lake was extremely useful in determining water quality problems and the causes of those problems. Phosphorus was identified as a problem for the lake. This parameter was difficult to relate to particular beneficial uses even though it is a widely used and understood. However, empirical models exist that relate phosphorus concentrations and/or phosphorus loadings to general lake condition (trophic state). Phosphorus loading reductions were then put in the context of a project goal related to trophic state and specific project tasks were formulated with phosphorus reductions in mind.

Fecal coliform bacteria counts were also very important and were the basis for beach closures at the State Park. Here was an example where a beneficial use (swimming) could be directly related to a metric (fecal coliform bacteria count and water quality criterion) and specific tasks were formulated to reduce bacteria counts. AWMS and livestock exclusion proved to be effective in reducing bacteria counts in the lake.

Documentation of the water quality problem was also very important for convincing local residents that a problem really exists. Local residents may be so inured to poor water quality conditions that they begin to believe that the lake condition is normal. Beauty may be in the eye of the beholder but a proper scientific assessment can make believers out of many people, including local residents.

Other NPS pollution control projects should make every effort to complete a detailed assessment of their waterbody to document the water quality problems, and the causes and sources of those problems.

2. MEETINGS.

Meetings are critical for a successful NPS pollution control project. At Richmond Lake there were two opposing groups of local people: the farmers who thought that the lakeside homeowners were causing all of the problems; and the lakeside homeowners who thought that the farmers were the cause of all the problems. Although they still maintained a certain level of animosity towards each other throughout the project, the project meetings enabled everyone to express their opinion and discuss the project goals and specific tasks. These meetings were very informative to the local people and kept everyone involved with the project up to date.

3. IDENTIFY ATTAINABLE PROJECT GOALS.

Projects must have goals that are reasonable, attainable and affordable. Every effort should be made to base project goals on proper scientific data as well as public input. The best developed plans can be wasted if local citizens aren't willing to implement them. This project was fortunate because it had a completed D/F Study to base its goals on. The SCS Hydrologic Unit planning process was also being promoted at that time. This process uses public input to develop goals for a particular watershed (hydrologic unit) and so the Richmond Lake Project had both a scientific study and a public input process to use in developing its goals and tasks.

It is also advantageous to get as much technical expertise involved as possible when developing a project plan. The SCS, DENR, and the CES were instrumental in developing the project goals and tasks and they were able to explain specific workplan items with the public.

4. COOPERATION.

The Richmond Lake Project was a success because everyone was willing to cooperate and work towards the project goals. Agency "turf battles" did not exist and the project provided more than enough opportunity for each agency to become involved and use their particular expertise.

Cooperation was also necessary for the local people. Through the many project meetings, the local operators realized that this project was geared towards them and controlling NPS pollution from their lands. A separate effort would be necessary for the lakeside homeowners. Because of their cooperation, the operators must be given credit for the success of this project. However, the lakeside homeowners must also be given credit for developing a sanitary district and looking into costs for a sewer system.

5. BUDGETARY CONSIDERATIONS.

Nonpoint source pollution control projects are often expensive and every effort should be made to seek financial assistance. This project was very successful in obtaining financial assistance. Not only did the project sponsor secure a Section 319 grant but it also acquired funding from the SCS, the ASCS, the State Conservation Grant Fund, the State Consolidated Water Facilities Construction Fund, the South Dakota Department of Game, Fish & Parks, and the James Water Development District. There are many funding sources available and one must be opportunistic and make the effort to seek them out.

Project planners must also be aware of inflation and the possibility of unforeseen costs. Be realistic when developing a project budget but also be willing to quickly secure additional funding if necessary.

6. PERSONNEL.

Dedicated personnel are necessary for a successful project. This project relied on local people for project coordination and local construction firms for actual construction of AWMS, shoreline rip-rap and watering facilities. It is important that the project stay as a "local" project because the local people are naturally more trusting of someone from their area. Project involvement is greater because of this.

7. FLEXIBILITY.

This project began with some relatively realistic goals and tasks but it soon became evident that the local people had the final say for implementing the project tasks. The local people did not want to exclude livestock from the lake by fencing. Many felt that the fencing would be too difficult to maintain and others felt that the livestock had a right to the lake for watering (the lake is assigned the beneficial use of livestock watering). The AWMS construction was moderately successful with six AWMS built out of ten planned. The lake shoreline, however, was in need of more stabilization than was originally planned and the CRP Program proved to be popular with many people.

Such alterations in a project's tasks may lead one to conclude that the project did not succeed. This was not the case and in fact, the project was considered a success. One should not confuse project tasks with project goals. There appears to be some flexibility in changing project tasks while still attaining the project goals. Project personnel should be made aware of this and be willing to alter project tasks if necessary.

X. POSTSCRIPT

The Richmond Lake Water Quality Demonstration Project is over but the effort to keep the lake clean is a continuous process. A Sanitary District has been formed and is looking into treatment system designs and costs. The informational effort in the watershed has brought an awareness to the local operators about water quality and their influence upon the lake. This awareness, combined with existing technical and financial assistance programs, will help them manage their lands and benefit their own operations as well as for the benefit of the lake.

XI. LITERATURE CITED

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APPENDIX

WATER QUALITY DATA

RICHMOND LAKE WATER QUA 1990
ALL CONCENTRATIONS IN MG/L,SECCHI DEPTH IN INCHES,TEMP IN C,FECAL COLI IN #/100ML

SITE	DATE	TIME	SAMPL	DEPTH	WTEM	ATEM	FLOW	SDISK	FLD_P	FCOLI	LAB_PH	TSOL	TDSOL	TSSOL	AMMO	Un-ion AMMO	NO32N	TKN_N	TPO4P	DPO4P
1	5-Nov-90	1045	SURF		5.0	-		24	7.9	2	8.28	529	519	10	0.4	.0097	0.4	1.33	0.234	0.170
1A	5-Nov-90	1125	SURF		3.0	-		30	8.3	2	8.25	532	520	12	0.39	.0072	0.4	1.32	0.231	0.166

RICHMOND LAKE WATER QUA 1991
ALL CONCENTRATIONS IN MG/L,SECCHI DEPTH IN INCHES,TEMP IN C,FECAL COLI IN #/100ML

SITE	DATE	TIME	SAMPL	DEPTH	WTEM	ATEM	FLOW	SDISK	FLD_P	FCOLI	LAB_PH	TSOL	TDSOL	TSSOL	AMMO	Un-ion AMMO	NO32N	TKN_N	TPO4P	DPO4P
1	4-Mar-91	1115	SURF		0	4.4		-	-	2	8.94	545	541	4	-		0.1	1.44	0.075	0.034
1	23-Apr-91	-	SURF		10	7.2		37	7.4	2	8.19	542	540	2	0.16	.0046	0.1	1.04	-	-
1	29-May-91	1515	GRAB		22	25.6		84	6.4	2	8.39	576	548	28	0.06	.0062	0.1	0.64	0.058	0.054
1	11-Jun-91	1130	GRAB		26	26.7		29	7.4	2	8.47	573	555	18	0.11	.0178	0.7	1.12	0.119	0.081
1	23-Jul-91	1130	GRAB		29	27.8		30	-	10	8.77	575	551	24	0.02	.0064	0.5	2.13	0.21	0.078
10	23-Jul-91	1130	NRDA		27	27.8		24	-	40	8.8	558	548	10	0.02	.0058	0.5	2.14	0.207	0.098
11	23-Jul-91	1145	NRDA		27	26.7		24	-	10	8.84	560	546	14	0.02	.0058	0.5	2.32	0.424	0.071
1	8-Aug-91	1200	GRAB		30	23.9		-	-	10	8.66	580	554	26	0.28	.0805	0.8	1.28	-	-
1	10-Oct-91	1300	GRAB		14	10		30	-	-	8.25	-	-	-	0.04	.0015	0.5	0.88	-	-
1	18-Nov-91	1030	GRAB		0	3.3		-	-	10	8.65	613	593	20	0.02	.0006	0.2	1.04	0.092	0.064
1	9-Dec-91	1330	GRAB		0	4.4		-	-	2	8.56	619	617	2	0.08	.0025	0.2	0.86	0.119	0.078
1	30-Dec-91	1145	GRAB		0	2.2		42	-	2	8.44	648	646	2	0.16	.0033	0.2	1.43	0.149	0.143
2	10-Jan-91	1205	SURF		0	5		-	7.8	2	8.37	629	622	7	0.25	.0051	0.1	1.65	0.115	-
2	13-Feb-91	1230	SURF		0	1.7		-	6.8	2	7.93	543	541	2	0.24	.0016	0.1	1.15	0.088	-
2	23-Apr-91	-	SURF		10	7.2		25	7.6	2	8.09	588	586	2	0.16	.0037	0.1	0.95	0.098	0.054
2	29-May-91	1445	GRAB		22	23.9		36	6.6	2	8.38	564	542	22	0.08	.0083	0.1	0.71	-	-
2	11-Jun-91	1100	GRAB		26	26.7		36	7.5	2	8.25	567	549	18	0.13	.0115	0.7	1.83	-	-
2	23-Jul-91	1030	GRAB		28	26.7		24	-	10	8.77	569	549	20	0.02	.0061	0.5	1.92	0.214	0.119
2	8-Aug-91	1200	GRAB		30	23.9		30	-	10	8.66	600	568	32	0.28	.0805	0.8	1.44	-	-
2	10-Oct-91	1230	GRAB		14	10		24	-	-	8.25	615	593	22	0.03	.0012	0.5	0.94	-	-
3	23-Apr-91	-	GRAB		10	7.2		22	7.6	2	8.17	590	586	4	0.13	.0037	0.1	1.03	0.108	0.108
3	29-May-91	1430	GRAB		20	23.9		24	6.9	2	8.32	582	550	32	0.07	.0051	0.1	0.64	0.088	0.085
3	11-Jun-91	1200	GRAB		26	26.7		24	7.2	2	8.24	562	550	12	0.11	.0097	0.7	1.18	-	-
3	23-Jul-91	1100	GRAB		28	26.7		18	-	10	8.51	567	543	24	0.13	.0237	0.5	1.14	0.23	0.136
3	8-Aug-91	1130	GRAB		30	23.9		12	-	10	8.57	601	563	38	0.29	.0704	0.7	1.37	0.342	0.332

Un-ion

SITE	DATE	TIME	SAMPL	DEPTH	WTEM	ATEM	FLOW	SDISK	FLD_P	FCOLI	LAB-PH	TSOL	TDSO	TSSO	AMMO	AMMO	NO32	TKN-N	TPO4P	DPO4P
3	10-Oct-91	1300	GRAB		14	10		22	-	-	8.21	622	600	22	0.06	.0023	0.5	0.97	-	-
3	18-Nov-91	1030	GRAB		0	3.3		-	-	10	8.69	456	446	10	0.03	.0012	0.2	0.96	0.074	0.074
3	9-Dec-91	1400	GRAB		0	4.4		-	-	2	8.92	624	620	4	0.02	.0012	0.1	0.86	0.073	0.066
3	30-Dec-91	1111	GRAB		0	2.2		-	-	2	9.04	674	672	2	0.02	.0015	0.1	1.15	0.096	0.037
4	23-Apr-91	-	GRAB		10	7.2		16	7.1	2	8.16	613	605	8	0.14	.0040	0.1	0.98	0.122	0.051
4	29-May-91	1400	GRAB		20	23.9		18	6.9	8	8.16	576	532	44	0.15	.0089	0.1	0.74	-	-
4	11-Jun-91	1230	GRAB		26	26.7		24	7.2	2	8.25	567	547	20	0.11	.0097	0.7	1.04	-	-
4	23-Jul-91	1000	GRAB		28	26.7		12	-	90	8.89	601	555	46	0.02	.0072	0.5	1.91	0.302	0.129
4	8-Aug-91	1100	GRAB		30	23.9		12	-	10	8.77	619	561	58	0.19	.0640	0.7	3.46	-	-
4	10-Oct-91	1200	GRAB		15	8.9		20	-	-	8.39	620	594	26	0.02	.0013	0.4	0.86	0.186	0.186
B	29-May-91	1300	STREA	GFEED	-	-	YES?	-	-	10	7.83	2660	2572	88	5.5	.1345	0.1	11.65	7.46	7.22
A	03-Jun-91	1030	STREA	INGER	24	26.7	YES?	-	7.4	10	7.65	596	590	6	0.1	.0021	0.1	1.17	-	-
C	03-Jun-91	1100	STREA	ESKE	26	29.4	YES	-	7.7	10	7.99	2104	2088	16	0.07	.0040	0.1	1.22	0.515	0.502
D	20-Jun-91	1445	STREA	NRDA	25	28.9	NO	-	7.7	2	7.69	741	677	64	0.29	.0080	0.6	2.01	0.698	0.671
H	24-Jul-91	1345	STREA	DMOU	30	26.7	YES?	-	-	50	8.14	621	601	20	0.02	.0018	0.5	2.35	0.197	0.098
E	03-Jun-91	1000	STREA	LEROY	26	26.7	YES	-	7.7	10	7.6	721	719	2	0.03	.0007	0.1	1.62	-	-
E	20-Jun-91	1330	STREA	LEROY	25	28.9	YES	-	7.5	2	7.65	615	597	18	0.11	.0024	0.6	1.44	1.32	1.27
E	24-Jul-91	1330	STREA	LEROY	30	26.7	NO?	-	-	10	8.43	882	828	54	0.02	.0034	0.5	1.44	-	-
F	20-Jun-91	1430	STREA	SOESK	25	28.9	YES	-	7.7	2	7.69	590	574	16	0.05	.0014	0.6	1.3	1.39	1.32

RICHMOND LAKE WATER QUA 1992

ALL CONCENTRATIONS IN MG/L,SECCHI DEPTH IN INCHES,TEMP IN C,FECAL COLI IN #/100ML

SITE	DATE	TIME	SAMPL	DEPTH	WTEM	ATEM	FLOW	SDISK	FLD_P	FCOLI	LAB-PH	TSOL	TDSO	TSSO	AMMO	Un-ion AMMO	NO32	TKN-N	TPO4P	DPO4P
1	28-Jan-92	1030	GRAB		0	-3.9		-	-	2	8.23	698	696	2	0.19	.0025	0.2	1.62	0.186	0.163
1	26-Feb-92	1330	GRAB		0	4.4		-	-	2	9.06	531	503	28	0.02	.0019	0.1	2.38	0.339	0.133
1	29-Apr-92	-	GRAB		-	-		-	-	10	8.47	631	622	9	0.21	.0145	0.1	0.83	-	-
1	11-Jun-92	1330	GRAB		22	29.4		54	-	10	8.65	663	659	4	0.57	.0881	0.1	1.08	-	-
1	14-Jul-92	-	GRAB		26	26.7		41	-	2	8.55	650	640	10	0.02	.0039	0.1	1.03	0.083	0.07
1	26-Aug-92	1430	GRAB		25.5	21.1		36	-	10	8.59	747	733	14	0.04	.0076	0.1	1.07	0.209	0.183
1	20-Sep-92	1500	GRAB	20	20	29.4		54	-	-	8.8	659	645	14	0.02	.0040	0.1	0.97	0.179	0.169
1	21-Oct-92	1330	GRAB	15	12	21.1		46	-	10	8.75	702	692	10	0.07	.0085	0.1	1.2	-	-
1	28-Dec-92	1130	GRAB	15	0	-12		-	-	10	8.32	714	711	3	0.02	.0003	0.1	0.86	-	-
2	29-Apr-92	-	GRAB		-	-		-	-	10	8.46	634	625	9	0.25	.0173	0.1	0.43	-	-
2	11-Jun-92	1345	GRAB		22	27.8		50	-	10	8.68	688	663	5	0.06	.0112	0.1	0.86	-	-
2	14-Jul-92	-	GRAB		26.7	26		30	-	2	8.71	669	658	11	0.02	.0049	0.1	1.18	0.086	0.06

Un-ion

SITE	DATE	TIME	SAMPL	DEPTH	WTEM	ATEM	FLOW	SDISK	FLD_P	FCOLI	LAB-PH	TSOL	TDSO	TSSO	AMMO	AMMO	NO32	TKN-N	TPO4P	DPO4P
2	19-Aug-92	1300	GRAB		24	25.6		-	-	40	8.82	676	652	24	0.11	.0276	0.1	1.19	0.239	0.159
2	26-Aug-92	1400	GRAB		25.6	21.1		12	-	10	8.72	693	647	46	0.02	.0046	0.1	1.55	0.272	0.193
2	23-Sep-92	1440	GRAB	10	20	29.4		48	-	-	8.71	666	646	20	0.02	.0033	0.1	1.08	0.212	0.156
2	21-Oct-92	1338	GRAB	24	12	21.1		36	-	10	8.77	694	686	8	0.04	.0048	0.1	0.95	0.159	0.136
2	12-Nov-92	1430	GRAB	5	4.4	6.7		42	-	-	8.93	705	687	18	0.02	.0017	0.1	0.85	0.103	-
2	28-Dec-92	No record rec																		
3	28-Jan-92	1000	GRAB		0	-3.9		-	-	2	8.48	678	672	6	0.11	.0028	0.2	1.22	-	-
3	26-Feb-92	1305	GRAB		0	4.4		-	-	2	9.11	487	475	12	0.02	.0019	0.1	1.83	0.246	0.106
3	29-Apr-92	-	GRAB		-	-		-	-	10	8.56	636	627	9	0.07	.0060	0.1	0.94	0.169	0.153
3	11-Jun-92	1400	GRAB		22	27.8		43	-	10	8.74	659	648	11	0.28	.0524	0.1	1.01	0.073	0.04
3	14-Jul-92	-	GRAB		23.9	26		14	-	22	8.55	674	634	40	0.46	.0802	0.1	1.03	0.133	0.017
3	26-Aug-92	1330	GRAB		25.6	21.1		24	-	10	8.62	673	651	22	0.48	.0912	0.1	1.23	0.212	0.179
3	30-Sep-92	1330	GRAB	10	20	26.7		18	-	10	8.78	669	653	16	0.02	.0040	0.1	1.08	0.186	0.12
3	21-Oct-92	1355	GRAB		15	21.1		36	-	10	8.69	704	691	14	0.06	.0072	0.1	0.94	-	-
3	12-Nov-92	No record rec																		
3	28-Dec-92	1100	GRAB	10	0	-12		-	-	10	8.57	734	726	8	0.03	.0010	0.1	1.06	-	-
4	29-Apr-92	-	GRAB		-	-		-	-	10	8.44	641	626	15	0.18	.0100	0.1	0.35	0.189	0.08
4	11-Jun-92	1430	GRAB		21	26.7		24	-	10	8.7	695	665	30	0.45	.0770	0.1	0.78	-	-
4	14-Jul-92	-	GRAB		25	23.9		17	-	46	8.44	684	652	32	0.18	.0225	0.1	1.59	0.199	0.046
4	26-Aug-92	1300	GRAB		21.1	21.1		24	-	10	8.95	691	651	40	0.02	.0061	0.1	1.42	-	-
4	30-Sep-92	1400	GRAB	15	20	29.4		36	-	10	8.82	661	651	10	0.02	.0040	0.1	1.41	0.229	0.176
4	21-Oct-92	1415	GRAB	20	12	21.1		48	-	10	8.93	705	681	24	0.02	.0029	0.1	0.98	0.146	0.1
4	12-Nov-92	1500	GRAB	4	3.3	6.7		36	-	-	8.8	738	724	14	0.02	.0013	0.1	1.15	0.139	-
4	28-Dec-92	No record rec																		
5	23-Mar-92	1430	GRAB	SNELS	10	15.6	-	-	-	2	8.63	585	575	10	0.02	.0014	0.1	0.82	0.199	0.153
C	2-Mar-92	1400	STREA	KRAGE	0	7.2	YES	-	-	4	7.23	805	795	10	0.49	.0006	0.6	3.2	1.062	0.763
C	23-Mar-92	1500	STREA	KRAGE	10	15.6	NO?	-	-	2	8.49	720	710	10	0.02	.0011	0.1	2.09	0.584	0.495
E	2-Mar-92	1500	STREA	SOBAN	0	4.4	YES	-	-	10	7.33	311	299	12	0.58	.0010	0.1	2.56	0.83	0.569
B	15-Jul-92	1130	GAUE	OUTL	26	23.9	YES	-	-	5000	7.5	1237	1191	46	0.22	.0042	0.5	2.14	0.631	-

RICHMOND LAKE WATER QUA 1993

ALL CONCENTRATIONS IN MG/L,SECCHI DEPTH IN INCHES,TEMP IN C,FECAL COLI IN #/100ML

SITE	DATE	TIME	SAMPL	DEPTH	WTEM	ATEM	FLOW	SDISK	FLD_P	FCOLI	LAB-PH	TSOL	TDSO	TSSO	AMMO	Un-ion AMMO	NO32	TKN-N	TPO4P	DPO4P
1	25-Jan-93	1000	GRAB	15	0	-12		-	-	10	8.4	769	761	8	0.08	.0016	0.1	1.28	-	-
1	25-Feb-93	1100	GRAB	20	0	-6.7		-	-	-	8.06	807	805	2	0.04	.0004	0.1	1.49	0.145	0.145
1	30-Mar-93	1000	GRAB	7	0	-6.7		-	-	10	9.19	261	253	8	0.02	.0023	0.1	1.75	0.305	0.076
1	29-Apr-93	1030	GRAB	17	8	12.8		-	-	10	8.3	636	623	13	0.02	.0006	0.1	0.96	-	-
1	02-Jun-93	1215	GRAB	20	15	10		17	-	20	8.1	637	613	24	0.06	.0020	0.1	1.55	0.076	0.033
1	23-Jun-93	1040	GRAB	15	18.3	26.7		29	-	10	8.2	651	638	13	0.17	.0091	0.1	1.45	0.063	0.056
1	10-Aug-93	1400	GRAB	20	19.4	31.1		12	-	10	8.3	453	435	18	0.02	.0014	0.3	1.39	0.418	0.372
2	30-Mar-93	0800	GRAB	-	0	-6.7		-	-	10	8.86	235	228	7	0.02	.0012	0.1	2.05	0.295	0.153
2	02-Jun-93	1205	GRAB	20	15	10		18	-	10	8.16	630	608	22	0.07	.0029	0.1	1.59	0.07	0.03
2	23-Jun-93	1100	GRAB	15	18.3	26.7		29	-	10	8.26	649	634	15	0.12	.0080	0.2	1.41	0.06	0.05
2	10-Aug-93	1330	GRAB	20	19.4	29.4		12	-	10	8.18	440	422	18	0.06	.0034	0.3	1.15	0.372	0.322
3	25-Jan-93	1030	GRAB	15	0	-12		-	-	10	8.35	816	811	5	0.08	.0016	0.1	1.38	-	-
3	25-Feb-93	1130	GRAB	15	0	-6.7		-	-	-	8.15	793	791	2	0.02	.0003	0.1	1.54	-	-
3	29-Apr-93	1030	GRAB	10	8	12.8		-	-	10	8.31	523	608	15	0.02	.0006	0.1	0.8	0.116	0.093
3	02-Jun-93	1150	GRAB	12	15	10		17	-	40	8.12	624	598	26	0.03	.0010	0.1	1.62	0.086	0.033
3	23-Jun-93	1100	GRAB	15	18.3	26.7		29	-	10	8.26	651	639	12	0.11	.0073	0.3	1.41	0.083	0.063
3	12-Jul-93	1110	GRAB	14	18.3	15.6		24	-	10	8.23	634	625	9	0.02	.0011	0.4	1.33	0.073	0.053
4	02-Jun-93	1100	GRAB	13	15	10		22	-	10	8.25	662	640	22	0.02	.0008	0.1	1.58	0.08	0.03
4	23-Jun-93	1040	GRAB	18	18.3	26.7		24	-	10	8.31	666	654	12	0.09	.0060	0.1	1.43	0.056	0.056
4	12-Jul-93	1140	GRAB	12	20	16.7		17	-	-	8.29	639	622	17	0.02	.0006	0.3	1.29	0.076	0.033
4	10-Aug-93	1300	GRAB	10	18.9	29.4		12	-	10	8.15	458	428	30	0.02	.0011	0.2	1.32	0.465	0.375
B	6-Apr-93	1030	GAUE	OUTL	4.4	-15	YES?	-	-	1400	7.98	1582	1574	8	0.27	.0032	0.3	0.99	0.096	0.076
C	6-Apr-93	1100	STREA	KRAGE	4.4	-15	YES?	-	-	10	7.92	574	567	7	0.02	.0002	0.1	1.37	0.212	0.202
C	21-Jul-93	1600	STREA	KRAGE	18.3	26.7	YES	-	-	170	7.45	226	212	14	0.02	.0002	0.1	1.51	0.601	0.561
F	21-Jul-93	1530	STREA	ESKES	20	26.7	YES	-	-	1600	7.39	597	417	180	0.02	.0002	0.1	1.61	0.581	0.442
A	27-Jul-93	1430	INLET		-	23.9	YES	-	-	3000	8.09	1019	997	22	0.07	-	0.4	3.18	0.89	0.717
D	27-Jul-93	1445	SPILL	WAY	-	23.9	YES	-	-	10	7.73	549	536	13	0.02	-	0.3	0.97	0.269	0.246

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