Big Shell Lake Community Watershed Management Project

Karen Benjaminson[1], Harvey Filson[1], Len Sinclair [2],
Brenda Thurston[2], Rebecca Kennel[3],

[1]Agriculture and Agri-Food Canada, PFRA, North Battleford, SK.
[2]Saskatchewan Environment and Resource Management, Prince Albert, SK.
[3]Big Shell Lake Watershed Stewardship Association, Shell Lake, SK.

Abstract

A community watershed management initiative, in the Big Shell Lake Watershed, approximately 90 km west of Prince Albert, SK, is helping the local community better understand water quality issues and devise measures to protect and improve water quality. PFRA North Battleford District Office is working in cooperation with the Big Shell Lake Watershed Stewardship Association (BSLWSA), Saskatchewan Water Corporation, Saskatchewan Environment and Resource Management, and Saskatchewan Agriculture and Food to implement the project.

The project focuses on all potential sources of pollution in the watershed. All forms of land use and development will be assessed with regard to their impact on water quality.

Current watershed management activities include: surface water quality monitoring on the lake and creeks; a ground water quality study to assess the environmental impact of two sewage lagoons; a riparian area project to better manage runoff from a cattle winter feeding site; a feasibility study for proposed sedimentation ponds along one creek to deal with nutrient loading from a cattle winter feeding site; and planning for public awareness and education events, including the development of a school program based on project wet.

Introduction

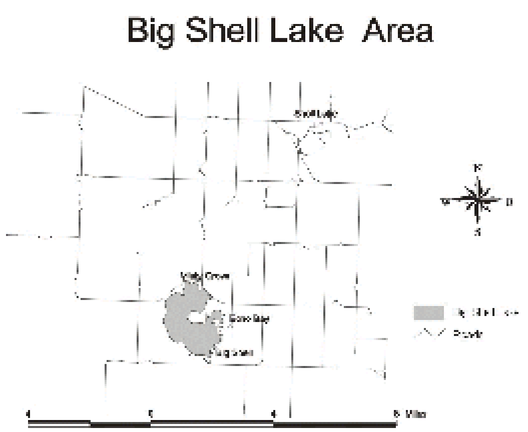
In the winter of 1996, Malcolm Black, PFRA, Regina, authored a proposal to AFIF for a community watershed management project. After AFIF approved the proposal, all District PFRA staff were asked to submit candidate watersheds. The main selection criteria was for a smaller watershed with multiple land use. The Big Shell Lake watershed was selected by AFIF as the first choice for the project.

In January, 1997, PFRA North Battleford set up a meeting with the other government partners to explain the project and find out what involvement the partners would contribute. All agencies appointed technical advisors to the project. By the spring of 1997, a plan was in place to deliver the concept to the Big Shell Lake Community. A series of meetings to present the idea to the community were organized and held in the summer of 1997. Two local people were hired to organize further meetings to help form an association with bylaws, and non-profit corporation status. Community participation included the election of a Board of Directors and the development of the association's mission statement and bylaws. In the fall of 1997, the BSLWSA became a legal entity.

The main focus of the BSLWSA is to act as a stakeholder group to make decisions on how to promote lake and watershed management, the monitoring and identification of water quality issues, the demonstration of various remedial options, and to develop a locally acceptable long term watershed management plan.

Big Shell Lake Watershed Study Area

Several municipal jurisdictions lie within the study area. The Rural Municipalities of: Spiritwood, No. 496; Meeting Lake, No. 466; Leask, No. 464; the Resort Villages of Big Shell and Echo Bay; and the unorganized hamlet of Misty Grove. Each of the Resort Villages have over 170 cottage lots, with a total of over 300 cabins or homes. Most of these residents are seasonal. Each Resort Village also has a garbage dump and sewage lagoon within less than 1 km of the lake. There are approximately 28 farm residences within the watershed. Agricultural land use in the watershed includes annual crop land, tame forage, other grassland and livestock operations. Approximately 33 sections of PFRA's Meeting Lake Community Pasture are within the south-western part of the watershed area. All land in the watershed area that is four or more miles from the lake is under permanent vegetative cover, with hay and pasture being the primary use in addition to wildlife. All annual crop land in the watershed is within a four mile radius of the lake.



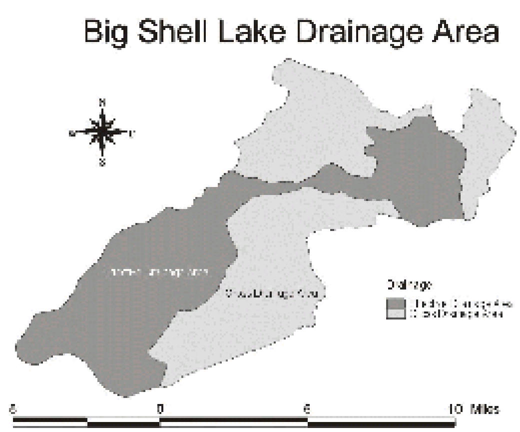


Figure 1. Big Shell Lake Location

Figure 2. Gross and effective drainage areas of Big Shell Lake watershed.

The Big Shell Lake Watershed is within the Boreal Transition Ecoregion. There are 15 soil associations and 30 combinations of soil associations within the watershed. Surface soil textures range from gravelly sand - loam to silty loam - loam. All soils are either Chernozemic Dark Grey or Grey Luvisolic soils. Wind erosion risk in the watershed is low or very low. Water erosion risk ranges from non-erodible to extremely erodible.

Water Quality Issues

Several water quality issues were identified at the start of the project: alteration of the lake's natural shore line (dumping sand, removing aquatic vegetation/weeds), potential impact of cattle on riparian areas, the potential impact of septic systems (leaks), impact of sewage disposal (sites used by septic services), overland flows from lakeshore development that may contain lawn fertilizer and organic wastes, potential impact of runoff from crop land, direct input of materials to the lake from boats (gasoline spills, garbage). Education and awareness activities are a major focus of the BSLWSA to create a local awareness of these potential problems and the remedial measures that could become solutions.

About 325 surveys were sent to residents and cabin owners early in 1999 to determine what the general understanding is of water quality. Thirty-one (9.5%) questionnaires were returned. Most people felt they had a fair to very good understanding of lake water quality and rated the quality of water in Big Shell Lake as fairly good (figure 3). Poor water quality was generally defined as: too much weed and algae growth; lack of clarity; and having a bad odour. Most respondents felt that the following activities have the most negative impact on water quality: lawn fertilizer/chemicals, pet waste, livestock grazing practices, cropping practices/farm chemicals, road salt, erosion, and destruction of vegetation adjacent to the lake. Assuming water quality is threatened, most respondents felt that BSLWSA should focus on the following areas: agricultural and livestock practices, septic tank testing and installation, curb beach development (cabins), and control weed and algae growth (figure 4).

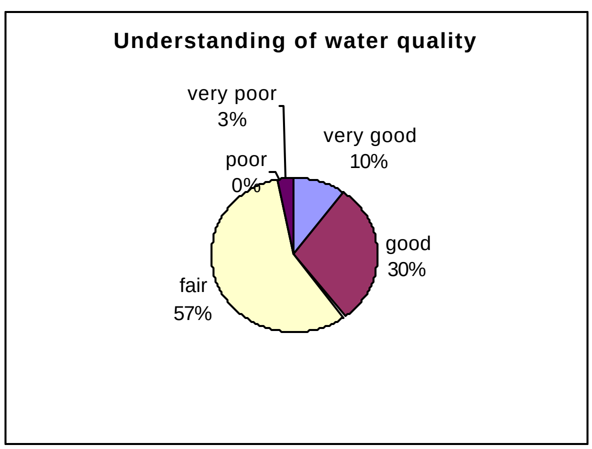


Figure 3. Survey results on participant’s understanding of water quality.

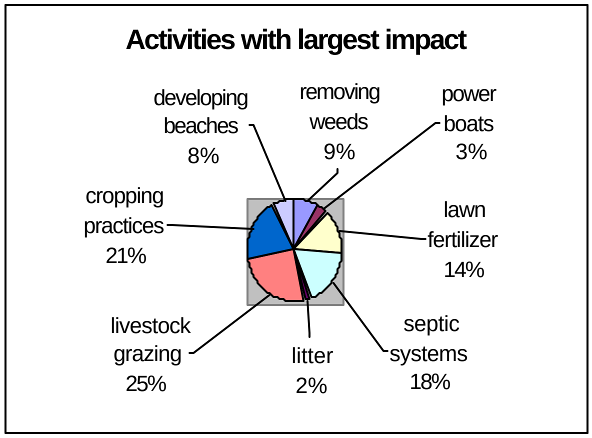


Figure 4. Survey participant's view on activities that have the largest impact on water quality.

Surface Water Quality Monitoring

Surface water quality monitoring on the lake and creeks commenced in 1997. SERM, Prince Albert, designed the monitoring program, provided staff, and paid the analysis costs during 1997. The BSLWSA used part of the AFIF grant to cover water quality analysis costs for sampling in subsequent years. The 1997 results indicated unnatural sources of nutrient inputs into the lake and also identified that internal phosphorous loading from lake sediments is occurring. One focus of the 1999 water sampling program was to find out how significant the internal nutrient loading is in terms of overall nutrient sources identified. This work is now scheduled to take place during 2000.

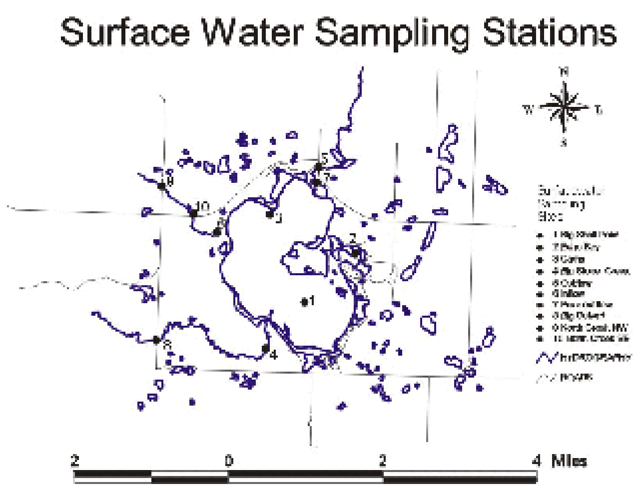


Figure 5. Surface water sampling stations.

Big Shell Lake Water Quality Report 1998

Data that was collected from May 15 to November 3, 1998 will be used in the following sections to describe the general water quality of Big Shell Lake in terms of the Saskatchewan Surface Water Quality Objectives and Municipal Drinking Water Guidelines.

Water Quality

Dissolved Oxygen

Dissolved oxygen is a fundamental requirement for aquatic life, without it there would be no fish or plants. Dissolved oxygen and temperature profiles were conducted on August 5 and 25, 1998 in order to determine the thermal layers of the water column and identify possible oxygen deficit. The data on dissolved oxygen profiles of Station 3 showed that the depth at which dissolved oxygen becomes less than 6 mg/L on August 5, is between 7 and 8 meters. On August 25, at Station 1, the depth at which dissolved oxygen becomes less than 6 milligrams per liter (mg/L), is between 8 and 9 meters. Levels of dissolved oxygen were less than 0.1 mg/L, 2 meters above the sediment-water interface. Saskatchewan Surface Water Quality Objectives recommend "a minimum concentration of 6 milligrams per liter, in order to preserve water quality for the protection of aquatic life."

Station 3 has very little oxygen in the lower half of the water column, despite the cooler temperatures. An anoxic environment is found 2 meters above the sediment-water interface on these sample dates. Several different chemical reactions take place within the sediments when levels of dissolved oxygen fall below 1 mg/L. Phosphorous release from sediments occurs because of these chemical reactions. The decomposition of organic and an association with sediment bound iron are two reactions that can cause phosphorous release. If lake stratification occurs due to wind, phosphorous is released from the lower portions of the lake into the overlying waters. Manganese and iron are also released from the sediments during these anoxic periods which can cause odor problems.

Total Dissolved Solids

The sum of the dissolved ions in water is closely related to the salinity in water and is usually expressed as total dissolved solids (TDS). Salinity of the water is most important with regards to various agricultural uses such as irrigation or livestock watering. TDS values for Big Shell Lake during August 1998 ranged from 273 mg/L to 348 mg/L. These values indicate relatively low salinity and good chemical quality. These salinity levels would not affect any of the expected uses of the water in Big Shell Lake.

Heavy Metals

Levels of heavy metals at all stations were below Surface Water Quality Objectives, and should not interfere with any of the intended uses of the lake.

NUTRIENTS

> *"The nutrients to be sampled in a lake study are those that contribute to plant growth, such as nitrogen and phosphorous. Phosphorous is most often the key nutrient in determining the quantity of algae and other aquatic plants in a lake. In comparison to some of the other nutrients required by aquatic biota, phosphorous is least abundant and commonly the first element to limit biological activity." (Wetzel 183)*

Surface Water Quality Objectives state that "phosphorous or nitrogen or other nutrient concentrations should not be altered from natural levels by discharges of effluents such that nuisance growths of aquatic weeds or algae results".

Total Phosphorous

Total phosphorous is the total sum of organic and inorganic phosphorous. In most lakes, the amount of algae in the water is a function of the amount of phosphorous. This is because phosphorous is in the shortest supply of all the nutrients that lake plants need for growth. When it runs out, the algae population can no longer increase and when the algae dies off the phosphorous is again returned to the water and sediments to be reused. A larger phosphorous supply usually results in more algae and aquatic weed growth.

Subsurface grab samples were taken May 15 and May 20, 1998 at Station 1, 2 and 3. Total Phosphorous levels ranged from 0.04 milligrams per liter (mg/L), to 0.20 mg/L. These concentrations show a high degree of productivity within the lake.

Orthophosphate (PO_4^{-3})

> *"Phosphorous in waters is present in several soluble and particulate forms, including organically bound phosphorous, inorganic polyphosphates, and inorganic orthophosphate. These orthophosphate are usually ions of phosphoric acid. At pH concentrations of most natural water (less than pH 9.0), the dihydrogen and monohydrogen phosphate ions are prevalent, although analytical techniques usually employed do not distinguish between ionic states and all inorganic phosphate is usually considered as PO_4^{-3}." (Lind 64)*

Orthophosphate was the parameter tested for at all stations at Big Shell Lake. The levels ranged form 0.02 to 0.06 mg/L.

An orthophosphate profile was done at Station 3 at two meter increments. The profile shows that there are greater concentrations of orthophosphate at lower depths of the water column, which may be an indication that it is being released from the sediment.

Ammonia-Nitrogen (NH_3)

> *"Ammonia is a product of the microbiological decay of animal and plant proteins. When ammonia is found in surface water it is usually the result of domestic sources. In most healthy freshwater systems, ammonia is present in low concentrations, usually less than 1.0 mg/L; it is the preferred form of nitrogen for uptake by algae and plants. Since ammonia is readily bioavailable as a nutrient for plant uptake, it may contribute greatly to the increase of productivity."* (*<u>Task Force on Canadian Water</u> iv-8)*

Ammonia may enter surface water through soil erosion and/or agricultural runoff.

The levels for ammonia-nitrogen varied from 0.02 mg/L to 0.08 mg/L for all stations during the 1998 sampling season.

Secchi Disk Transparency

A secchi disk was used to measure the amount of suspended material such as algae and sediment (turbidity) in the water. These materials influence the depth to which the secchi disk can be seen, value increases as clarity of the water increases. The secchi disk measurements varied from 1.9 m to 2.8 m in August.

TROPHIC STATUS

Trophic status may be evaluated periodically to determine whether or not a significant change in status has occurred over time. Although eutrophication is a natural characteristic of aging in virtually all lakes, it is a slow process which can be accelerated by man-made influences such as wastewater discharges, drainage, agricultural practices, development, etc.

In order to classify lakes according to their trophic status, several factors have to be considered which at certain levels indicate that a lake belongs in one of the above categories. The most commonly used "trophic indicators" are:

- nutrients (nitrogen and phosphorous),
- chlorophyll "a" (correlated to algal weight filtered from water) and
- secchi disk transparency (water clarity).

Since the values for these trophic indicators can be highly variable in Saskatchewan lakes, the province has not established specific water quality objectives for these parameters.

The trophic status for 1998 has been established by using total phosphorous as an indicator. Chlorophyll "a" is an important factor in establishing a trophic status, however, analysis for this parameter was not conducted in 1998 and will not be used. Secchi disk transparency was recorded in August only and will not be used as a trophic indicator in this report.

Using levels of total phosphorous as a guideline in establishing a trophic status for 1998, Big Shell

Lake can be classified as Eutrophic (high productivity) to Hypereutrophic (excessive productivity) from May through to November. Levels for all stations range from 0.04 and 0.2 mg/L. Results showing levels of <0.01 mg/L on May 27, 1998 are questionable, and have not been included in this report.

Bacteriological Ground Water Quality Monitoring

On August 3, 1998, sixty wells surrounding the lake were randomly selected and sampled: analysis included total Coliforms and Escherichia coli (E-coli analysis was done on only those samples in which positive results for Total Coliforms were reported).

The results showed that thirty-one of the sixty wells sampled tested positive for Total Coliforms and two those thirty-one samples, tested positive for E-coli. Levels of Total Coliforms ranged from 1 to greater than 2420 (count per 100 mLs of sample). E-coli levels ranged from 2 to greater than 1986 (count per 100 mLs of sample).

On September 7 and November 20, 1998, wells that had initially shown a positive result from the August 3, 1998 sample date were retested. These samples were analyzed for the presence of total coliforms., E-coli, and levels of nitrates were also analyzed. Not all wells that initially tested positive were retested because access to the water supply was not possible.

Thirty-three wells were sampled and the results showed that twenty-two wells tested positive for Total Coliforms ranging from levels of <2 to greater than 2420 (count per 100 mLs of sample). E-coli levels ranged 1 to greater than 21 (count/100 mLs of sample) and were found in five wells tested. Comparison results show that six well tests came back positive on the first and second sample date, six were positive for Total Coliforms and four were positive for E-coli. This is an indication that there is a possibility of sewage contamination due to septic tank leakage or from decay of other possible sources. This could also be a possible source of increased nutrient levels entering the lake through groundwater sources.

The Municipal Drinking Water Quality Objectives state that "The maximum concentration (MAC) for total coliforms is no organisms detectable per 100 mL sample". The analysis of the Bacteriological samples were conducted through SRC Laboratories in Saskatoon.

Observations were noted during the 1998 study, that all shorelines were covered with extensive weed growth and that the entire bottom of Echo Bay was covered in water milfoil and pondweeds.

Conclusion

The water quality study that was conducted for 1998 at Big Shell Lake indicates that there are high levels of nutrients. These sources stem from various external and internal sources. The mass amounts of submergent and emergent vegetation and algae are the result of nutrient loading. The relative fertility of the lake can be classified as mainly eutrophic (highly productive) for this sampling period. The parameters that were used to establish a trophic status were limited, and this assessment was based on the data that was obtained in 1998.

Ground Water Quality Monitoring - Sewage Lagoon Study - 1999

In early 1999, PFRA, in co-operation with the BSLWSA and the Resort Villages of Big Shell and Echo Bay, launched a study of the two village lagoons. The main goal of the study is to determine whether the sewage lagoons should continue to operate as they are.

PFRA carried out a drilling program to install piezometers to measure ground water levels and to allow the collection of water samples for analysis in the area around the lagoons. Three piezometers were installed near the Resort Village of Echo Bay sewage dump site and two piezometers were installed near the Resort Village of Big Shell sewage dump site. The soils encountered include clays, silts, and sandy materials. Initial readings taken in the piezometers indicate there is a ground water gradient towards the lake, and water levels are measured every time sampling is done. Water sampling began in March 1999 and further samples were taken monthly from June 1999 to February 2000. One piezometer was installed at the Caswell's farm, near the south end of Big Shell Lake, less than 2 miles from the Resort Village of Big Shell sewage dump.

Water samples are tested for the following nutrients: nitrate + nitrite as N, Total Kjeldahl N, and Phosphorous. Bacteriological tests conducted are for : total coliforms, E. coli (only on samples testing positive for total coliforms) , fecal colifoms, and fecal streptococci.

Bacteria

Possible sources of total coliform bacteria include: soil, and feces from humans, livestock or wildlife. Sources of E. coli, fecal coliform and fecal streptococci bacteria are human or animal feces. Canadian Drinking Water Guidelines for the four types of bacteria studied are no organisms detectable in a 100 mL sample.

Data collected from piezometers near Echo Bay sewage dump between March and December 1999 show that total coliforms have been detected in 22 of 23 samples, and range from 1 to 1410 ct/100 mL. E. coli has been detected in 4 of 23 samples, and ranges from 1 to 87 ct/100 mL. Fecal coliforms have been detected in 2 of 23 samples, and were 5 and 26 ct/100 mL. Fecal streptococci were detected in 8 of 23 samples, and range from 3 to 197 ct/100 mL.

Data collected from piezometers near the Resort Village of Big Shell sewage dump between March and December 1999 show that total coliforms have been detected in 6 of 14 samples, and range from 3 to 866 ct/100 mL. Fecal streptococci was detected in 2 of 14 samples, and were 3 and 7 ct/100 mL. E. coli and fecal coliforms were not detected in any samples.

No bacteria has been detected in any of the 8 water samples collected from the Caswell farm piezometer, which is near their old (1998 and previous years) cattle winter feeding site. These samples were taken between March and December 1999.

Sources of nitrate in water include decaying plant or animal material, agricultural fertilizers, manure, domestic sewage, or geological formations containing soluble nitrogen compounds. Test results for nitrate plus nitrite ranged from <0.01 mg/L to 346 mg/L from water samples taken from the Echo Bay piezometers; <0.01 mg/L to 0.66 mg/L RV of Big Shell samples; and 0.08 mg/L to 9.5 mg/L from the Caswell farm piezometer. Total Kjeldahl Nitrogen test results

ranged from 0.26 mg/L to 2.9 mg/L for Echo Bay piezometers; 0.19 mg/L to 5.9 mg/L for piezometers near the Resort Village of Big Shell piezometers; and 0.33 mg/L to 0.92 mg/L for the Caswell farm piezometer.

Domestic effluents, industrial effluents, and agricultural drainage from fertilized land contribute phosphorous to waters. Soil erosion, natural weathering of geologic materials and precipitation also contribute phosphorous to waters. In Western Canada, the environmental concentration range for total phosphorous in surface waters was 0.003 to 3.0 mg/L; based on the concentrations found in 7324 samples taken between 1980 and 1985. Groundwater phosphorous concentrations average approximately 0.02 mg/L. The phosphorous content of precipitation is generally less than 0.03 mg/L in background areas, but may increase to more than 0.01 mg/L in urban and industrial areas. Source: Canadian Water Quality Guidelines, Task Force on Water Quality Guidelines of the Canadian Council of Ministers of the Environment, Environmental Quality Guidelines Division, Water Quality Branch, Inland Waters Directorate, Ottawa, Ontario.

Phosphorous tests for water samples range from 0.01 mg/L to 0.26 mg/L for samples taken from the piezometers near Echo Bay; 0.01 mg/L to 4.0 mg/L for samples taken from the Big Shell piezometers ; and 0.26 mg/L to 1.3 mg/L.

Riparian Area Management Projects

1. **Relocation of cattle winter feeding site, water supply, and management of runoff.**

This project was done in cooperation with Dave and Linda Caswell who farm and ranch near the south end of Big Shell Lake. Runoff from the previous cattle wintering sites and corral areas drained into two depressions at the south end of Big Shell Lake, hence the potential for nutrient and bacterial loading of surface waters. The runoff in the depressions slowly leaches into the ground during the growing season, with potential for groundwater contamination. Water testing from a piezometer installed on the property near one depression has not detected bacterial contamination (eight tests since March 1999). The tests have shown elevated levels of nitrate + nitrite and total phosphorous; however the levels found are within the Canadian Drinking Water Quality Guidelines.

The initial proposal was to construct a retention pond to capture the runoff from the corral and winter feeding areas; but due to unsuitable soil and geology and other factors it was decided to move the wintering site to a more suitable location. A new corral was built and a new watering bowl was set up for the new wintering site. Water and power were trenched from existing water and power lines. A retention pond to collect runoff from the new winter feeding site was constructed. The collected runoff will evaporate by the end of each summer. This project will manage surface runoff from the wintering site and will also prevent leaching of the runoff into groundwater. Project construction was completed in November 1999. Funding for the project was received from NSWCP RAMP in addition to BSLWSA's AFIF grant.

2. **Development of an alternate watering site for range cattle.**

During summer and fall, Lloyd and Brent Brewer's cattle utilize pasture land along the west side of Big Shell Lake. The cattle drink from the sloughs on the pasture until late summer or early fall, when the sloughs usually dry up. Once water on the pasture becomes unavailable, the cattle wander down to the lakeshore to drink.

In December 1999, a dugout was constructed on the pasture to provide a more secure water source for the cattle so that they will no longer need to water at the lakeshore. Because the pasture land is quite hummocky, there was no ideal location for a dugout. All potential locations have small drainage areas, meaning they would probably not completely fill the dugout from spring runoff.

The nature of the landscape made it necessary to trench from the dugout, which was constructed in an existing slough area, to several other sloughs on the pasture. The water that will flow from these three other sloughs during spring runoff will contribute water to the dugout, in addition to that contributed from the dugout's own drainage area.

The previous impact of cattle watering along the lakeshore was minimal, however, it is beneficial to eliminate as many impacts as possible to protect water quality. In any watershed, it is typically the cumulative effects of many sources of water degradation that cause problems, so elimination or reduction of as many sources of pollution as possible is advisable.

3. **Feasibility study of sedimentation pond to ameliorate contamination from a cattle wintering site.**

Concerns were raised at a BSLWSA Director's meeting about the potential impact of a cattle winter feeding site along an unnamed creek that flows into Big Shell Lake from the north-west. Two of the Directors visited the site during July, 1999, and concluded that it would be too expensive to relocate the site (estimate over $100,000) due to the cost of getting power to a new site, as well as buildings, and other infrastructure. The directors wondered if a sedimentation pond on the creek downstream of the wintering site would help to protect or improve water quality. These circumstances and questions by the BSLWSA lead to PFRA's checking into the feasibility of a sedimentation pond.

Surface water sampling station 9 is immediately upstream of the wintering site and sampling station 10 is immediately downstream of the wintering site. Station 6 is on the same creek, further downstream of the wintering site and just prior to the outflow of the unnamed creek into Big Shell Lake (figure x). The cattle wintering site occupies the land on the south side of the creek between sampling stations 9 and 6; the south and west boundaries are the grid roads.

Table 1. Surface Water Quality Monitoring, Stations 6, 9, and 10 (mg/L and ct/100 mL).

Sample Date 1997	May 20 Station 9	May 20 Station 10	July 29 Station 6	August 4 Station 6
Ammonia as N	0.1	2.8	0.09	0.08
Nitrate as N	1.1	6.6	<0.01	<0.01
Total Kjeldahl N	1.8	5.4	0.84	1.0
Total Phosphorous	0.06	0.14	0.1	0.07
Orthophosphate as P	0.04	0.27	N/a	N/a

The water quality data indicates that nutrient loading was detected at station 10 on the May 20, 1997 sampling date. There was very little runoff during 1998 and 1999, so the 1997 data is all that is available for the unnamed NW Creek. It is not known whether any sedimentation was occuring during spring runoff.

The portion of the creek and surrounding pasture downstream of station 10 was observed on several occations during September, 1998 and August, 1999. The condition of both the pasture and riparian vegetation was very good on both occasions. It was concluded that even if there were sedimentation occurring upstream of station 10, the riparian vegetation would be a very effective filter and thus ameliorate any negative impact of sediments from manure or soil erosion. Thus, dissolved nutrients in the stream would be the only concern, as long as the existing pasture and riparian vegetation remains in good condition. It was further noted that there are two small pond areas downstream of station 6, just prior to the creek's inflow. These two pond areas are full of cattails and other aquatic vegetation. It is surmised that these 2 pond areas likely function similar to wetlands, which are known to be sinks of nutrients, and very beneficial to water quality.

It was concluded that the natural vegetation in the riparian areas and the small wetlands is protecting and improving water quality. It was further noted that construction of a sedimentation pond along the creek would probably be detrimental to water quality due to short term soil erosion risk after construction, prior to re-vegetation of the site. The final conclusion is that the sedimentation pond would not be feasible for protecting or improving water quality.

Future Web Sites for the BSLWSA Community Watershed Management Project are under development. One web site will be at PFRA North Battleford's Web Page:

http://aceis.agr.ca/pfra/offices/nbtlfrd.htm

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