Shoreline Study and Water Quality Assessment of Farm, McConnell, Little Shea, Lyons et Little Danford lakes

A report presented to the Lakes Association of Kazabazua
by the Agence de bassin versant des 7 (ABV-7)
(Mai 2018)

This Report can be downloaded from LAK's website at www.kazlakes.com under Environmental Issues.

This is an English translation of the French original report. In case of discrepancy between the original French and the English translation, the original French shall prevail. (English Translation: Michèle Borchers)

Please note:

Some parts of the original French text have been abridged in the English translation.

Other parts (dealing with general information) have been copied and pasted from the 2016 Report.

For technical reasons, a few graphics or pie-charts could not be imported from the original French report into the English version; where indicated, please follow the reference to the French Report.

An asterisk* in the text refers to the short Glossary that follows the translation.

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THANKS

ABV-7's team wishes to thank Mr. Stephen Markey, LAK's President, and LAK's board for their trust.

We also wish to express our gratitude to a few members of LAK or lake property owners for their precious collaboration over the duration of the project and during the drafting of the report—more particularly to Michèle Borchers, George McCormick, Bruce Shorkey, Phil Champagne, Michael Bernard, Sean van Liempt, and Chadrick Buffel.

SUMMARY

In May 2016, the Lakes Association of Kazabazua mandated the Agence de bassin versant des 7 (ABV7 at www.abv7.org) to establish the characteristics of its three larger lakes (Danford, McAuley and Shea) in order to determine the condition of their health. In May 2017, the Association mandated the Agence again to complete the health check-up of its lakes by establishing the characteristics of five of its smaller lakes (Little Danford, Farm, Little Shea, McConnell, Lyons)—at the request of its property owners, Red Pine Lake was not included in this study. The five lakes are situated in the Municipality of Kazabazua, MRC de la Vallée-de-la Gatineau, Outaouais Region. Based on the information collected, ABV7 made the following diagnosis and is presenting in this report corrective and preventive measures to ensure preservation of these five lakes.

Table 1— LIST of ABREVIATIONS, SYMBOLS AND ACRONYMS

ABV des 7	Agence de bassin versant des 7
CFU	Colony Forming Unit
CRE Laurentides	Conseil régional de l'environnement des Laurentides
E. coli	*Escherichia coli*
Ha	Hectares
Km	Kilomètre
L	Litre
LAK	Lakes Association of Kazabazua
LQE	Loi sur la qualité de l'environnement
m	Mètre
MDDEP	Ministère du Développement durable, de l'Environnement et des Parcs (avant 2014)
MDDELCC	Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques (après 2014)
MFFP	Ministère de la Forêt, de la faune et des parcs
mg	Milligramm
mL	Milliliter
MRC	Municipalité régionale de comté
µg	Microgramm

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1. INTRODUCTION

1.1 Background Information

The Lakes Association of Kazabazua's five smaller lakes (Little Danford, Farm, Little Shea, McConnell, Lyons) are situated in the Municipality of Kazabazua, MRC de la Vallée-de-la Gatineau, Outaouais Region. (The three larger lakes were studied in 2016.) This research project had two goals: to test the five lakes' water quality (in order to determine their trophic status) and to assess the condition of their shorelines. Based on the information collected, ABV-7 made the following diagnosis and is presenting in this report corrective and preventive measures to ensure preservation of these five lakes.

The analysis of samples and photographs collected onsite in June/July and in September 2017 shows that the physical and chemical properties of these five lakes' water are characteristic of an oligotrophic (Stage I of III) or of a mesotrophic lake (Stage II of III), depending on the date and location of sampling since local weather conditions (precipitation, temperature) can influence the results.

An **oligotrophic lake** is characterized by low nutrient (phosphorus, nitrogen) concentrations, a low accumulation of sediment and organic matter, a good oxygen concentration, a low plant growth, and a good water transparency—all factors which have a positive impact on aquatic life.

A **eutrophic** (="well-nourished") **lake** has high nutrients and high plant growth.
A **mesotrophic lake** falls somewhere in between.

Keeping a lake at the first (oligotrophic) stage is important in order to prevent its premature aging.

Fig. 1 - The three trophic states of a lake: (I) oligotrophic, (II) mesotrophic and (III) eutrophic
Source : ABV des 7

1.2 Mandate

In May 2017, the *Lakes Association of Kazabazua* (LAK) mandated the *Agence de bassin versant des 7* (ABV7 at www.abv7.org) to establish the characteristics of five of its smaller lakes (Little Danford, McAuley and Shea), which are situated in the Municipality of Kazabazua, MRC de la Vallée-de-la Gatineau, Outaouais Region—at the request of its property owners, Red Pine Lake was not included in this study.

This research project had two goals: to evaluate the condition of their shores and to assess the lakes' water quality (using physical and chemical parameters—dissolved oxygen, pH, temperature, transparency, chlorophyll a, turbidity, and total phosphorus) in order to establish their risk of eutrophication (premature aging).

2. GENERAL INFORMATION

2.1 Description of the five lakes[1] studied

2.1.1 Location, hydrography and geology

About 80 km northwest of the City of Gatineau, the five small lakes are in the Municipality of Kazabazua (approx. 991 permanent residents in 2016). They are situated in the watersheds of the Picanoc River and of the Kazabazua River. Both rivers flow into the Gatineau River, to the East. The Gatineau River flows into the Ottawa River.

The five lakes are between 182 m and 168 m above sea level. The area is in a physiographic region named the Southern Laurentians. This region is part of the southern rim of the Canadian Shield, which covers most of Canada and includes some of the oldest rocks on earth.

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[1] Translator's Note:
For general information about recreational activities, demography, road network, geology, and septic systems, please see the 2016 French report.

All lakes studied are in the Gatineau Valley, which is a former arm of the Champlain Sea, the limits of which are located north of the Maniwaki area (Daignault et al., 2013, Verret, 2015). These geological features may influence the physical and chemical characteristics of the water, especially its pH, which tends to be acidic or alkaline depending on the nature of the underground rock formation[2]. None of the five lakes has any significant tributaries or emissaries, and their bottom coincides with the limit of the underground water table (the water of which is filtered by the soil layers above it). Therefore the level of the underground water table has a strong influence on these lakes' average water level. Like other LAK's lakes, the five smaller lakes are probably kettle* lakes, occupying depressions left behind after partially-buried ice blocks melted about 10,000 years ago. This geomorphological feature would explain why these smaller lakes have a relatively great depth and their water transparency levels are high.

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[2]Translator's Note: The French report contains detailed information about the geology of our region. This information in French was translated from the two English sources shown below, which are available in public libraries. Please refer to them if you want to know more on the geology of our region:

Baker, D. R. 1956. Geological report, Aylwin-Cawood area, Pontiac and Gatineau counties, Department of Mines. Québec).

Daigneault, R.-A, Roy, M., Lamothe, M., Milette, S., Dubois Verret, M., Hurtubise, M.-A., Lamarche, 0 ., Leduc, É., Godbout, P.-M. et Horth, N. (2013, août). Deglaciation Pattern in the Outaouais Region, Southwestern Québec. Canadian Quaternary Association (CANQUA), Meeting 2013 - Edmonton, Alberta.

Table 2 — Main characteristics of the five lakes

FARM Lake area (ha)	2.4
Perimeter (m)	896
Max. Length (m)	291.8
Average breadth (m)	174.35
Max. Depth (m)	24
Altitude (m)	183
McCONNELL Lake area (ha)	26
Perimeter (m)	4.026 m
Max. Length (m)	1.060
Average breadth (m)	220
Max. Depth (m)	26.0
Altitude (m)	178.7
LITTLE SHEA LAKE area (ha)	5.7
Perimeter (m)	1 300
Max. Length (m)	317.6
Average breadth (m)	133.4
Max. Depth (m)	24.1
Altitude (m)	176.36
LYONS LAKE area (ha)	9.38
Perimeter (m)	1,260
Max. Length (m)	477.22
Average breadth (m)	187
Max. Depth (m)	24.8
Altitude	177.1
LITTLE DANFORD LAKE area (ha)	13.7
Perimeter (m)	1,760
Max. Length (m)	705
Average breadth (m)	218
Max. Depth (m)	14.3
Altitude	175.2

2.1.2 Land Use

The way the land is used in a lake’s watershed has a direct impact on the quality of its water.

Like the three larger lakes in the Lakes Association of Kazabazua (Danford, Shea, McAuley), its five smaller lakes are surrounded mainly by forests. There are no farming or urban activities in any of these lakes’ watersheds. Because vegetation acts as a natural shield, these five lakes’ immediate forest environment should have a positive impact on their water quality but only as long as the shore’s vegetation cover is preserved.

2.1.3 Bathymetry

No bathymetric maps were available for the five lakes. We used a depth finder to locate their deepest spots:

Location of greatest depth in McConnell and Little Danford

Lake	Greatest Depth (m)	Coordinates
Farm	24	45^{0} 55’ 58,25” N 76^{0} 8’ 6,883” O
McConnell	26	45^{0}56’10.49” N 76^{0} 7’ 56.454” O
Little Shea	24.1	45^{0} 55’55.456 N 76^{0} 7 27,1 “ O
Lyons	24.8	45^{0} 58. 8.852 76^{0} 8’ 20.907”
Little Danford	14.3	45^{0} 56’ 20.115” N 76^{0} 7’ 12,5” O

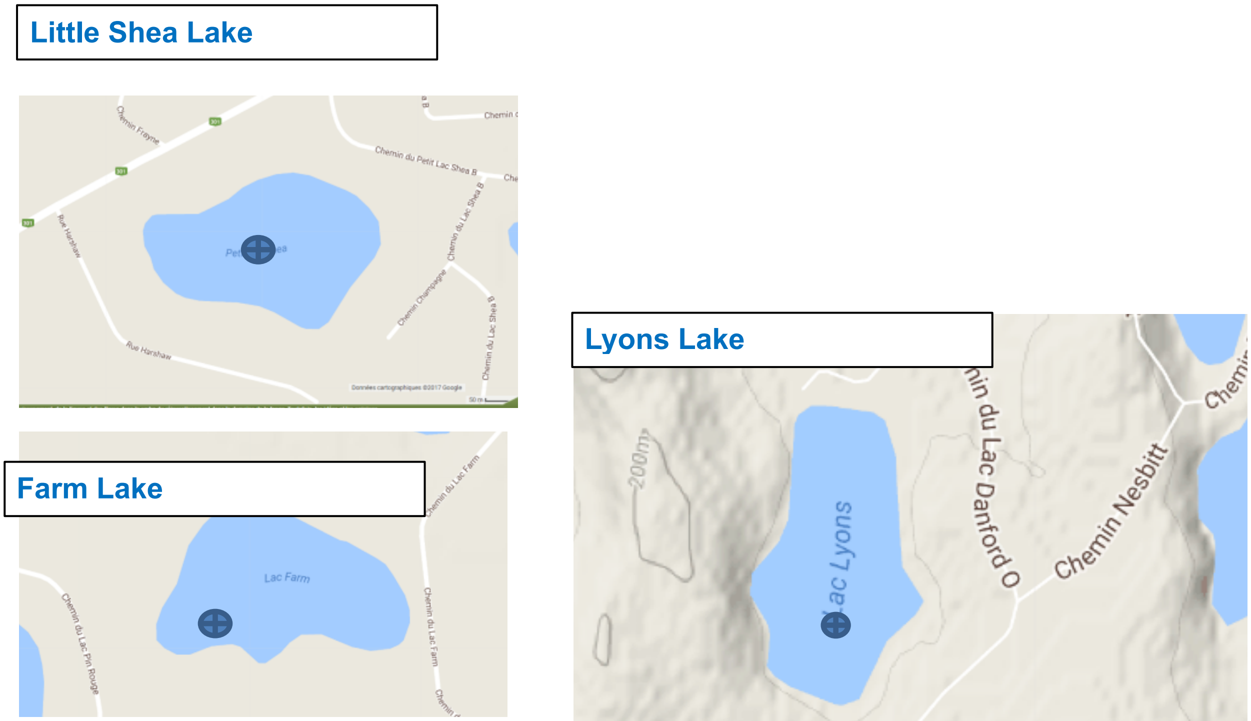


Fig. 2 - Location of greatest depth in Little Shea, Farm, and Lyons Lake

3. RESULTS AND DISCUSSION

The same methodology has been used as in the 2016 Report.

In addition to LAK's own annual data collected since 2007 for *E. coli* and *Phosphorus*, ABV-7 analyzed the data obtained from lab tests with water samples taken:

- on June 16 and 19, 2017 (Small Danford, McConnell, Little Shea),
  on July 31, 2017 (Farm, Lyons), and

- on September 18, 2017 (all five lakes).

Samples were taken at the greatest depth in each lake, where conditions are theoretically the least favourable.

3.1 Water transparency and turbidity

Water transparency is another indicator of a body of water's trophic status (aging status). It relates to the depth that light will penetrate water and is influenced by the amount of sunlight and the quantity and nature of substances present in the water. These substances can be mineral (sand, silt or clay, and inorganic chemical compounds) or organic (microscopic algae, organic debris and organic chemical compounds); they can be dissolved or present as particles.

To measure the transparency of water, a Seqqui disk is lowered into the water column until it can no longer be seen from the surface. The point at which the disk disappears is a function of the transparency. Turbidity (cloudiness) is related to transparency and indicates the concentration of suspended particles clouding the water. A turbidity reading lower than 1 NTU (*Nephelometric Turbidity Unit*) is not problematic, but a higher reading should be investigated for possible pollution.

Trophic status		**Average transparency (m)**
Status	**Intermediate status**	
Ultraoligotrophic		>12
Oligotrophic		12 – 5
	Oligo-mesotrophic	6 – 4
Mesotrophic		5 – 2,5
	Mesa-Eutrophic	3 – 2
Eutrophic		2,5 – 1
Hypereutrophic		<1

Source : MDDELCC, 2014.

Table 3 - Correlation between transparency levels and trophic status (Stages I, II, III)

The Spring of 2017 was exceptionally wet, with record high precipitation levels and low temperatures. It is therefore possible that increased run-off had an impact on the readings.

In most lakes, the water was transparent at a depth greater than 5 meters, which is characteristic of oligotrophic lakes. The water of Little Shea Lake was transparent at a lesser depth (4 m—5 m)—a turbidity level that would be indicative of an oligotrophic-mesotrophic* lake. McConnell Lake had the best transparency level of all five lakes (below 6 meters).

On the whole, readings showed a good water transparency in all five lakes. The summer heavy rains do not seem to have impacted the water transparency. This is probably due to a couple of factors. First, there are not any tributaries to speak of flowing into the lakes so that no sediments could be brought in with flood waters. Second, the lake water level is closely linked to the water table, the water of which is filtered by the soil layers above it.

Table 3 — Turbidity levels in the five lakes (2017)

Transparency (m)				
Lake	June	July	September	Average
Farm		5.4	5.0	5.2
McConnell	6.2		6.5	6.3
Little Shea	4.0		4.5	4.3
Lyons		5.0	5.0	5.0
Little Danford	5.7		5.5	5.6

3.2 Dissolved Oxygen, pH and Temperature

Dissolved oxygen is essential for aquatic life. In lakes, it comes from the atmosphere and is also produced from phytoplankton. It is consumed through biological activity and the decomposition of organic matter.

ABV7 collected data on the concentration of dissolved oxygen by using a YSI multi-parameter probe (model 600QS) at the deepest point of each lake. The data were measured first on the surface, then the probe was lowered in 1-metre stages until it reached bottom. The data collected in the first layer of lake-bottom sediment were later removed from analysis to avoid a distorted reading.

At the same time, data on temperature and depth were compiled in order to complete analysis.

Dissolved oxygen levels increase with depth in an oligotrophic lake, which typically has low concentrations of mineral and organic matter. This promotes the breakdown of the organic matter produced in the 'epilimnion' (upper layer of the waterbody). A high level of dissolved oxygen at the lake bottom has a chemically stabilizing effect on the sediment layer accumulated there.

Usually, a lake progresses gradually from oligotrophy to mesotrophy (from Stage I to Stage II of its aging process). This natural process can be accelerated by the supply of phosphorus resulting from human activity. An increased phosphorus level promotes the growth of aquatic plants and algae, which diminishes the overall quality of the water when their growth is excessive. An eutrophic lake (Stage III of its aging process) is a shallow lake characterized by an abundant accumulation of nutrients that support a dense growth of algae, the decay of which depletes the shallow waters of oxygen in summer.

Dissolved oxygen (saturation and concentration), pH, and temperature were measured at various depths in the deepest part of each of the five lakes.

Oxygen concentration (measured in percentage) and oxygen saturation (measured in mg/L) must be high (over 80%) in the 'epilimnion' (upper water layer) in order for aquatic life to have enough oxygen. Generally, these two parameters decrease rapidly at a depth greater than 3-5 m. When oxygen saturation is below 60%, the oxygen level is too low for aquatic life (G3E, 2014).

3.3 Chlorophyll *a*

Chlorophyll *a* is a pigment found in plant cells which is used by plants, along with other pigments, to carry out photosynthesis. This process uses the sun's energy to convert carbon dioxide and water into oxygen and organic matter.

Chlorophyll *a* is a measure of the amount of algae biomass in a lake. At the base of the food chain, algae determine a lake's productivity, i.e. how much organic matter it can produce. Balanced productivity reflects a healthy lake. When it is in excessive quantities, it reveals the presence of too many nutrients, particularly phosphorus.

Trophic status		Chlorophyll *a* (µg/l)
Status	**Intermediate status**	
Ultraoligotrophic		<1
Oligotrophic		1 – 3
	Oligo-mesotrophic	2.5 – 3.5
Mesotrophic		3 – 8
	Meso-Eutrophic	6.5 – 10
Eutrophic		8-25
Hypereutrophic		> 25

Source : MDDELCC, 2014.

Table 4 - Correlation between chlorophyll *a* levels and trophic status (age)

Chlorophyll *a* levels were measured in June and in September for each of the five lakes.

Table 5 - Chlorophyll a levels (June/July and September 2017) in the five lakes

Chlorophyll a	µg/l		
	June or July	September	Average
Farm	2.13*	2.20	2.17
McConnell	1.10	1.19	1.15
Little Shea	1.24	1.30	1.27
Lyons	1.88*	4.12	3.0
Little Danford	3.09	3.34	3.22

All chlorophyll a levels varied between 1.0 and 4.5 µg/L, which is characteristic of oligotrophic lakes (Stage I of III), except for Little Danford Lake, where readings are more characteristic of a mesotrophic lake. However, all levels observed are fairly stable, which is typical of healthy lakes. In Lyons Lake, the higher chlorophyll a level observed in September 2017 (4.12 µg/L) indicates an increased density of micro-algae, probably due to the fact that the lake water level remained fairly high all summer. In fact, the chlorophyll a levels could have been much higher considering the summer heavy rainfalls. The summer average low temperatures must have had a dampening effect on the growth of micro-algae.

3.4 Farm Lake

This small lake (2.4 ha) has a low rate of occupancy and reaches a surprising depth considering its size. Like other lakes in the area, it probably is a kettle lake*.

3.4.1 Water Quality

Data collected indicated that thermal stratification* had already taken place in July, with a thermocline* situated at around 10 m below the surface, which is fairly deep. The June/July and September curves are comparable, and oxygen levels remained stable over the season.

3.4.2. Temperature

The slight variations in temperature may be due to a higher water turnover caused by violent storms. However, the temperature is normal for this type of lake. The temperature of 4 °C at the bottom of the lake is comparable to temperatures observed in the other lakes studied. The water temperature was higher in September than in July because July was cool and wet with many storms while September was warmer, drier and less windy than usual.

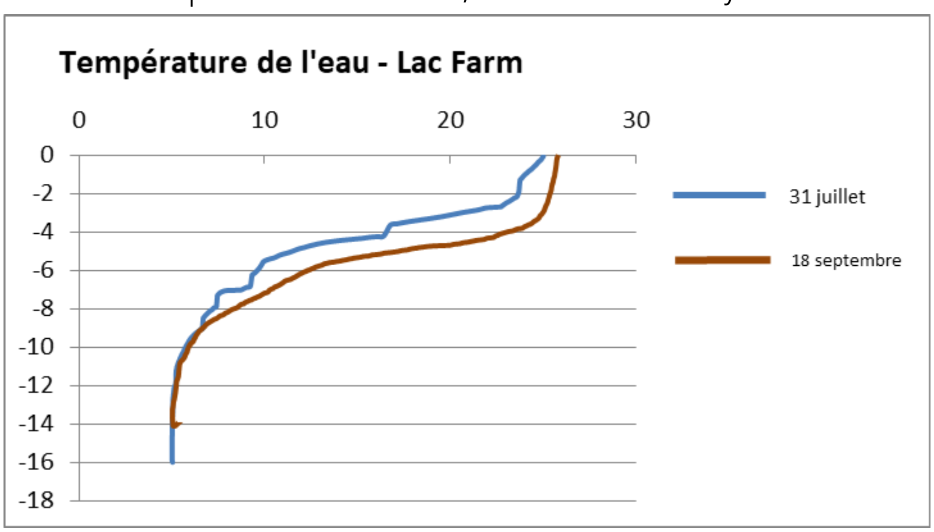


Fig. 3 - Temperature at various depths (0 m to -18 m) in Farm Lake in July and September 2017

3.4.3 *E. coli*

LAK has been collecting data on *E. coli* since 2007. The average concentrations found are indicative of an excellent water quality. Higher levels were found in 2014, but they remained far below the levels at which swimming should be prohibited (200/100 mL).

Table 6—*E. coli* concentrations used for water quality assessment (Source: MDDELCC)

Water Quality	Grade	E. coli / 100mL	What is allowed / What is not
Excellent	A	0-20	all recreational activities
Good	B	21-100	all recreational activities
Mediocre	C	101-200	all recreational activities, but time spent in the water may have to be limited
Poor	D	over 200	Swimming and other forms of direct contact with water are not recommended.
Very poor	E	over 1000	All recreational activities are prohibited.

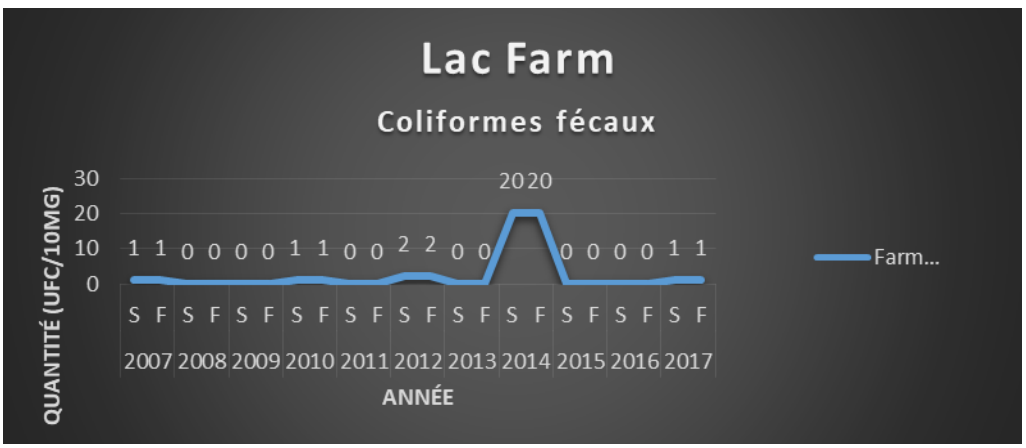
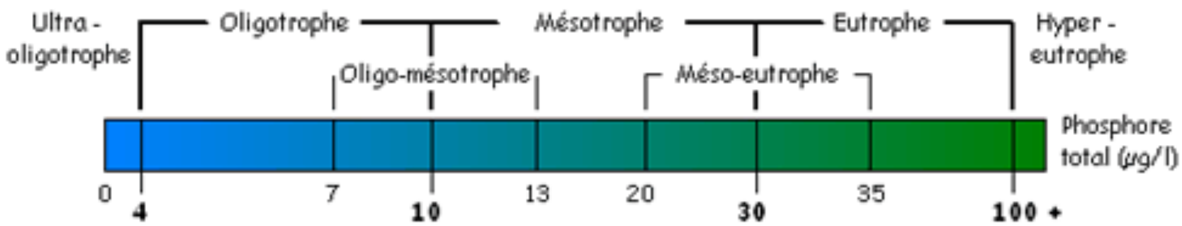


Fig. 4—*E. coli* concentrations (CFU/10 mg) in Farm Lake over 10 years (2007-2017)

3.4.4 Total Phosphorus

Phosphorus, a biological requirement for plants and algae, is found naturally in small amounts in lake water. Phosphorus normally promotes the growth of algae and aquatic plants. Although phosphorus is naturally present in a lake, the main sources of this nutrient in lakes are linked to human activity: use of fertilizers, pesticides, and soaps and detergents containing phosphates; failing septic systems; soil erosion as a result of clearing trees or constructing buildings; shores without vegetation; and poorly designed drainage ditches. The concentration of phosphorus in a lake is an indicator of its trophic status, i.e. of its aging. The threshold of eutrophication is 0.03 mg/L of total phosphorus.



Correlation between total phosphorus concentrations and a lake's trophic status (age)

Over the years, all samples (taken by LAK alternatively in the Spring or in the Fall of each year) show relatively stable phosphorus levels which remain way below the threshold of eutrophication (0.03 mg/L), with the exception of 2011. This peak might have been caused by unfavourable weather conditions or a leak from a faulty septic system. The situation would be worrisome if the levels were repeatedly high from one year to another, but this is not the case here. Phosphorus levels in Farm Lake are characteristic of an oligotrophic lake.

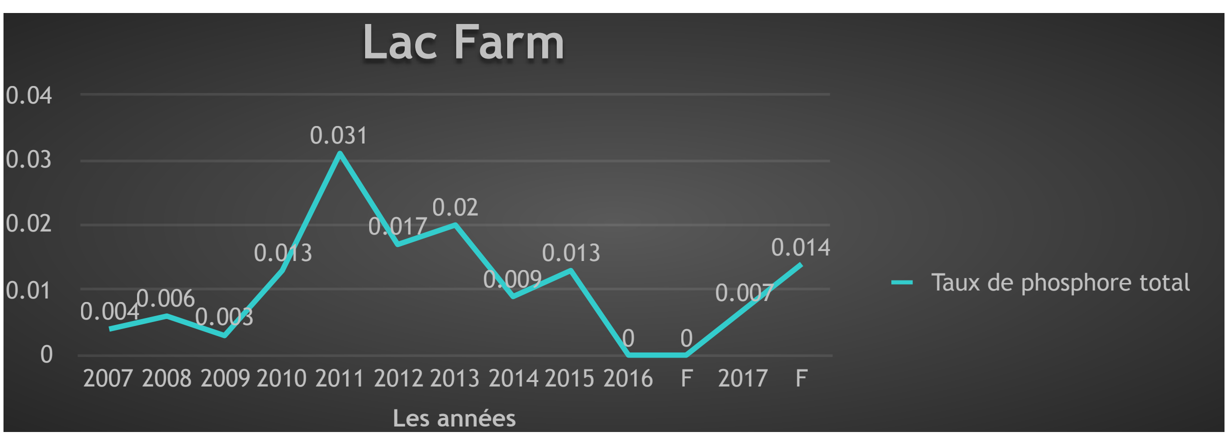


Fig. 5 — Total Phosphorus levels (mg/L) in Farm Lake over 10 years (2007-2017)

3.4,5 Dissolved Oxygen

Dissolved oxygen readings in Farm Lake's upper water layer were average only. Three factors might have been at play here: (a) because of its small size, the lake's surface is less exposed to winds capable of generating waves high enough to oxygenate the upper layer adequately; (b) there are no tributaries contributing to a better circulation of oxygen; and (c) there are no water-related activities that increase the mixing of the water layers. Consequently, the dissolved oxygen levels remained stable from the surface down to a 4 m-depth. Below 4 m, they gradually dropped to reach about 5% at the bottom of the lake, which is normal for a lake of this size and depth. However, dissolved oxygen readings in the upper layer remained average to low. A slight improvement was observed at the end of the summer, probably caused by a better mixing of the water layers. The results obtained here for dissolved oxygen are characteristic of a mesotrophic lake (State II of III). *New testings should be carried out again in 2018 for comparison*.

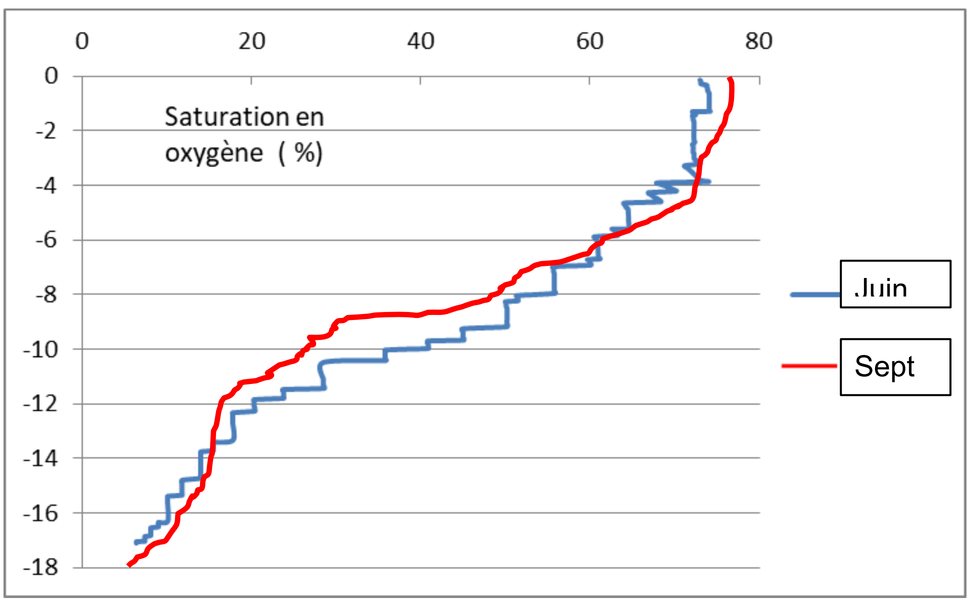


Fig. 6 — Oxygen Saturation Levels (%) at various depths (0 m to -18 m) in Farm Lake in June and in September 2017

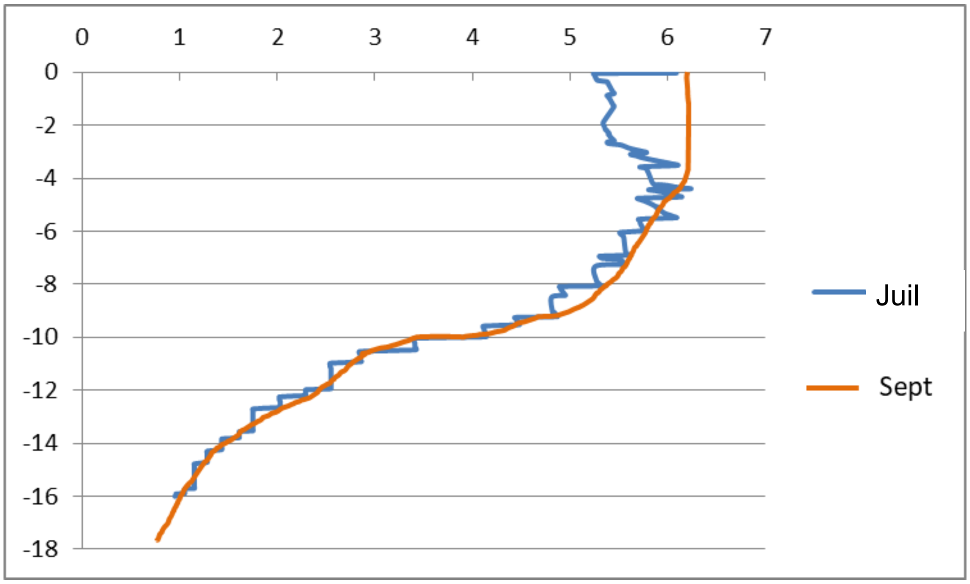


Fig. 7 — Oxygen Concentration Levels (mg/L) at various depths (0 m to -18 m) in Farm Lake in July and in September 2017

3.4.6 pH

Farm Lake's pH varied between 7.31 and 6.4, i.e. within a normal range—the ideal pH bracket for aquatic life being 6.5 to 9. Therefore, its water is neither too acidic nor too alkaline.

3.5 McConnell Lake

This lake has a complex morphology, with a long bay extending eastward. It is the largest of the five smaller lakes studied, with an area of 26 ha. Its greatest depth (26 m) is rather significant for a lake of this size. Like the other four smaller lakes, its water level is closely linked to the underground water table. McConnell lake has a small emissary, and no permanent tributary.

3.5.1 Water Quality

Data collected showed that thermal stratification* had already taken place in June 2017, with a thermocline* at approximately 10 m below the surface. June and September curves are comparable. Dissolved oxygen levels remained stable over the season.

3.5.2. Temperature

As in the other four lakes studied, the water average temperature was higher in September than in June because June was cool and wet with many storms while September was warmer and drier.

At depths greater than 12 m, the water remained cold all summer. In September, the water temperature was fairly warm down to 5 m below the surface before reaching the thermocline*. The higher water temperature registered on September 18 was probably caused by two factors: (a) the weather had been unusually warmer, drier, and less windy for the past few days and (b) the good water transparency of this lake allows sunlight to better penetrate the water layers and, thus, to raise their temperature.

(Please look for this graphic in the original French Report)

Fig. 8—Temperature at various depths (0 m to -18 m) in McConnell Lake in June and September 2017

3.5.3 *E. coli*

The average concentrations found in McConnell Lake are indicative of good—even excellent— water quality. The higher concentrations found in 2014 remained far below the levels at which swimming should be prohibited (200/100 mL). The 2014 peaks might have been weather-related or due to a failing septic system.

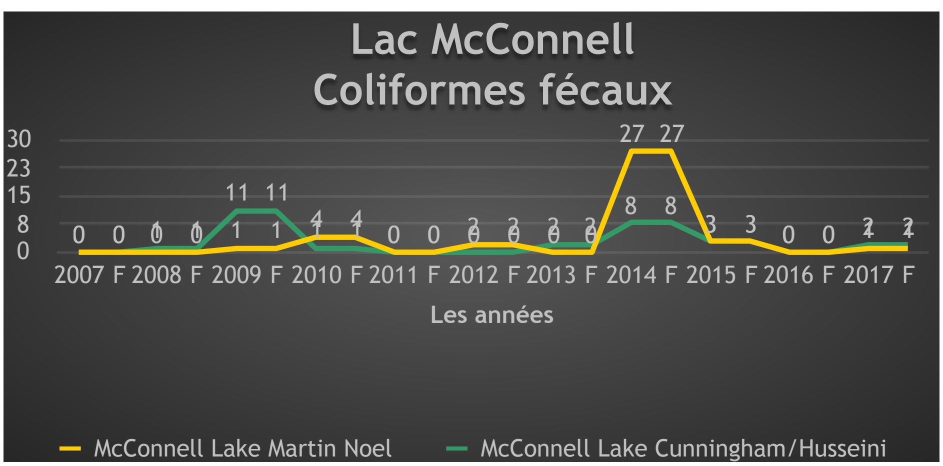


Fig. 9 — *E. coli* concentrations (CFU/10 mg) in McConnell Lake over 10 years (2007-2017)

3.5.4 Total Phosphorus

Over the years, all samples (taken by LAK alternatively in the Spring or in the Fall of year) show stable total phosphorus concentrations which remained way below the threshold of eutrophication (0.03 mg/L), with the exception of a few discrepancies that are probably weather-related. These results are characteristic of an oligotrophic lake (Stage I of III).

Phosphorus is found naturally in small amounts in lake water, but the main sources of this nutrient in lakes are linked to human activity (use of fertilizers, pesticides, and soaps and detergents containing phosphates; failing septic systems; soil erosion as a result of clearing trees or constructing buildings; shores without vegetation; and poorly designed drainage ditches). The concentration of phosphorus in a lake is an indicator of its trophic status, i.e. of its aging.

The high temperature of the water upper layer does not seem to have had any influence on the phosphorus concentrations.

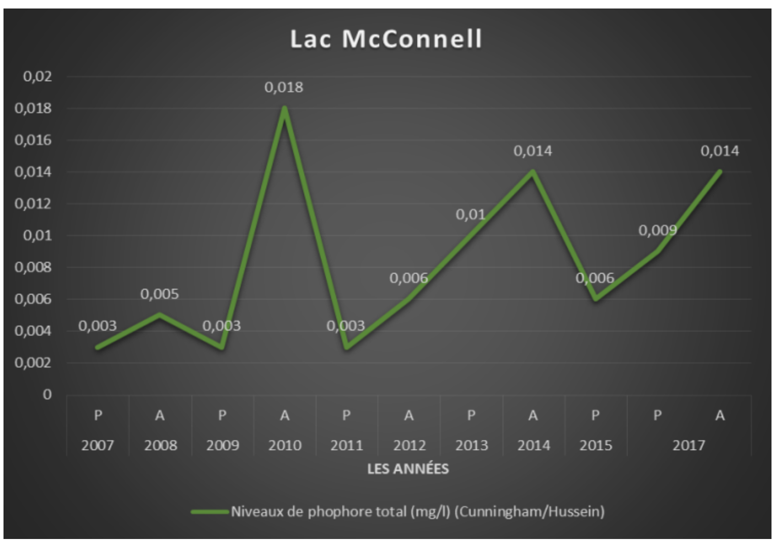


Fig. 10 — Total Phosphorus Concentrations (mg/L) in McConnell Lake over 10 years (2007-2017)

3.5.5 Dissolved Oxygen

Readings showed a better oxygenation of the lake water towards the end of the summer. The dissolved oxygen concentration was above 10 mg/L in the upper water layer down to a 10 m-depth. Oxygen saturation levels too were excellent—they are typical of an oligotrophic lake (Stage I of III).

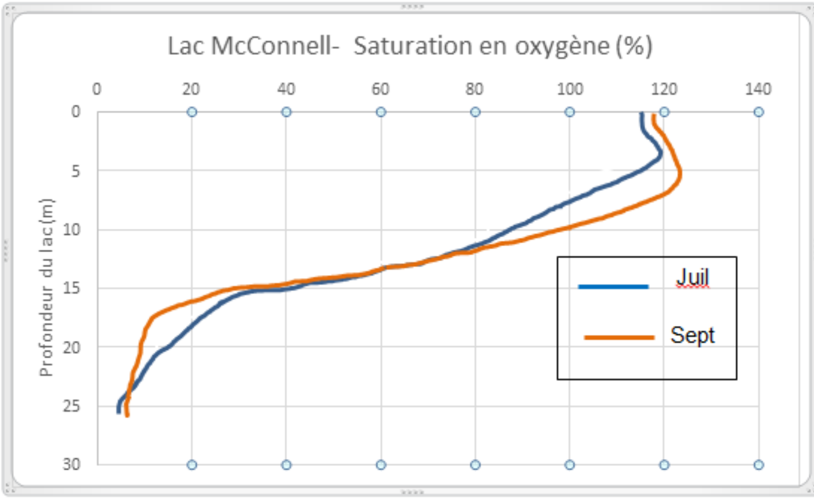


Fig. 11 — Oxygen Saturation Levels (%) at various depths (0 m to -30 m) in McConnell Lake in July and in September 2017

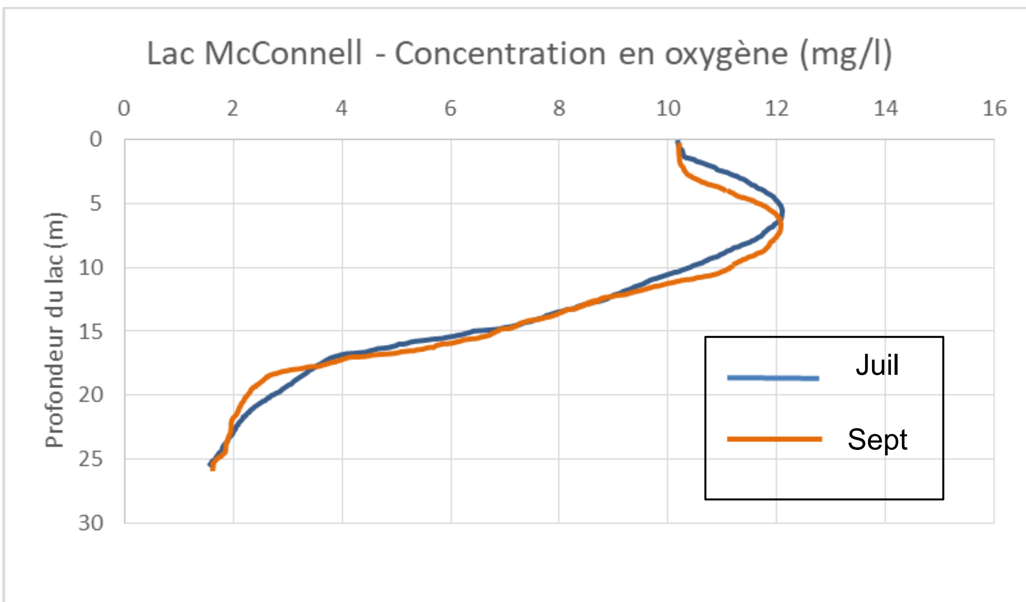


Fig. 12 — Oxygen Concentration Levels (mg/L) at various depths (0 m to -30 m) in McConnell Lake in July and in September 2017

3.5.6 pH

McConnell Lake's pH varied between 8.5 and 7.38, i.e. within a normal range while indicating a slightly alkaline water (higher than 7.5). This may be due to the fact that the underlying bedrock contains more limestone than granite. Consequently, its water is neither too acidic nor too alkaline for aquatic life.

3.6 Little Shea Lake

Little Shea Lake is a small lake (5.7 ha) with a depth of 24.1 m. Like most of the other four lakes studied, it is steep-sided and has no emissaries nor any tributaries to speak of.

3.6.1 Water Quality

All parameters studied for this lake are indicative of a good water quality. The variations observed are not significant enough to suspect any deterioration of the water quality. In this lake too, thermal stratification was well established in July and in September. The oxygen level measured in September was excellent. E. coli et phosphorus concentrations remained way below the recommended thresholds. Consequently, Little Shea Lake can be considered oligotrophic.

3.6.2. Temperature

Data collected showed that thermal stratification* was already in place in June and in September. Temperature values were normal for this type of lake, and the temperature of about 4 °C at its bottom compared with the other four lakes studied. Like in these other lakes, the water average temperature was higher in September than in June because June was cool and wet with many storms while September was warmer and drier.

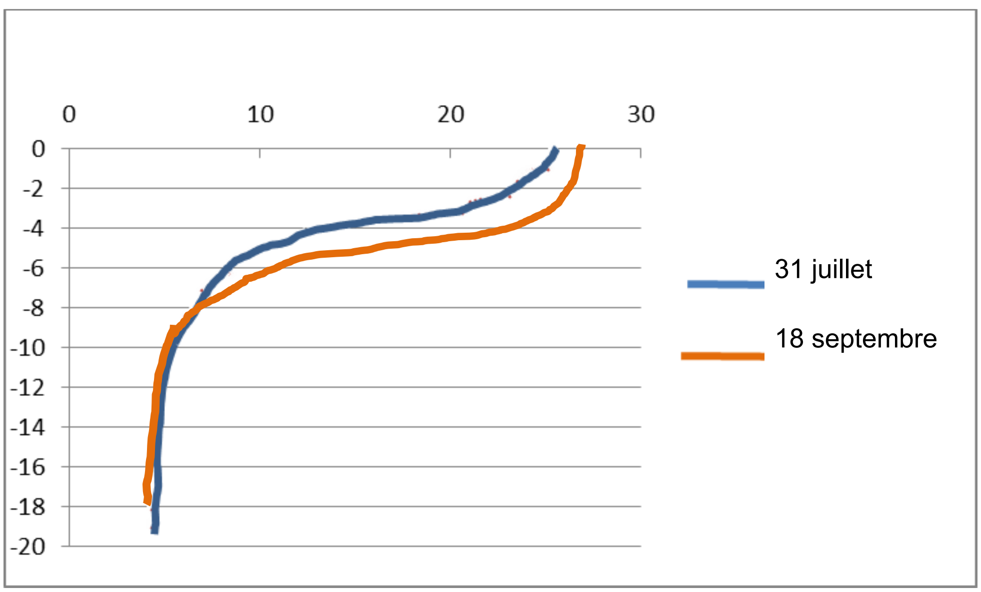


Fig. 13 — Temperature at various depths (0 m to -20 m) in Little Shea Lake in July and September 2017

3.6.3 *E. coli*

The average concentrations found in Little Shea Lake are indicative of good—even excellent— water quality. The higher concentrations found in 2014 remained far below the levels at which swimming should be prohibited (200/100 mL). Like in the other four lakes studied, the 2014 peaks were probably weather-related.

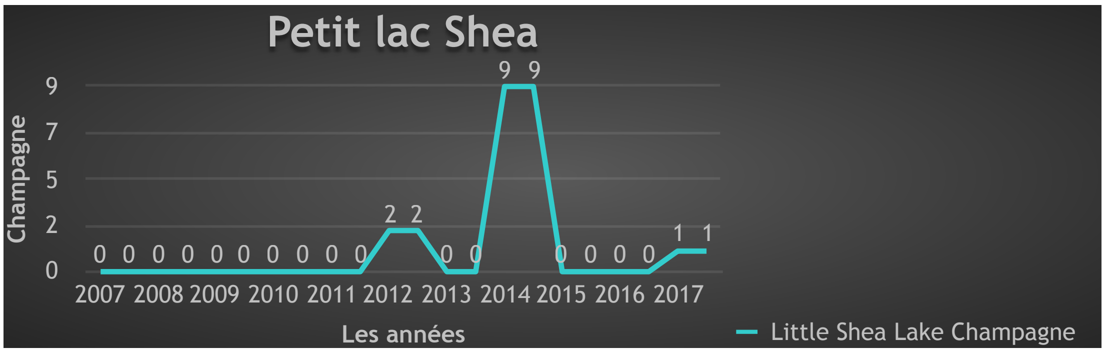


Fig. 14 — *E. coli* concentrations in Little Shea Lake (CFU/10 mg) over 10 years (2007-2017)

3.6.4 Total Phosphorus

Over the years, all samples (taken by LAK from 2012 to 2016, in the Spring or in the Fall) showed stable phosphorus levels. They varied between 0.007 and 0.014 while remaining way below the threshold of eutrophication (0.03 mg/L). These results are characteristic of an oligotrophic* lake (State I of III). Phosphorus is found naturally in small amounts in lake water, but the main sources of this nutrient in lakes are linked to human activity. We recommend further testing in the future for monitoring purposes.

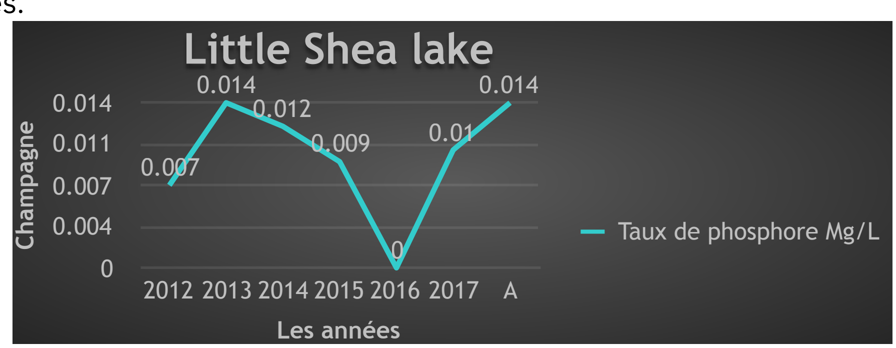


Fig.15 — Total Phosphorus levels (mg/L) in Little Shea over 5 years (2012-2017)

3.6.5 Dissolved Oxygen

Because of a malfunction, the results obtained with our probe in June and on July 31 showed atypically low readings and could not be used. This is why we are giving here only the September readings, which nevertheless give us a good indication of the oxygenation levels in Little Shea. These are excellent from the surface down to a

10 m-depth. Then, they decrease rapidly to reach normal values at the bottom of the lake. Little Shea can therefore be considered an oligotrophic lake (Stage I of III).

(Please see original French Report)

Fig. 16 — Oxygen Saturation Concentrations (%) in Little Shea Lake at various depths (0 m to -16 m) in September 2017

(Please see original French Report)

Fig. 17 — Oxygen Concentrations (mg/L) in Little Shea at various depths (0 m to -16 m) in September 2017

3.6.6 pH

Little Shea Lake's pH varied between 7.59 and 6.3, i.e. within a normal range. Its water is neither too acidic nor too alkaline for aquatic life.

3.7 Lyons Lake

This oval-shaped (9.8 ha) lies further north than the other four lakes. Like them, it is deep and steep-sided, surrounded by hills that can reach 30 m above the water level. Lyons Lake's deep depression between escarpments is of a structural nature, meaning that the geology is responsible for the lake's morphology. The greatest depth (almost 25 m) is significant for a lake of this size. It has no permanent tributary nor any emissary to speak of. Its water level is largely linked to precipitation and the underground water table. This explains why it remained high all summer until September. The occupancy rate of its shore is low—only a dozen of properties can be found on its banks or on the hills surrounding the lake. There are trees all around the lake.

3.7.1. Temperature

The lake's thermal stratification was already in place in July and in September, which is normal for this type of lake. The temperature of approximately 4 °C at the bottom of the lake all year around is in line with what we found in the other four lakes studied. In this case again, the water average temperature was higher in September than in July because July was cool and wet with many storms while September was warmer and drier.

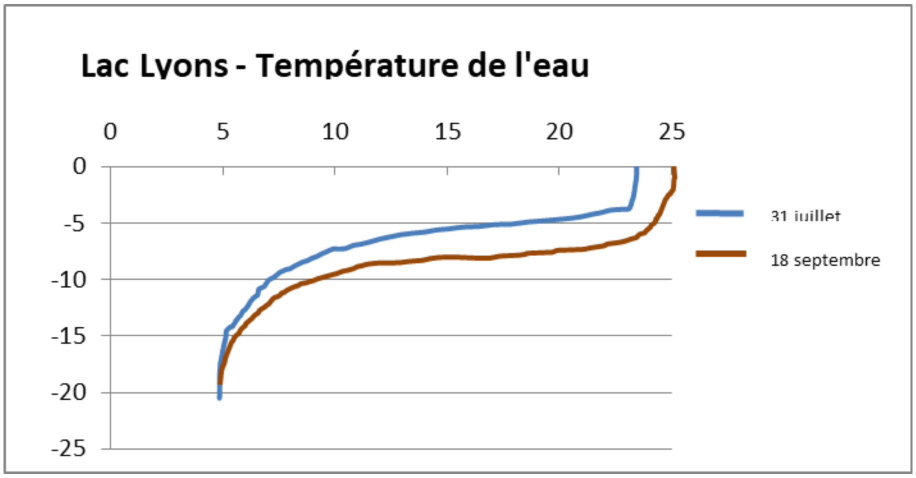


Fig. 18 — Temperature at various depths (0 m to -25 m) in Lyons Lake in July and September 2017

3.7.2 *E. coli*

E. coli concentrations in Lyons Lake have varied over the years, and it is difficult to say whether they are the result of natural processes or caused by human activity. However, they remain way below the levels at which swimming should be prohibited (200/100 mL). Like in the other four lakes, the 2014 peaks observed are probably weather-related. Lyons Lake water is therefore of a very good quality in this regard.

Fig. 19 — *E. coli* concentrations in Lyons Lake (CFU/10 mg) over 10 years (2007-2017)

3.7.3 Total Phosphorus

Over the years, all samples (taken by LAK each year, in the Spring or in the Fall of each year) show a steady increase of phosphorus levels, but they remain way below the threshold of eutrophication (0.03 mg/L). Phosphorus is found naturally in small amounts in lake water. In the case of Lyons Lake, the rainy summers of 2013 and 2017 may have impacted the level of phosphorus concentrations. *It would be interesting to keep testing for this parameter for monitoring purposes.*

Fig. 20 — Total Phosphorus Levels (mg/L) in Lyons Lake over 10 years (2007-2017)

3.7.4 Dissolved Oxygen

Oxygen levels remained above 80% from the surface down to a 15m-depth, which is excellent for aquatic life. However, they rapidly decreased to reach approximately 25% at a depth greater than 20 m, which can be insufficient for cold water species. However, this oxygen deficit is counterbalanced by the fact that the cold water layer is established below 10 m. Springs may have an impact on the curves observed. At the bottom of the lake, the oxygen levels remained normal.

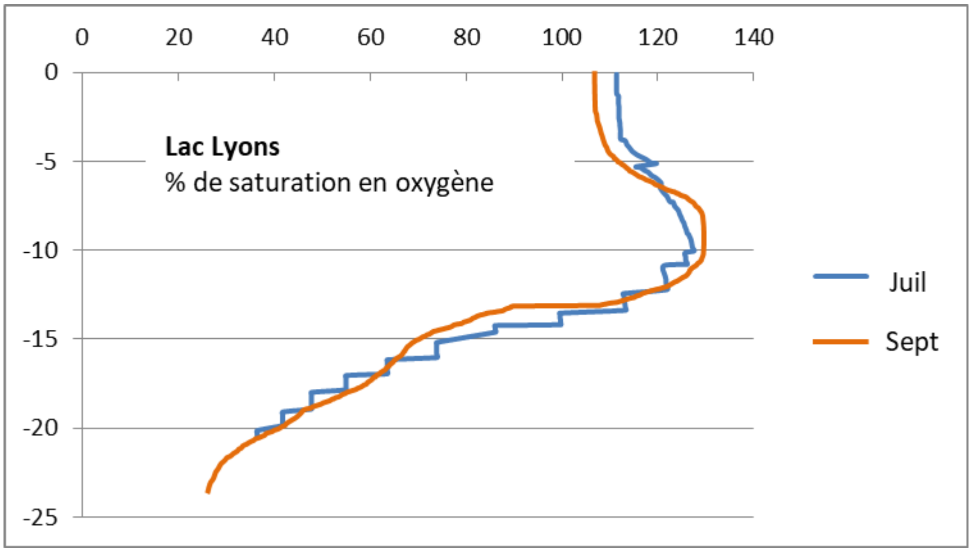


Fig. 21 — Oxygen Saturation Levels (%) at various depths (0 m to -25 m) in Lyons Lake in July and in September 2017

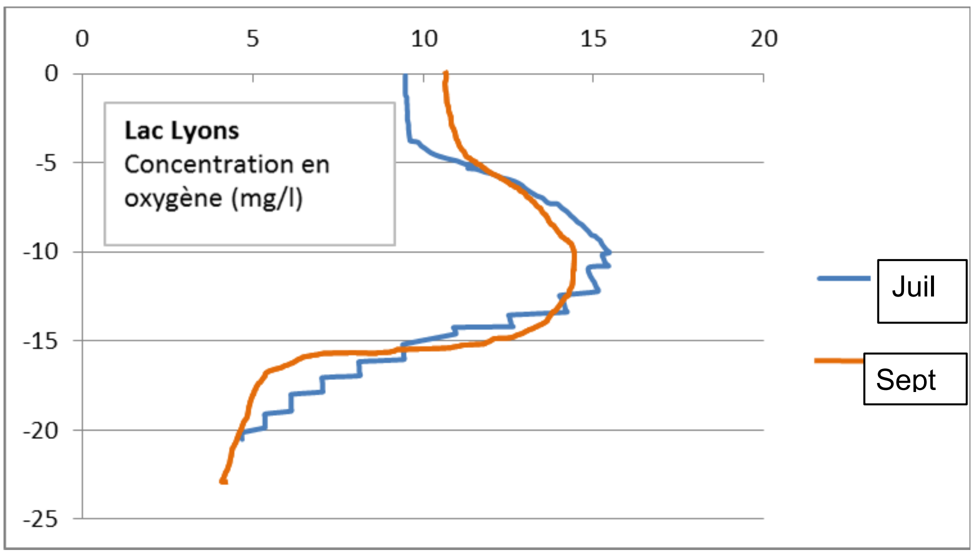


Fig. 22 — Oxygen Concentration Levels (mg/L) at various depths 0 m to -25 m) in Lyons Lake in July and in September 2017

3.7.5 ph

Lyons Lake's pH was slightly acidic (6.5–5.7), which can be harmful to some aquatic species requiring a pH between 6.5 and 9. This is probably due to the underlying bedrock containing more granite than limestone and also to the heavy precipitation over the summer. Although this is a normal situation for lakes on the Canadian

Shield, it would be interesting to carry out this test in more normal weather conditions to see if this trend continues.

3.8. Little Danford Lake

This elongated, oval-shaped lake is the shallowest of all four lakes studied in 2017 and also the most densely populated, especially on its western bank. Geographically, it is an extension of Danford Lake's depression, and both lakes may have formed one unit in a distant past. Little Danford does not have any noticeable tributaries or emissaries.

3.8.1 Temperature

At the end of July 2017, the water temperature of Little Danford Lake was fairly high in the first 4 meters below the surface, its thermocline* being reached between 4 and 6 m. The temperature remained fairly high even in the deepest water layer (7-8 °C).

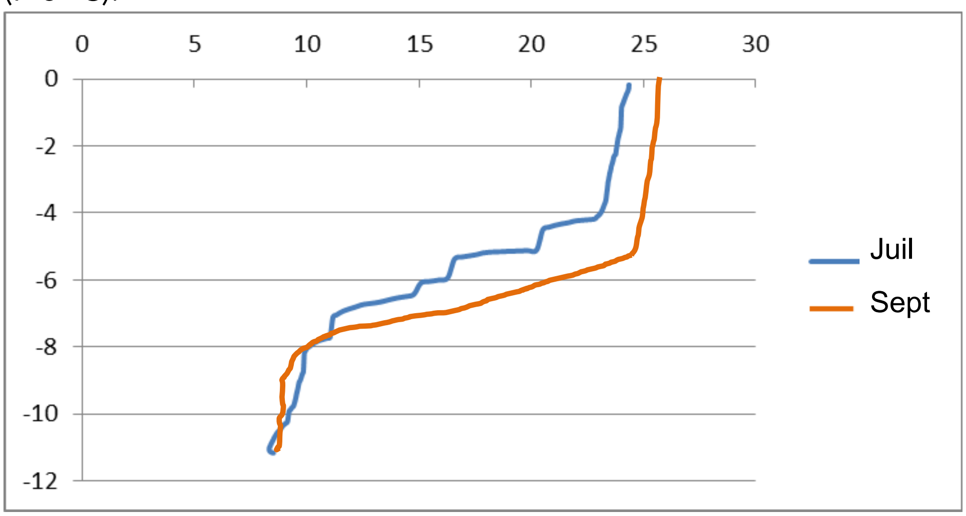


Fig. 23 — Temperature at various depths (0 m to -12 m) in Little Danford Lake in July and in September 2017

3.8.2 *E. coli*

E. coli concentrations varied slightly over the years, while remaining way below the levels at which swimming should be prohibited (200/100 mL). The peaks observed in 2010 and 2014 may be due to faulty septic systems or to weather-related events causing runoff. The water quality of Little Danford can be deemed excellent.

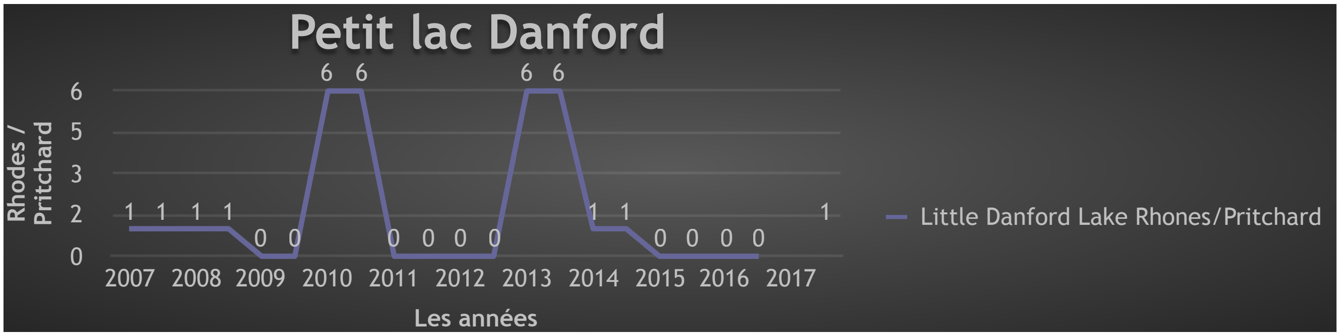


Fig. 24 — *E. coli* (CFU/10 mg) n Little Danford Lake over 10 years (2007-2017)

3.8.3 Total Phosphorus

Over the years, all samples (taken by LAK in the Spring or in the Fall of each year) showed a slight increase of phosphorus levels, but they remained way below the threshold of eutrophication (0.03 mg/L). Phosphorus is found naturally in small amounts in lake water, but the main sources of this nutrient are linked to human activity. In the case of Little Danford Lake, the rainy summers of 2013 and 2017 may have impacted the level of phosphorus concentrations. It would be interesting to carry out further tests to see if this trend continues.

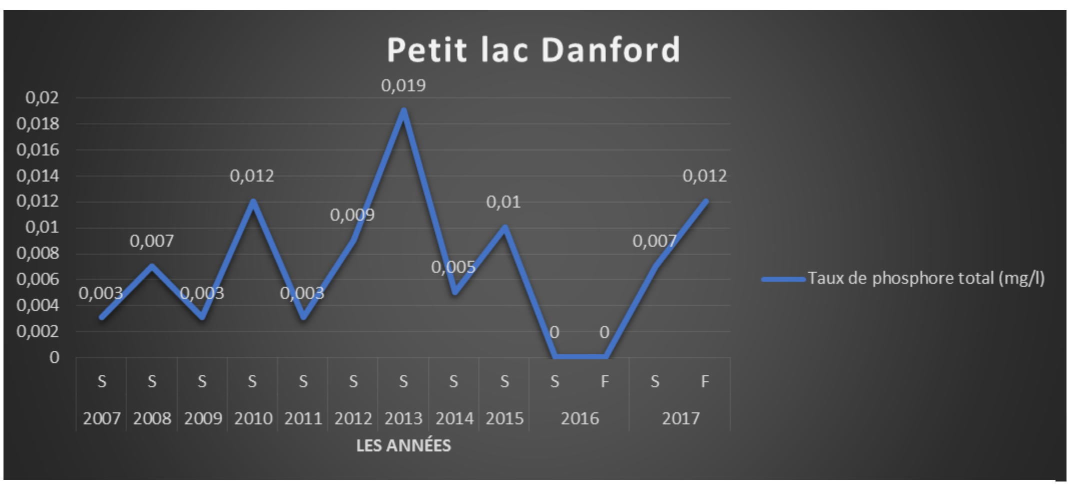


Fig. 25 — Phosphorus concentrations (mg/L) in Little Danford over 10 years (2007-2017)

3.8.4 Dissolved Oxygen

Dissolved oxygen levels have been stable over the summer of 2017—the July and September curves (6 week-interval) are very similar. Little Danford Lake's water is well oxygenated, and we even observed a slight increase of oxygen concentrations between 6 and 10 m below the surface. At greater depths, the oxygen levels remained high for this lake, which is excellent for freshwater organisms.

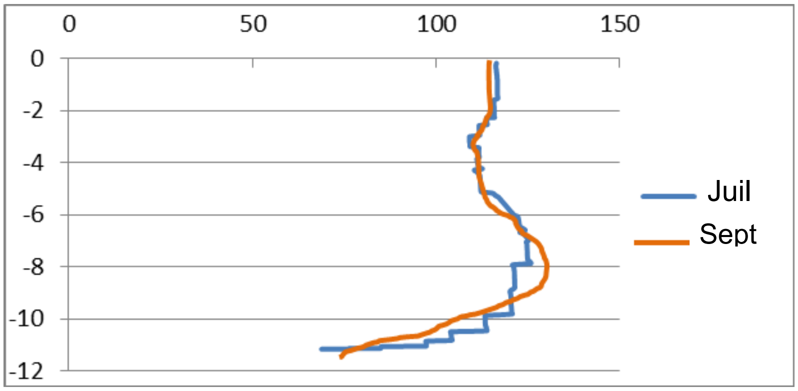


Fig. 26—Dissolved Oxygen Saturation Levels (%) at various depths 0 m to -12 m) in Little Danford in July and in September 2017

(Please see this graphic in the original French Report)

Fig. 27 — Dissolved Oxygen Concentrations (mg\L) at various depths 0 m to -12 m) in Little Danford in July and in September 2017

3.8.5 pH

pH readings varied between 9.34 and 7.26. These values remain normal while indicating an alkaline water (higher than 7.5), particularly in the water upper layer and down to 4 m below the surface. An ideal pH for aquatic life is between 6.5 and 9.

These fairly high readings are probably due to the underlying bedrock containing more limestone (than granite) and also to the presence of alkaline water springs near the location of sampling. It is recommended to take new pH readings at another location to see if this trend continues. A high alkalinity has a negative impact on the fish reproduction capacity and on the development of the aquatic microfauna that predatory species feed upon.

3.9 Summary on Water Quality of the Five Lakes Studied

Test results obtained by the Lakes Association of Kazabazua and by ABV-7 for the five lakes in question show that, on the whole, these lakes are healthy—they all have good oxygenation levels in the first 10 meters below the surface, and their phosphorus concentrations are low, albeit with slight variations. Depending on the parameters studied and also on the time and location of sampling, the five lakes can be considered oligotrophic or oligo-mesotrophic. This means that their transparency level is good, that they have an oxygenation level favourable to aquatic life, a good depth, and low levels of Chlorophyll *a* and total phosphorus.

However, we did note differences among the five lakes, and further tests should be carried out for monitoring purposes. Because of their small size, of the absence of tributaries and emissaries and because they are surrounded by steep-sided hills or ridges which, by protecting them from the wind, do not allow a good mixing of the water layers—and hence a good oxygenation—of the surface water ,the water quality of these five lakes can be seriously affected by variations of the parameters studied.

Furthermore, because their water levels seem to be very closely linked to the underground water table, it will be very important to monitor any situation that might erode the soil and introduce pollutants in the water table. The same vigilance applies to all activities carried out on the shore that may negatively impact the lake's main natural defence (its natural shoreline)—this includes the use of chemical products that may end up in the lake and any backfilling or construction activity directly on the shore.

Parameter	Lake	Average	Ministry's standard value	Category
Total Phosphorus (mg/L)	Farm	0.011	higher than 0.03mg/l: Eutrophic	Oligotrophic
	McConnell	0.011		Oligotrophic
	Little Shea	0.011		Oligotrophic
	Lyons	0.013		Oligotrophic
	Little Danford	0.010		Oligotrophic
Chlorophyll *a* (µg/L)	Farm	2.17	0 – 3 µg/L: Oligotrophic 3 – 8 µg/L: Mesotrophic 8 µg/lL and over: Eutrophic	Oligotrophic
	McConnell	2.29		Oligotrophic
	Little Shea	1.27		Oligotrophic
	Lyons	3.0		Oligo-mesotrophic
	Little Danford	3.22		Oligo-mesotrophic
Transparency	Farm	5.2	lower than 1.2m: Eutrophic	Oligotrophic
	McConnell	6.3		Oligotrophic
	Little Shea	4.3		Oligo-mesotrophic
	Lyons	5.0		Oligotrophic
	Little Danford	5.6		Oligotrophic

Table 6—Summary of results obtained in 2017 for the three main parameters in the five lakes studied

3.9.1 *E. coli*

The Lakes Association of Kazabazua has been testing for *E. coli* since 2007. The average concentrations found in all five lakes is indicative of a good—even excellent—water quality. A few peaks were observed in Lyons Lake and Little Shea Lake, but this is nothing serious because, in every case, the concentrations remain way below the levels at which swimming should be prohibited (200/100 mL). These occasional variations may be due to faulty septic systems or to higher-than-normal concentrations of beaver or wild-fowl excrements.

3.9.2 Total Phosphorus

With the exception of a few moderately higher readings, results have shown generally low total phosphorus levels, which is typical of oligotrophic or oligo-mesotrophic lakes. As a comparison, the average total phosphorus concentration measured since 2007 is 5 μg/L (0.006 mg/L) in Big Danford and 11 μg/L (0.01 mg/L) in Little Danford, which is the lake closest to having a mesotrophic status (State II of III).

All five lakes have different profiles with variable concentrations. In Farm, McConnell, and Little Shea lakes, total phosphorus concentrations have been fairly stable over time whereas we observed an upward trend in the case of Lyons and Little Danford lakes. However, over the years, each of these five lakes has shown one or several peaks, which may have been caused by a weather-related event (e.g. a violent storm in the days preceding sampling, heavy precipitation. etc.) or by some accidental discharge of unknown origin.

Further annual testing is recommended for monitoring purposes.

4. STUDY of SHORELINE

To assess the current condition of the shore, we used the Protocole established by the Quebec Ministry of the Environment and the Conseil régional de l'environnement des Laurentides (2007).

4.1 Land Use

According to the Quebec Ministry of the Environment's Protocole, five different so-called '*homogeneous zones*' can be identified on a lake shore, each zone being defined by the predominant use made of the land on its shore:

1. No Use of the Land (natural vegetation throughout);
2. Land Used for Agricultural Purposes;
3. Land Used for Forestry Purposes;
4. Land Used for Infrastructure (road, dam, railway, logging trail);
5. Land Used for Buildings (cottages, residences, others) or for Recreational Purposes (public access, camping, beach, public park).

While touring the five lakes by boat, we were able to determine how many 'homogeneous zones' each lake has (Table 7):

Lake	Homogeneous zones
Farm	4
McConnell	20
Little Shea	18
Lyons	10
Little Danford	10

Table 7—Number of homogeneous zones in the five lakes studied

Three categories of homogeneous zones are usually observed around lakes:

1 (No Use of the Land), 4 (Land Used for Infrastructure), and 5 (Land Used for Buildings or Recreational Purposes).

Using aerial photographs as well as photos and notes taken onsite, we identified only two categories of 'land use' on LAK's five smaller lakes, i.e. 1, and 5. (Category 4 was not represented).

Below are examples of these two categories of land use identified on the five lakes:

Category 5 (Land used for buildings, etc.)	Category 1 (No use of the land=vegetation throughout)
	
Little Shea Lake	Farm Lake

Fig. 28—Examples of the two categories of land identified on the five lakes

Based on the information gathered, we then assessed the degree of vegetation cover for each zone using the following categories from the Ministry:

1. Full Natural Cover;

2. Modified Cover (ornamental vegetation);

3. Presence of Inert Materials (zone partially covered with buildings, asphalt, concrete, sand or gravel);

4. Bare Soil, Signs of Erosion;

5. Presence of Retaining Walls.

Finally, we determined the deterioration rate of the shorelines.

4.2 Human-made Changes to the Shoreline

Three categories of human-made changes to the shoreline were identified on the five lakes. Below are some examples:

Presence of Inert Materials

Little Danford Lake

Modified Cover (Ornamental Vegetation)

McConnell Lake

Full Natural Cover

Lyons Lake

Fig. 9—Examples for the three categories of human-made changes identified on the five lakes' shorelines

Ornamental vegetation (e.g. lawn) and inert materials contribute to runoff, erosion and the washing of nutrients in the lake.

The majority of zones identified on the five lakes' shores show a mix of the three categories (*Inert Materials, Ornamental Vegetation, and Full Natural Cover*). In order to give a truly representative picture of what we observed on the 15m-wide strip of land constituting the shoreline, we are giving the percentages of human-made changes to the shoreline.

A reminder: The M.R.C. Vallée-de-la-Gatineau's By-law 2009-206 prohibits any construction or work of any kind on the 15-wide shoreline—this includes lawn or grass mowing, brushing, the clearing of trees and the use of fertilizers. A list of changes to the natural shoreline requiring a municipal permit is part of that By-law. *(Translator's Note: This By-law is now a municipal by-law.)*

4.3 Deterioration Level of Shoreline

The deterioration level of shoreline is caused by the presence of any type of structure, by the clearing of trees, by any changes to the natural shore, and by any ecosystem disturbance which causes soil degradation or erosion or which can impact, positively or negatively, a landscape's appearance.

Two types of human-made changes to the shoreline are taken into account for assessing the level of deterioration:

- **bare soils**, because they increase the risk of erosion and pollution (pollutants, sediment, and nutrients are washed into the lake by rain).
- **stone walls and embankments** because they can concentrate run-off, facilitate erosion and contribute to the supply of phosphorus. When stone walls and embankments are present on the lakeshore, waves cannot break against them in the way they do on a natural shore, and this leads to decreased oxygen in the water close to the shore (littoral zone).

The levels of deterioration on the 15m-wide shore strip constituting the shoreline are based on the percentage of disturbed shoreline.

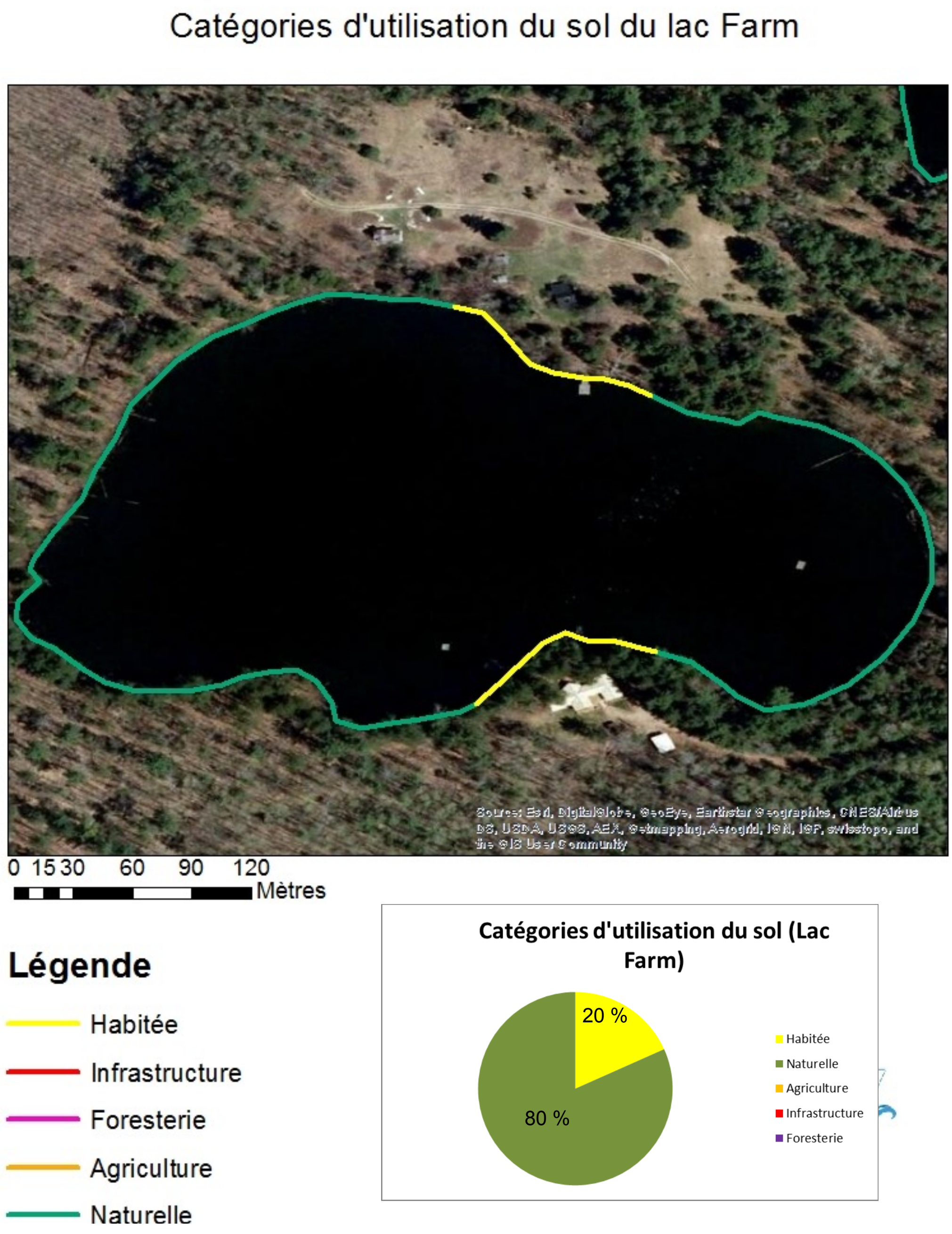
Below are the results obtained for each of the five lakes studied.

4.4 FARM Lake

This small lake (2.5 ha) does not have any emissaries, but it is fed in part by small seasonal creeks. Its bottom coincides with the underground water table, which explains its relatively good transparency and its slow reaction time to precipitation and summer drought. Its water level is therefore relatively stable, with slight seasonal variations. However, the summer of 2017 was particularly wet, so that the lake water level remained high all summer. Like other kettle* lakes in the area, it is fairly deep for its size (21.6 m at its greatest depth).

4.4.1 Land Use

Farm Lake has a low rate of occupancy (20%)—only two dwellings can be found on its wooded banks. Because the natural vegetation cover is well preserved all around it, there are no problems as long as that natural vegetation is preserved.



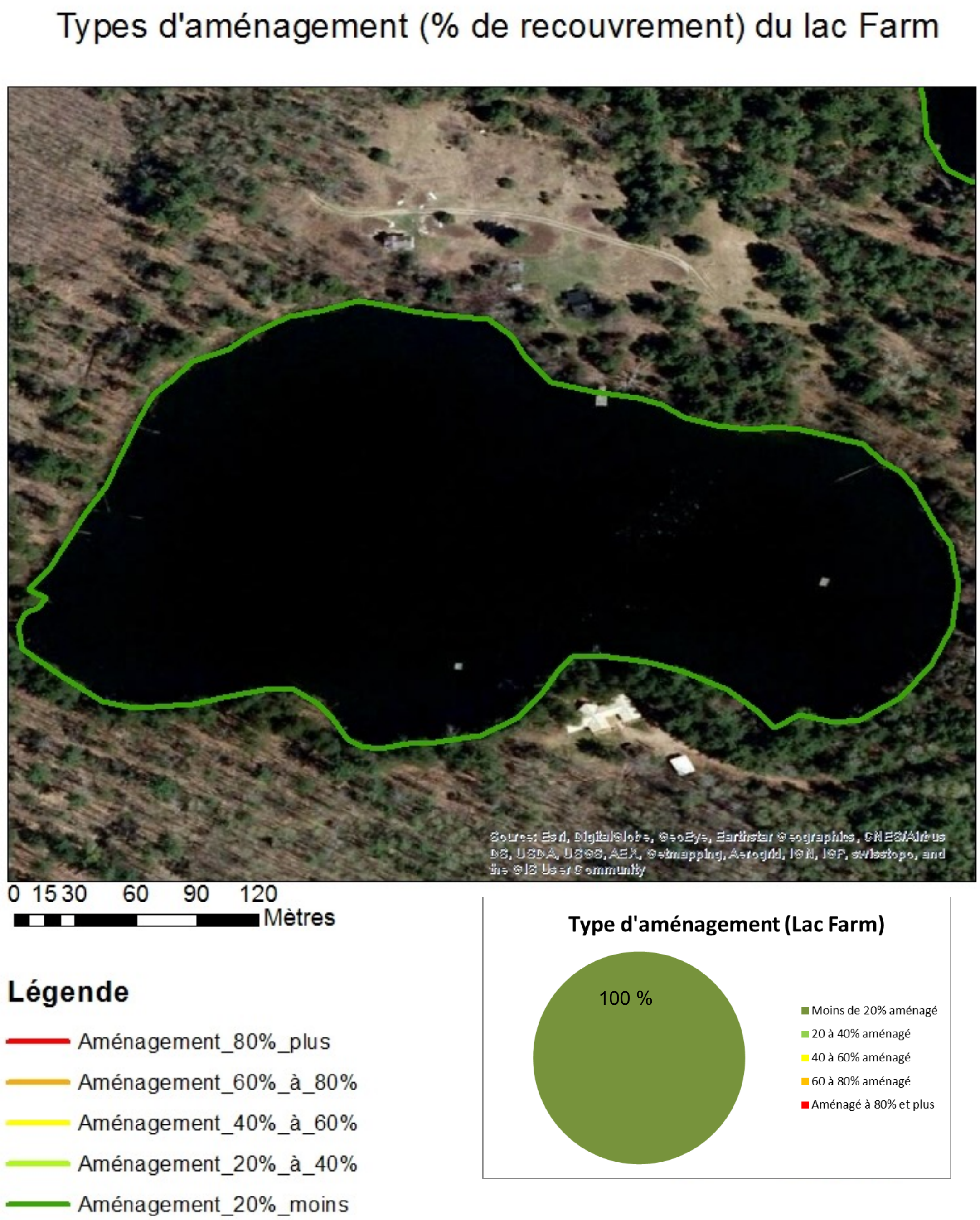
20% — Used for Buildings

80% — No Use (natural vegetation throughout)

Fig. 29—Land Use Categories on Farm Lake

4.4.2 Human-Made Changes to Shoreline

Except for a couple of docks, we did not see any human-made changes on Farm Lake's shoreline, which is entirely covered by natural vegetation. Consequently, this lake is at no risk of deterioration as long as its wooded banks are left untouched.

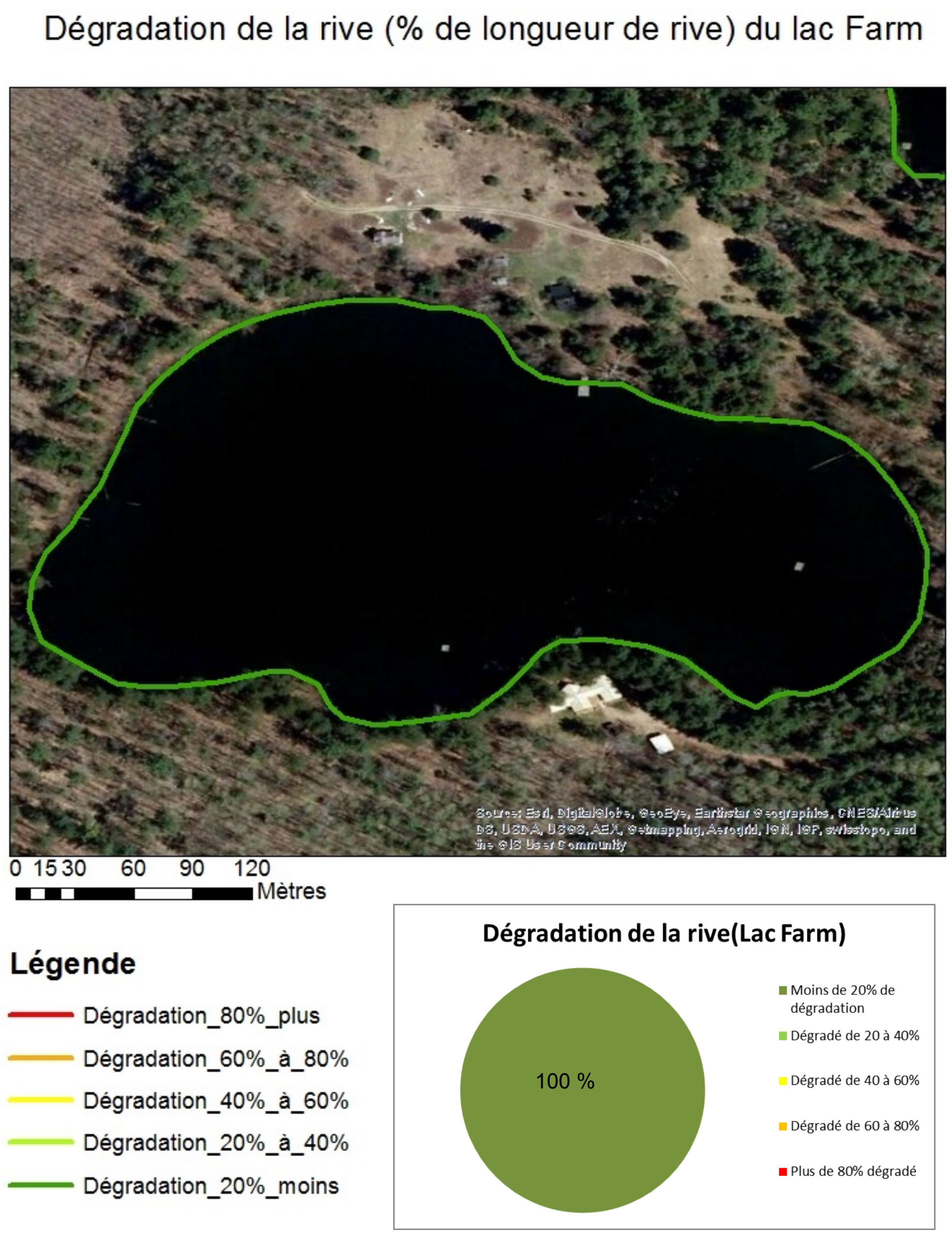


Less than 20% of Farm Lake's shoreline is used, which means that natural vegetation covers close to 100% of its shoreline.

Fig. 30—Human-made changes on Farm Lake in percent

4.4.3 Deterioration Level of Shoreline

There is no deterioration of Farm Lake's shoreline since almost 100% of it is covered by natural vegetation Its steep banks are all wooded.



Less than 20% of Farm Lake's is deteriorated
(almost 100% of its shore has been left untouched).

Fig. 31— Deterioration of Farm Lake's shoreline in percent

4.5 McConnell Lake

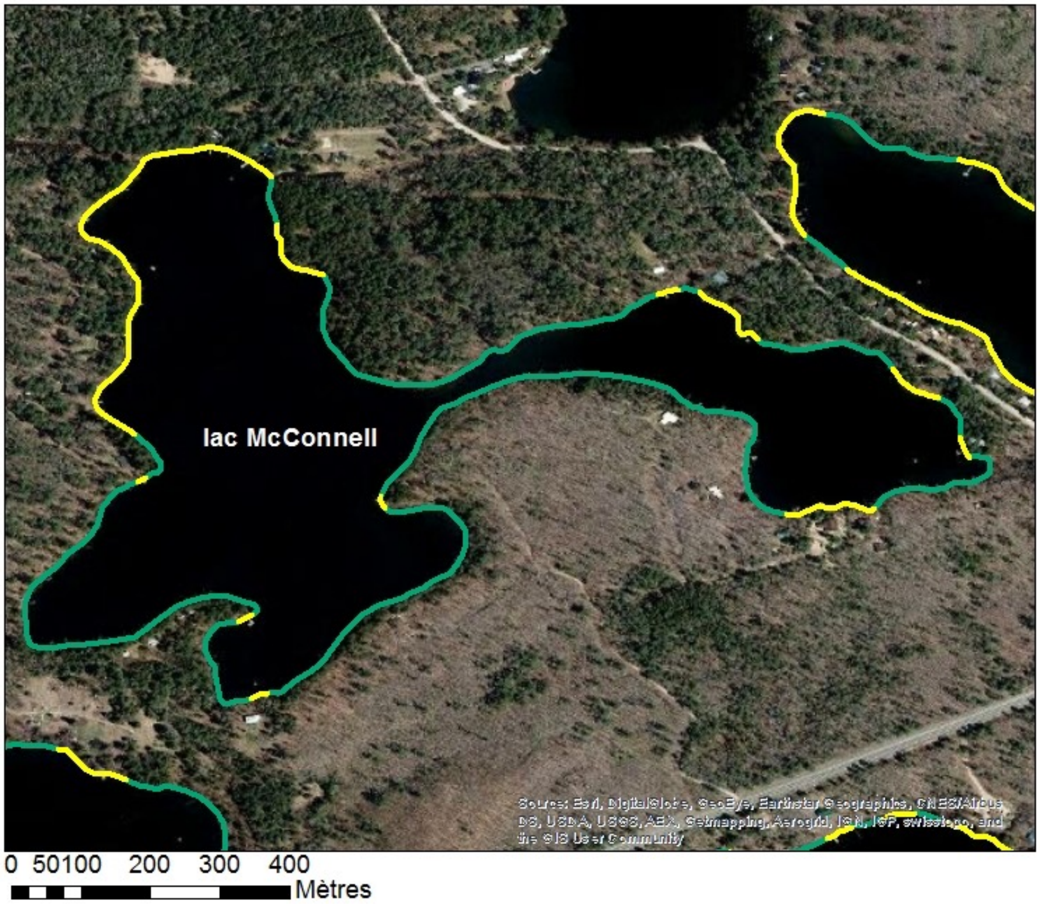
McConnell is the largest of the five lakes studied in 2017 (area: 26 ha, depth: 26 m). It has a complex morphology, with a large bay extending eastward. We counted approximately 30 cottages on its banks. Most of the property owners take relatively good care of their shoreline. However, in three cases, the shoreline has an insufficient vegetation cover (there is only lawn or grass down to the water with only a few shrubs here and there). We also noted a couple of retaining walls and dwellings situated directly on the shoreline.

4.5.1 Land Use

On the whole, McConnell's shoreline is well-preserved—with natural vegetation covering 76% of it. The largest number of residences, mostly seasonal, are concentrated in the northern part of the lake, the others are scattered here and there—all together they occupy 24% of the banks. Whenever cottages occupy the top of the hills or ridges surrounding the lake, the shoreline natural cover has not been heavily disturbed.

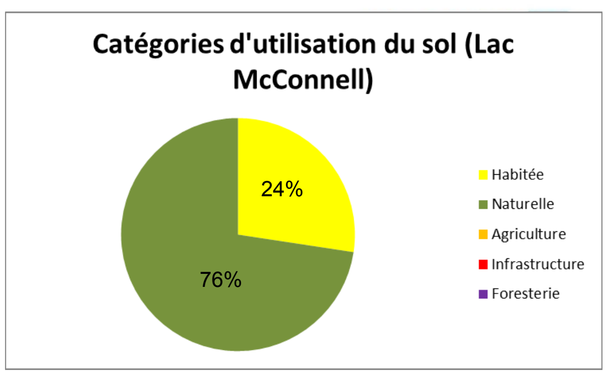
However, a few properties have too much bare land down to the lake, and their shoreline could be revegetated more densely.

Catégories d'utilisation du sol du lac McConnell



Légende

- Habitée
- Infrastructure
- Foresterie
- Agriculture
- Naturelle



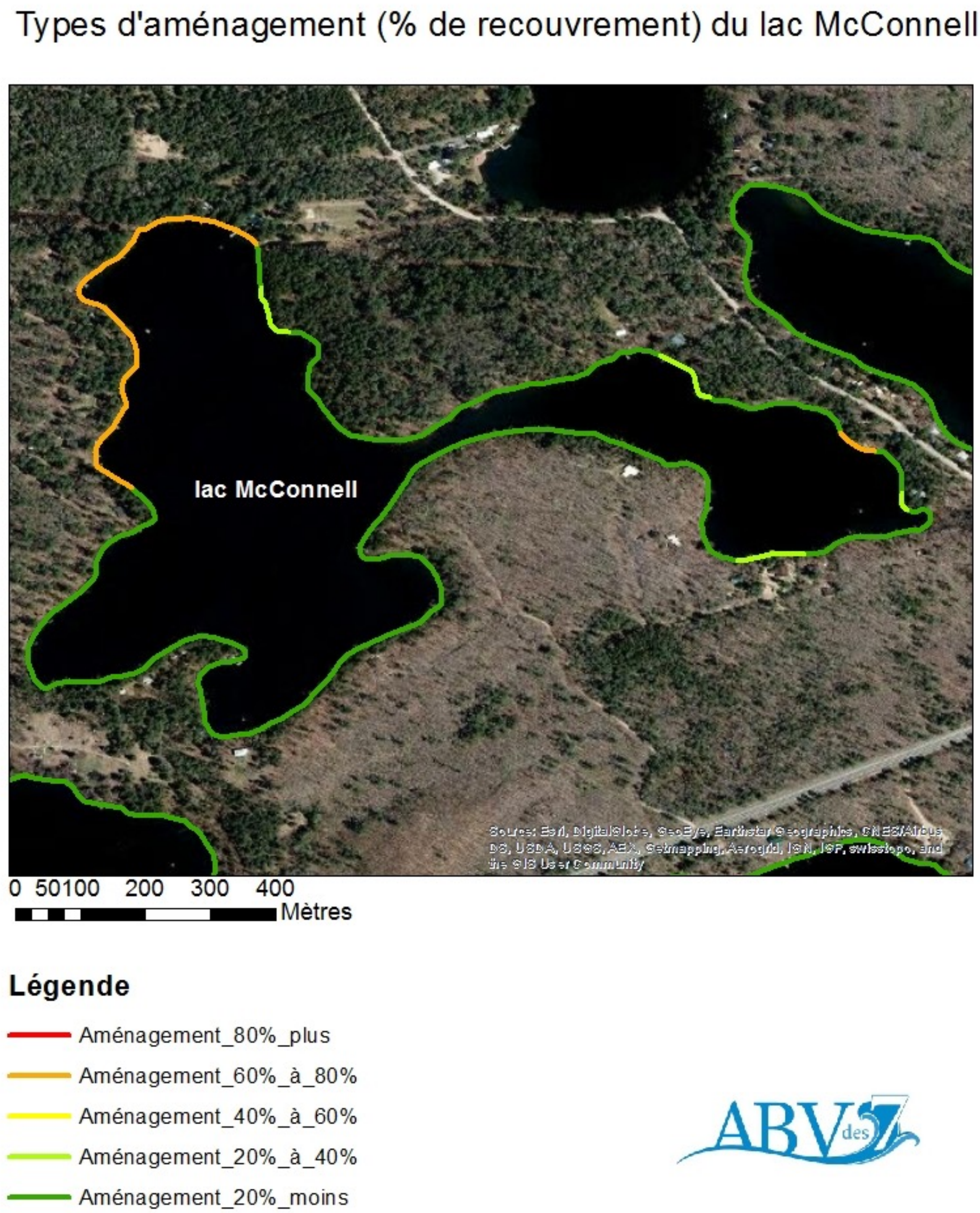
26% — Land Used for Buildings

74% — No Use By Humans (natural vegetation throughout)

Fig. 32 - Land Use Categories on McConnell Lake's Shoreline

4.5.2 Human-made Changes to Shoreline

Most of the human-made changes consist in the partial clearing of trees on the shoreline directly in front of cottages. The most problematic situations are found in the northern and northwestern parts of the lake, as well as in the bay extending eastward . We also noted a couple of retaining walls and dwellings built right on the shoreline.



(Please see the pie chart in the French Report.)

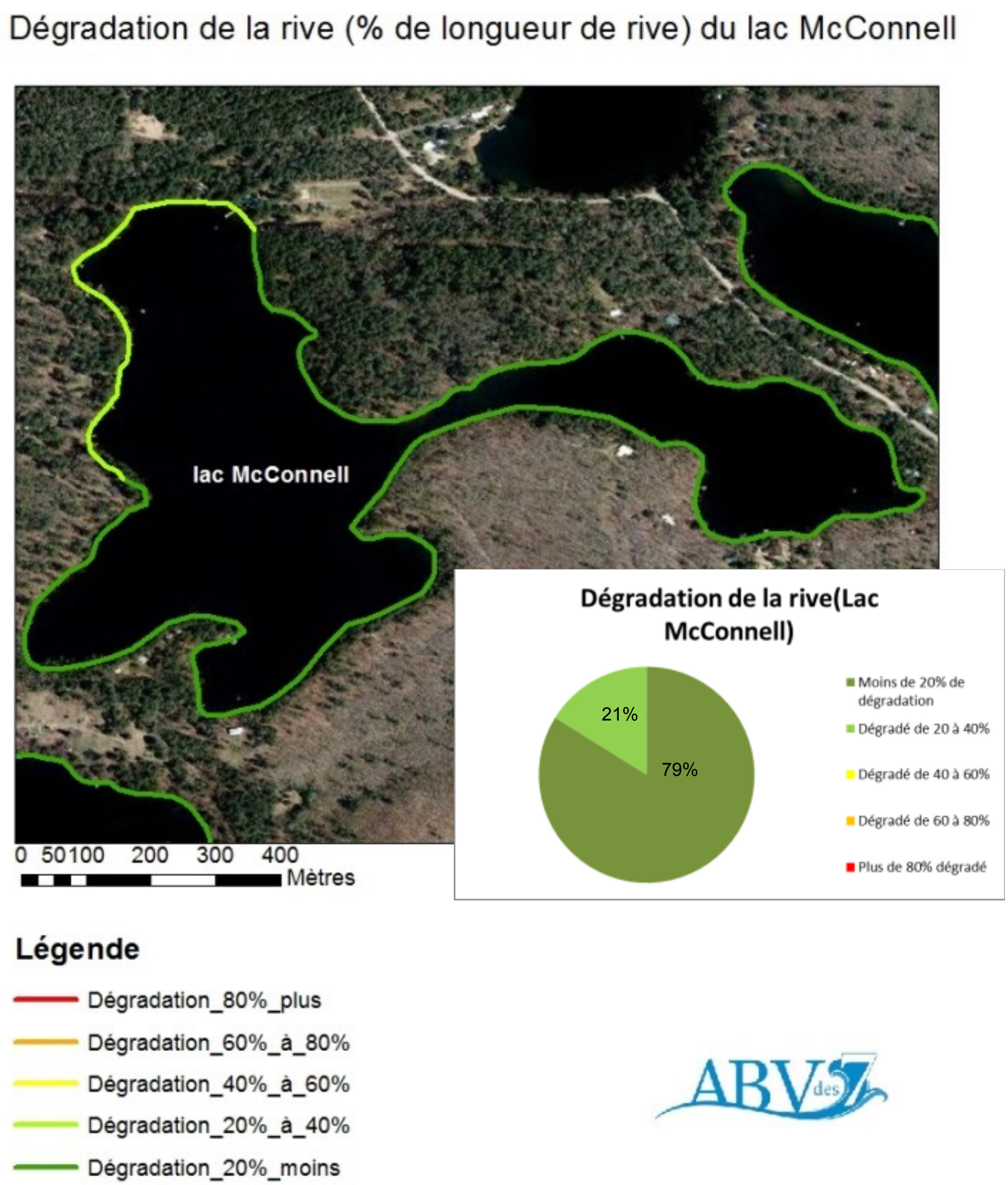
76% of the shoreline shows a modification rate of less than 20% (vegetation almost throughout), 9% a modification rate of 60%-80% (the colour should be orange on the graphic), and 5% a modification rate of 20%-40%.

Fig. 33—Human-made Changes on McConnell Lake's Shoreline in percent

4.5.3 Deterioration Level of Shoreline

McConnell Lake's shoreline is generally well-preserved. However, 21% of the total shoreline (north-western part of the lake) shows a deterioration of 20% to 40%. The remaining shoreline (79%) has been left untouched (less than 20% deterioration). There is consequently no real concern as long as the vegetation cover is preserved. Natural vegetation could be easily restored on areas deprived of it, especially in front of some cottages.

There is a (partially collapsed) concrete retaining wall along a property shoreline in the northern part of the lake, and a wooden retaining wall along a property shoreline in the bay extending eastward. We also noted a boat house and a small dwelling built right on the water line.



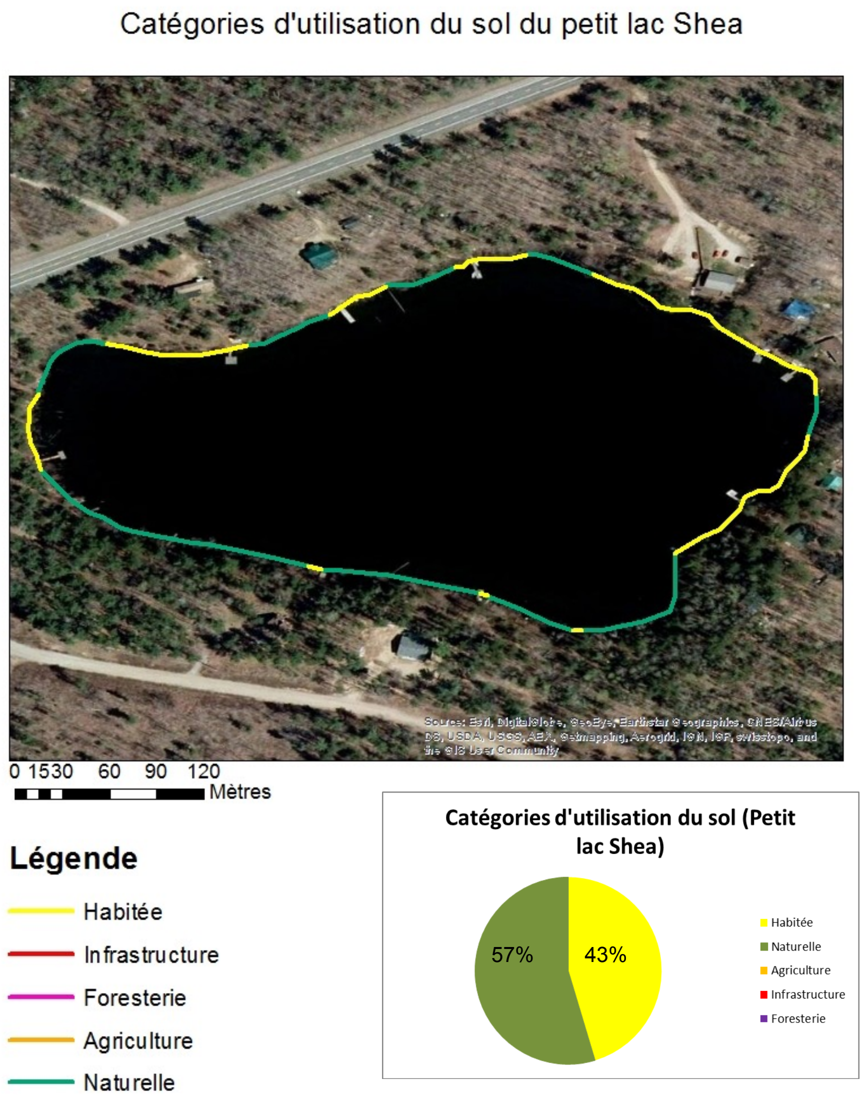
79% of the shoreline is less than 20% deteriorated.
21% shows a 20%-40% deterioration rate.

Fig. 34—Deterioration Level on McConnell Lake's Shoreline

4.6 LITTLE SHEA LAKE

4.6.1 Land Use

Little Shea is situated south of the 301, less than 50 m from that road. Eleven dwellings occupy the banks of this small (5.7 ha) lake—most are cottages, a few are used as permanent residences. The 43% occupancy rate exerts some pressure on the lake.



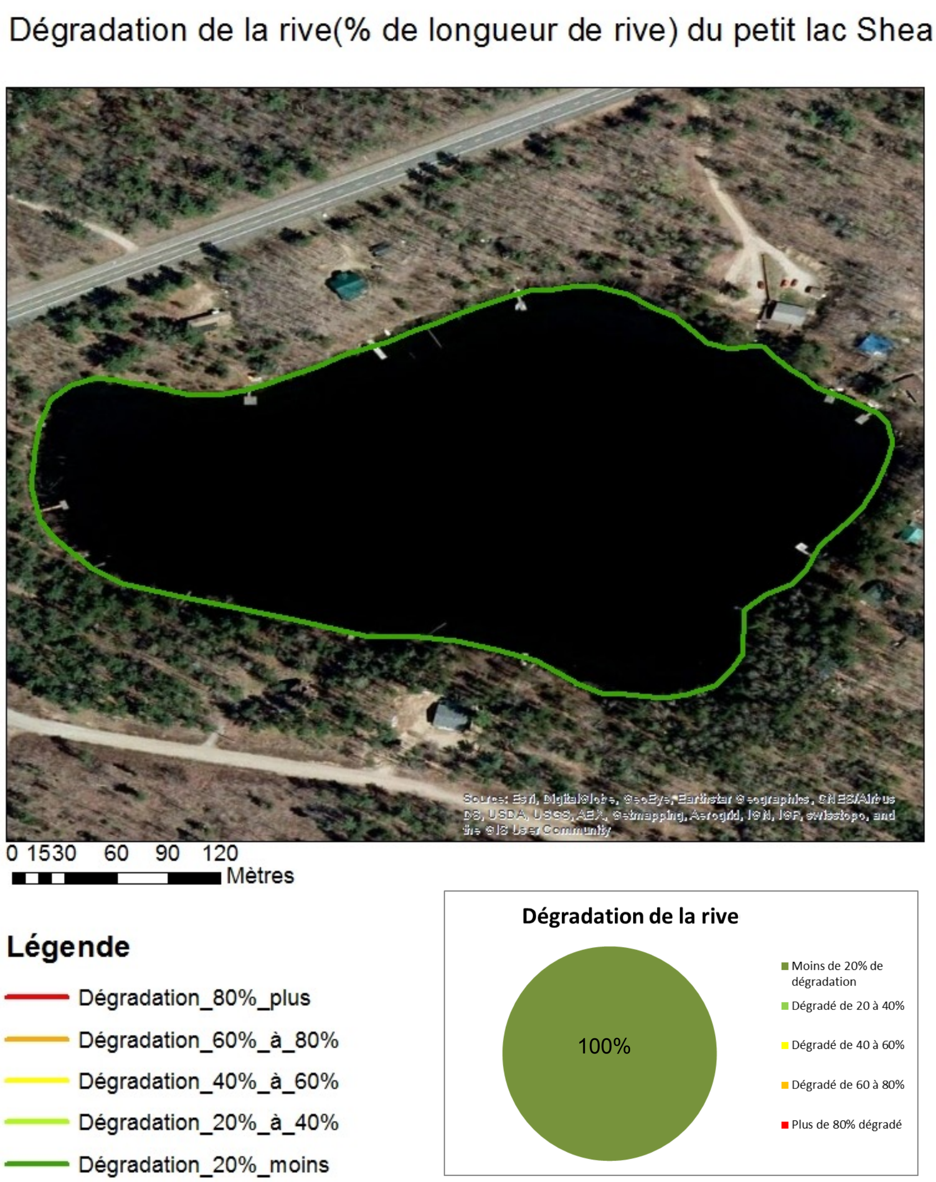
43% — Land Used for Buildings or Recreational Purposes

57% — No Use (natural vegetation throughout)

Fig. 35—Land Use Categories on Little Shea Lake

4.6.2 Deterioration Level of Shoreline

In spite of a 43% occupancy rate, we have not observed any deterioration of Little Shea Lake's shoreline—all lake banks are wooded, and the openings onto the lake for access to the docks comply with regulations. We have not observed any retaining walls, construction work or trails used for a boat launch—all factors which usually contribute to the deterioration of a lakeshore.



100% of the shoreline is less than 20% deteriorated.

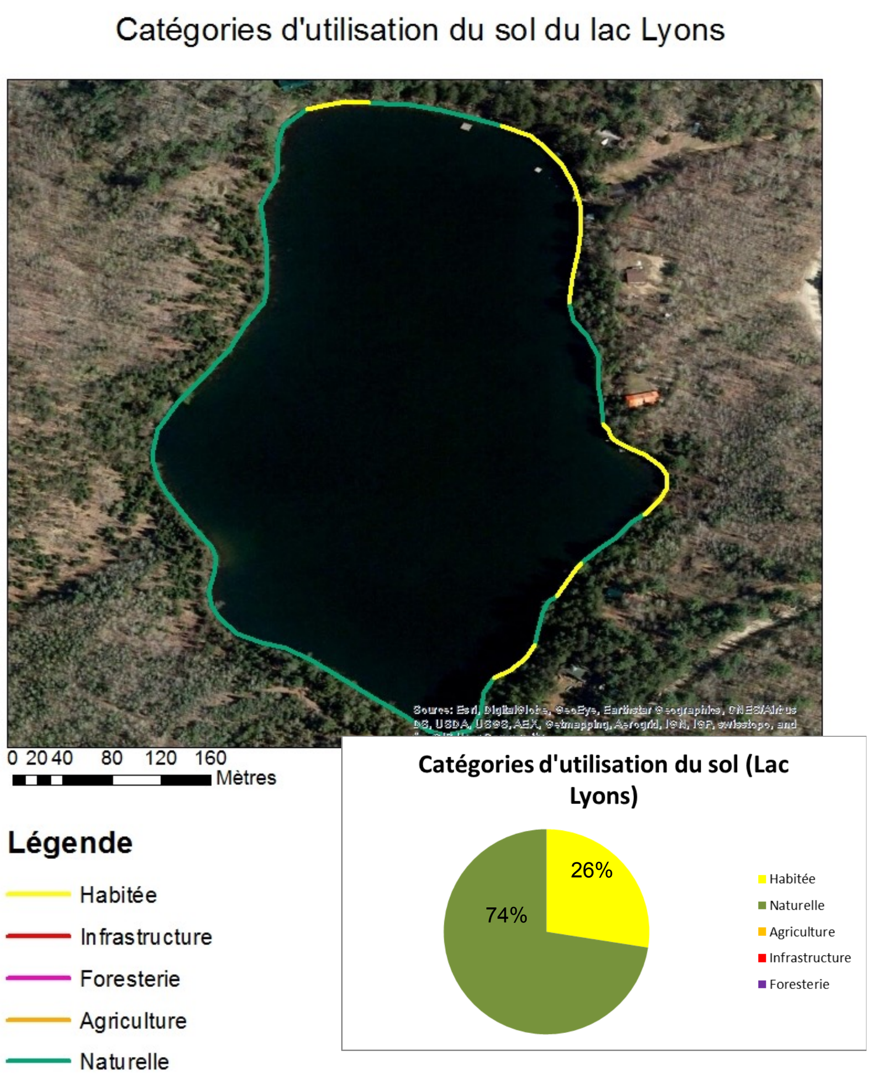
Fig. 36—Deterioration of Little Shea Lake's Shoreline

4.7 LYONS LAKE

Lyons Lake is a small lake (9.4 ha) with low human pressure—75% of its shore is covered with natural vegetation throughout. This is a relatively steep-sided lake, with its high banks covered with forest vegetation.

4.7.1 Land Use

Eight cottages or permanent residences occupy the western and northern parts of the lake (26% occupancy rate). Forest occupies the remaining 74% .



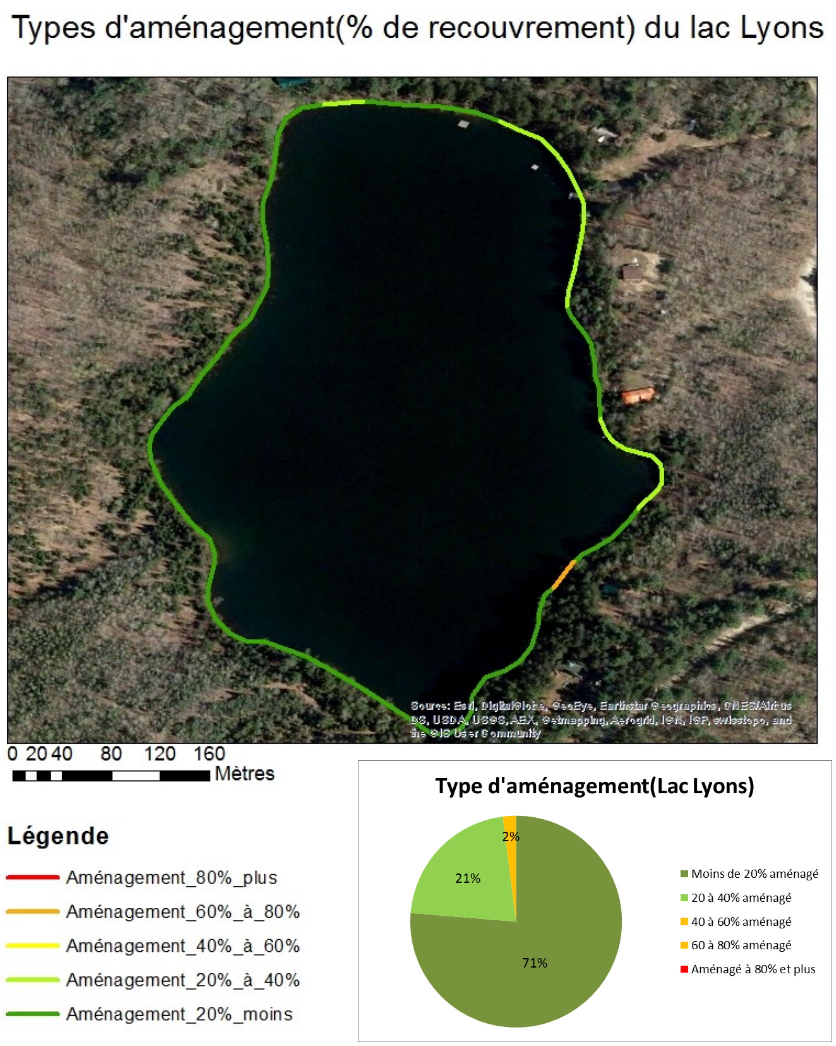
26% — Used for Buildings or Recreational Purposes

74% — No Use by Humans (forest vegetation throughout)

Fig. 37—Land Use Categories on Lyons Lake

4.7.2 Human-made Changes on Shoreline and Deterioration of Shoreline

There are relatively few human-made changes to Lyons Lake’s natural shoreline, except in one case where the percentage of deterioration reaches 60%-80%: too many trees have been cleared, and old structures (docks, etc.) were left abandoned, which is problematic. We also noted a few old structures scattered elsewhere on the lakeshore, e.g. a few sheds situated directly on the shoreline, a few old retaining walls, piles of garbage or old boats abandoned and in ruins. They are an eye sore and can be a source of pollution. Together these disturbances represent 2% of the total shoreline, and corrective measures could easily be applied. If the overall percentage of deterioration remains low it is solely because 77% of the shoreline remains covered with natural vegetation.



2% of the shoreline shows a 60%-80% deterioration rate, 21% shows a 20%-40% deterioration rate, and 77% is less than 20% deteriorated.

Fig. 38 - Human-made Changes on Lyons Lake Shoreline in percent

		
Old boat and chair abandoned on the shoreline	Shed too close to the water line	Insufficient vegetation cover on this grassy area

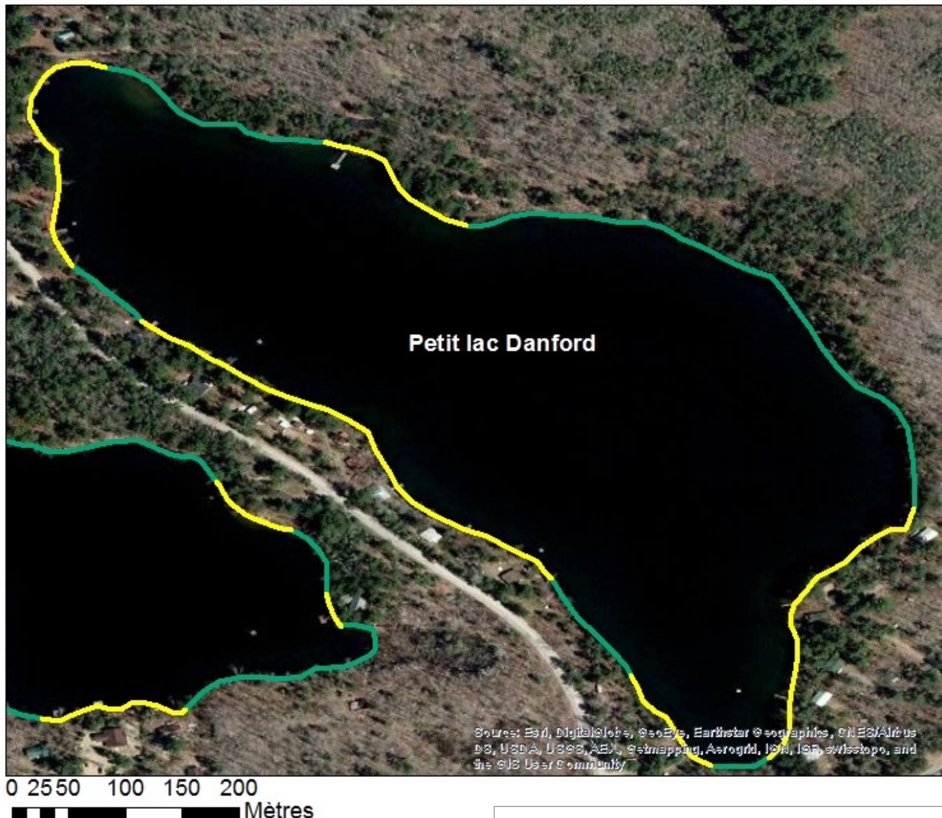
Fig. 39—Examples of human-made changes on Lyons Lake's shoreline

4.8 LITTLE DANFORD LAKE

4.8.1 Land Use

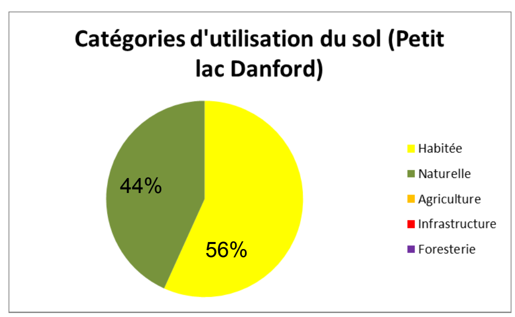
Of all five lakes studies in 2017, Little Danford Lake has the strongest human pressure. Almost all of its western bank is occupied with cottages, i.e. 56% of its shore are used for buildings and only 44% are covered with natural vegetation.

Catégories d'utilisation du sol du petit lac Danford



Légende

- Habitée
- Infrastructure
- Foresterie
- Agriculture
- Naturelle



44% — No Use by Humans (natural vegetation throughout)

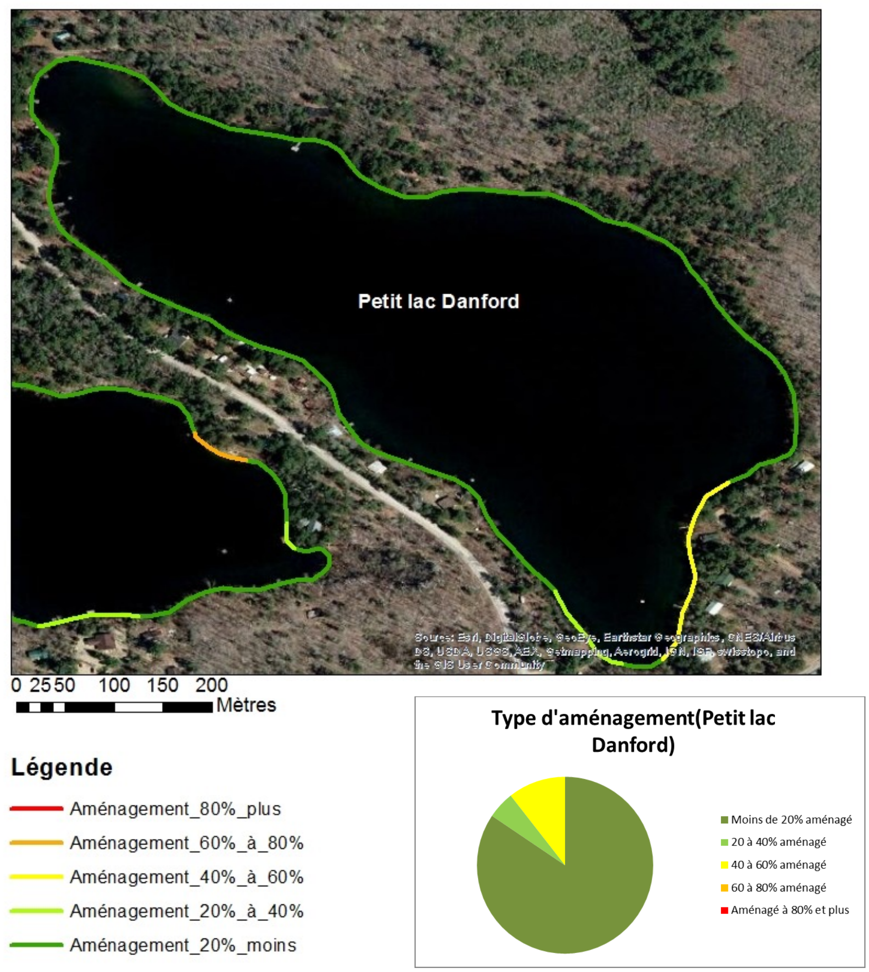
56% — Used for Buildings or for Recreational Purposes

Fig. 40—Land Use Categories on Little Danford Lake

4.8.2 Human-made Changes on Shoreline

In spite of a high occupancy rate, Little Danford Lake's shoreline is relatively well-preserved, probably because the 21 cottages occupy the ridges or hills surrounding the lake. A few properties have a lawn or grass down to the waterline, but in most cases, a strip of natural vegetation is maintained on the shoreline. It should be noted that some of these strips of vegetation, although preferable to lawns, remain insufficient to protect the lake effectively.

Types d'aménagement (% de recouvrement) du petit lac Danford



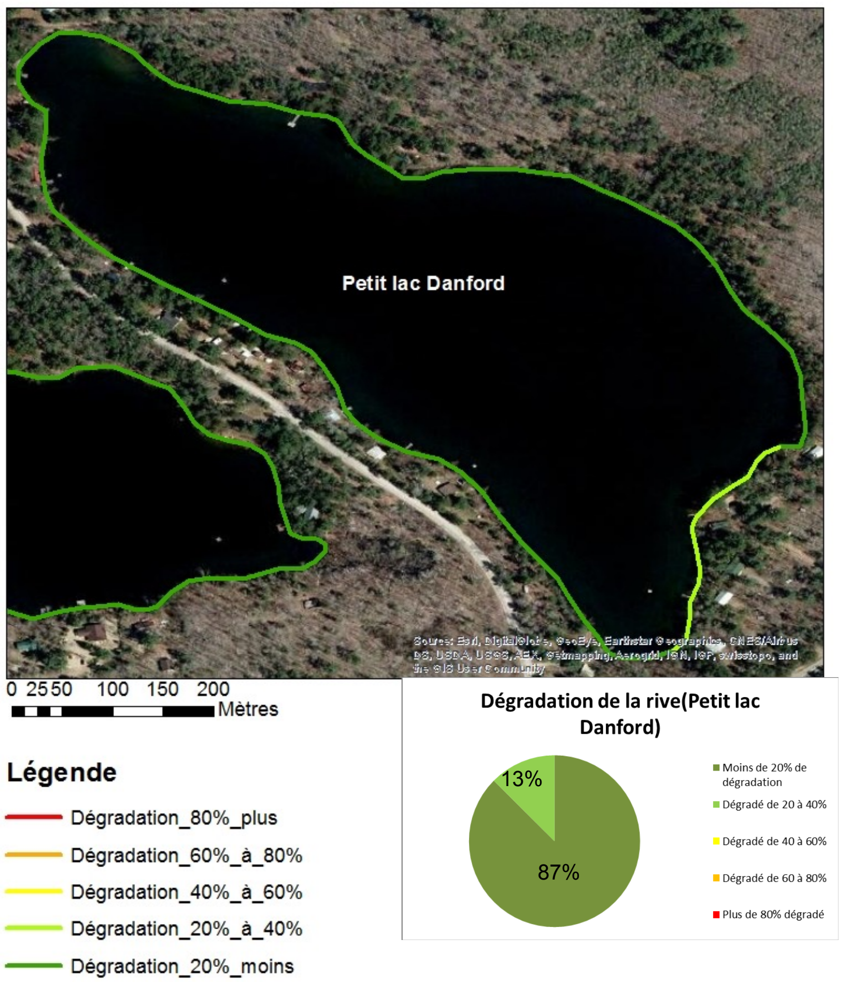
87% of the shoreline (dark green) has been modified less than 20%,
4% (light green) shows a modification rate of 20%-40%, and
9% (yellow) a modification rate of 40%-60-%.

Fig.41 - Human-made Changes on Shoreline in percent

4.8.3 Deterioration Level of Shoreline

On Little Danford Lake, the shoreline's deterioration rate is average in some places, and higher in the southern part. Some properties have a boat launch area, thereby creating erosion with direct runoff into the lake. A few properties' shoreline has no vegetation cover, which increases the risk of erosion. Most of the time, the deterioration is due to an excessive clearing of trees and an exposed shore.

Dégradation de la rive (% de longueur de rive) du petit lac Danford



On 13% of the shoreline, the deterioration rate is 20%-40%.

On 87% of the shoreline, there is less than 20% deterioration.

Fig. 42 - Deterioration Level on Little Danford Lake's shoreline

		
Excessive clearing of shoreline	Boat launch area on a slope, creating erosion and runoff	Excessive clearing of shoreline, with building directly on the waterline

Fig. 43 - Examples of inadequate human-made changes to the shoreline on Little Danford Lake

4.8.4 Conclusion on Shoreline Study

When we combine the data gathered on land use and on the vegetation cover, we clearly see that natural vegetation predominates on the shoreline of all five lakes studied in 2017. The categories *Presence of Inert Materials* and *Erosion* represent a very small percentage of the total shoreline. The vegetation cover is generally adequate, with a few exceptions (dwellings too close to the waterline). Cases of ornamental vegetation with insufficient shoreline cover are rare and localized. As most of the dwellings occupy the hills ridges surrounding the lake, the shore can be protected but only as long as the vegetation cover is left untouched.

However, a few lake properties contribute to erosion and runoff because their shoreline is insufficiently preserved: lawn down to the waterline, insufficient tree density, presence of sheds or small structures right on the waterline, piles of garbage or abandoned canoes or chairs.

The less disturbed the shore, the better the lake's natural protection against erosion, eutrophication, and increased water temperature in the littoral zone. Consequently, efforts should be made (a) to restore natural vegetation on the shoreline itself, (b) to remove abandoned buildings or structures. All these measures would contribute to slowing down the eutrophication process and would prevent the introduction and spread of invasive species.

5. RECOMMENDATIONS

5.1 Potential Sources of Phosphorus in Lake Water

The concentration of phosphorus in a lake is an indicator of its trophic status and the main cause of eutrophication. In Kazabazua lakes' watershed, phosphorus is found naturally, but its main sources are linked to human activity (see Table 10).

Results from lab tests carried out for years for the Lakes Association of Kazabazua have shown that the water quality is good in each lake, albeit with some variations or a slight increase of the phosphorus concentrations in a given year. LAK's lakes are very vulnerable to any additional natural or human-made supply of phosphorus because of their small size and their slow water renewal rates. It is also possible that weather events prior to onsite sampling impacted lab test results, especially in the case of runoff caused by heavy rains. Although a study of results obtained so far indicate that the lakes are healthy, we recommend to keep testing the lakes for phosphorus on an annual basis.

Table 10—Potential Sources of Phosphorus in Lake Water

Natural Origin	**Wetlands and lakes**
	Erosion and runoff
	Release of phosphorus stored at the bottom of lakes
	Forest ecosystem
	Atmosphere
	Animal excrements (e.g. beaver, wild fowl) and biodegration of organic matter
Human Origin	**Bare Shoreline** Soil erosion, lack of vegetation cover on shorelines; presence of ornamental vegetation (most of the time, lawn) or of inert material in the 15m-wide shoreline
	High occupancy rate of lake banks
	Failing septic systems
	Use of soaps and detergents containing phosphates **Use of fertilizers**

5.2 Recommendations

Recommendations	Findings and actions	
1. To enforce regulations on lakeshore protection	**Findings**	The largest inhabited portion of McConnell, Little Danford, and Little Shea's shorelines is occupied with cottages and a few permanent residences. Some of them have an insufficient natural vegetation cover. An adequate vegetation cover is essential in order to avoid erosion and runoff which impact negatively the water quality and speed up the eutrophication (aging) process.
	Actions	**MRC Vallée de la Gatineau should** - develop tools for monitoring the enforcement of regulations efficiently - carry out annual lake inspections and raise awareness - apply strict criteria and limits when granting new permits de l'occupation des rives and approving projects that would increase the use of shores or new recreational, tourism or commercial (logging) activities on shores that might compromise the health of the lakes. **Lakes Association of Kazabazua (LAK)** - continue raising awareness on good practices and current regulations on lakeshore protection - Develop incentives for good practices.
	Findings	Natural vegetation is present on a fair percentage of the five lake shores. However,some sections of their shorelines are bare or disturbed. Moreover, in some places, the mandatory (10m or 15m-wide) shore strip is either too narrow or insufficiently covered with vegetation.

Recommendations	Findings and actions	
2. To restore natural vegetation on lakeshore	**Actions**	**MRC, Municipality of Kazabazua (KAZ), and LAK should** - join efforts in initiating projects aimed at (a) restoring natural vegetation on those parts of the lakeshore that do not comply with regulations and (b) raising awareness with regard to existing regulations - encourage lake property owners to apply good practices with a view to maintaining and preserving a healthy lakeshore vegetation cover - encourage lake property owners to *either* add vegetation on inadequate structures (retaining walls, riprap, buildings, decks, etc.) *or* to replace them altogether with vegetation, thus decreasing their negative impacts on lakes
3. To continue water quality testing	**Findings**	LAK's annual water testing is essential for monitoring the situation and implementing corrective measures if needed.
	Actions	**KAZ and LAK should** - continue annual water sampling at the same locations and testing using the same method. Monitoring results.

<table>
<tr><td rowspan="2">4. To Monitor Septic Systems</td><td>Findings</td><td>Kaz does a monitoring of all septic systems on its territory in compliance with provincial regulations (Règlement sur l'évacuation et le traitement des eaux usées des résidences isolées, LQE, 2002).</td></tr>
<tr><td>Actions</td><td>KAZ

- Continue present monitoring and explore the possibility of passing stricter regulations

- Keep a record of every lake property on pumping frequency and maintenance and, if needed, of replacement

LAK

- request from KAZ annual monitoring reports that give the number of failing septic systems for each lake</td></tr>
<tr><td rowspan="2">5. To raise awareness on good practices aimed at protecting water quality</td><td>Findings</td><td>Some property owners may have practices that are harmful to the environment. LAK should make them aware of the negative impacts of such practices.</td></tr>
<tr><td>Actions</td><td>LAK should
. continue (through its website, the use of flyers, newsletters, articles, etc.)
- to inform its members of the negative impact of fertilizers and pesticides and to offer alternatives;
- to encourage its members to use phosphate-free products, to recover ashes from fire pits, and to take measures aimed at limiting the flow of nutrients and poluutants into the water;
- to monitor the spread of chemicals on those sections of the roads that are in close proximity (within 15 m) to the water; and
. raise awareness with local farmers about the need to limit water pollution caused by animals, and raise awareness with forestry companies about the need to protect the shore of streams or creeks that cross parcels where logging occurs.
- Monitor fishing catches, introduction and proliferation of invasive species, non-authorized boats, etc.</td></tr>
</table>

6. CONCLUSION

Our study of the Lakes Association of Kazabazua's five smaller lakes (Farm, McConnell, Little Shea, Little Danford and Lyons) had two goals:

- test their water quality based on two samplings carried out in June/July and in September 2017 as well as on data collected by LAK since 2007;

- assess the condition of their shorelines in order to identify areas that might contribute to premature aging of the lakes (eutrophication),

thus completing the second and last phase of the research project on the health of LAK's lakes, which was initiated in 2016.

In a nutshell:

- in all five lakes, water quality is generally good. Depending on the parameter studied, and on the time and location of sampling, the lakes can be considered oligotrophic or oligo-mesotrophic. One of the parameters studied may have, at one point in time, indicated a more or less notable trend toward mesotrophy, but these occasional findings do not modify our overall conclusions. Human pressure is stronger on a few lakes, where the shoreline is deteriorated in some places. Consequently, this makes those five smaller lakes vulnerable, and the eutrophication process may be accelerated if measures are not taken to preserve the shoreline, i.e to restore natural vegetation on it.

- Human pressure is lower on Farm, Little Shea and Lyons lakes than on McConnell and Little Danford lakes, where this pressure is however still acceptable but only as long as their shoreline vegetation cover and their water quality are preserved.

- All water quality data show that Farm, McConnell, Little Shea and Lyons lakes can be considered oligotrophic, whereas Little Danford Lake shows early signs of eutrophication, although this risk remains low. In the case of Little Danford Lake, the eutrophication process seems to be a mainly natural origin (tributaries, run-off), and there are too few deteriorated sections of its shoreline to impact on the whole lake. All septic installations around that lake should be inspected.

Two factors should contribute favourably towards preserving these three lakes: the MRC's 2009 regulations on lakeshore protection (http://www.mrcvg.qc.ca/images/reglements/2009-206.pdf), and the fact that the Municipality of Kazabazua is among the MRC's municipalities using the MRC Septic Waste Management Plant.

In the light of this information, ABV7 recommends the following:

1. that the current regulations on lake shore protection be enforced; special consideration should be given to the fact that all five lakes have no tributaries or emissaries to speak of, which contribute to water circulation.
2. that natural vegetation be restored on those sections of the shores showing deterioration;
3. that annual water tests be continued by LAK;
4. that an annual update on the condition of septic systems be requested from the Municipality of Kazabazua, if possible;
5. that LAK continue to raise lake residents' awareness of good practices (e.g. the use of phosphate-free products, the recovery of ashes from fire pits, preservation of the shoreline vegetation cover, avoiding situations likely to cause erosion and runoff, washing of any outside boat entering the lakes in order to avoid the introduction and spread of invasive species.

7. BIBLIOGRAPHY

Lakes Association of Kazabazua (LAK). http://www.kazlakes.com/

MDDELCC. Loi sur la qualité de l'environnement, L.R.Q., c. Q-2.

MDDELCC. Code de gestion des pesticides.

http://www.mddelcc.gouv.qc.ca/eau/recreative/qualite.htm

MDDELCC (2016). La qualité de l'eau et les usages récréatifs.

http://www.mddelcc.gouv.qc.ca/eau/recreative/qualite.htm

MDDELCC (2016). Critères de qualité de l'eau de surface.

http://www.mddelcc.gouv.qc.ca/eau/criteres_eau/index.asp

MDDEP et CRE Laurentides (2007). Protocole de caractérisation de la bande riveraine. *In* MDDELCC. *Eau*. http://www.mddelcc.gouv.qc.ca/eau/rsvl/bande_riveraine.pdf

MRC de la Vallée de la Gatineau (2016), Règlement de contrôle intérimaire numéro 2009-206 visant à établir des mesures de protection des eaux superficielles, de protection des rives et du littoral à l'ensemble du territoire municipalisé de la MRC de La Vallée-de-la-Gatineau à l'exception du territoire du bassin versant du lac Heney et du territoire de la Ville de Maniwaki.

http://www.mrcvg.qc.ca/index.php/reglements/reglements-2009

RAPPEL (2012). L'eutrophisation (vieillissement des lacs). *In* RAPPEL. *Lac*.

http://www.rappel.qc.ca/services-et-produits/informations-techniques/lac/eutrophisation.html

RAPPEL (2005). La chlorophylle a, « a » pour algues?

http://www.rappel.qc.ca/IMG/pdf/Fiche_technique_4_-_chlorophylle_a.pdf

Geology :

Baker, D. R. 1956. Geological report, Aylwin-Cawood area, Pontiac and Gatineau counties, Department of Mines. Québec.

Bourque, Pierre-André. 2010. La Plate-forme du St-Laurent et les Appalaches : le Paléozoïque. En;ligne: http://www2.ggl.ulaval.ca/personnel/bourque/intro.pt/planete_terre.html. Consulté le 6 octobre 2016.

Daigneault, R.-A, Roy, M., Lamothe, M., Milette, S., Dubois Verret, M., Hurtubise, M.-A., Lamarche, 0 ., Leduc, É., Godbout, P.-M. et Horth, N. (2013, août). Deglaciation Pattern in the Outaouais Region, Southwestern Québec. Canadian Quaternary Association (CANQUA), Meeting 2013 - Edmonthon, Alberta.

Perreault, Serge; Mouksil, Abdelali (2014). Territoire de la Province de Grenville. MERN, publications/mines p. 45-52

Lessard, Henri (2009) : Géo-chronologie de l'Outaouais, Géo-Outaouais, En ligne : http :/ Geo-outaouais.blogspot.ca

Verret, Mélina Dubois (2015). Géomorphologie quaternaire de l'Outaouais (Québec) : écoulements glaciaires et paléogéographie de la déglaciation . Mémoire de Maitrise du département de Géographie, Université du Québec à Montréal, 174 p.

8. GLOSSARY

Fall turnover	As the weather cools during autumn, the upper layer (epilimnion) cools too, reducing the density difference between it and the lower layer (hypolimnion). As time passes, winds mix the lake to greater depths, and thermocline gradually deepens. When surface and bottom waters approach the same temperature and density, autumn winds can mix the entire lake; the lake is said to "turn over." As the atmosphere cools, the surface water continues to cool until it freezes. A less distinct density stratification than that seen in summer develops under the ice during winter. Most of the water column is isothermal at a temperature of 4°C, which is denser than the colder, lighter water just below the ice. In this case the stratification is much less stable, because the density difference between 0°C and 4°C water is quite small. However, the water column is isolated from wind-induced turbulence by its cap of ice. Therefore, the layering persists throughout the winter.
Kettle lake	Kettles are depressions left behind after partially-buried ice blocks melt. Many are filled with water, and are then called "kettle lakes".

Spring turnover	In the Spring, the water near a lake's bottom will usually be at 4°C just before the lake's ice cover melts. Water above that layer will be cooler, approaching 0°C just under the ice. As the weather warms, the ice melts. The surface water heats up and therefore it decreases in density. When the temperature (density) of the surface water equals the bottom water, very little wind energy is needed to mix the lake completely. This is called turnover. After this Spring turnover, the surface water continues to absorb heat and warms. As the temperature rises, the water becomes lighter than the water below. For a while winds may still mix the lake from bottom to top, but eventually the upper water becomes too warm and too buoyant to mix completely with the denser deeper water.

Thermal stratification	Lakes are dynamic systems which change during a year, and from year to year. Water in a lake is moving within the water column (surface to bottom), as well as through the length of the lake (inflow to outflow). During a year it is possible for lakes deeper than 5-7 meters to form layers of water having different temperature and oxygen concentrations. This is termed thermal stratification and is due to the changes in the density of water at different temperatures. Shallow lakes however, tend to mix more readily and avoid this stratification. From one season to the next, lake temperatures change creating a cyclical pattern that is repeated year after year. As summer progresses, the temperature (and density) differences between upper and lower water layers become more distinct. Deep lakes generally become physically stratified nto three identifiable layers, known as the epilimnion, metalimnion, and hypolimnion. The epilimnion is the upper, warm layer, and is typically well mixed. Below the epilimnion is the metalimnion or thermocline region, a layer of water in which the temperature declines rapidly with depth. The hypolimnion is the bottom layer of colder water. The density change at the metalimnion acts as a physical barrier that prevents mixing of the upper and lower layers for several months during the summer. The depth of mixing depends in part on the exposure of the lake to wind, but is most closely related to the lake's size. Smaller to moderately-sized lakes (50 to 1000 acres) reasonably may be expected to stratify and be well mixed to a depth of 3–7 meters in north temperate climates. Larger lakes may be well mixed to a depth of 10–15 meters in summer. This pattern (spring turnover — summer stratification — fall turnover — winter stratification) is typical for temperate lakes.

Thermocline	The thermocline is the transition layer between the mixed layer at the surface and the deep water layer. The definitions of these layers are based on temperature. The mixed layer is near the surface where the temperature is roughly that of surface water. In the thermocline, the temperature decreases rapidly from the mixed layer temperature to the much colder deep water temperature. The mixed layer and the deep water layer are relatively uniform in temperature, while the thermocline represents the transition zone between the two.