PRIORITIZED ISSUES FOR 2024-2034

Bank erosion

ORGANISME
DE BASSIN VERSANT
de la rivière du Nord

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1. Factual description

According to the *Act respecting land use planning and development*, for public health and the protection of wetlands and aquatic environments (WAEs), erosion and landslide zones are designated as stress zones before being defined in Regional County Municipality (RCM) land use and development plans (Chapter A-19.1, Section 5). Data currently available on erosion and landslide zones in the Integrated Water Management Zone (ZGIE) comes from RCM land use and development plans and personal communications from some municipalities. Historical erosion and landslide event data come from civil security event histories made available by the Ministère de la Sécurité publique (MSP) (Gouvernement du Québec, 2020).

1..1 Hydrography and hydrology

The Pays-d'en-Haut RCM carried out studies along the Rivière du Nord between Sainte-Adèle and Piedmont in areas susceptible to erosion due to uneven terrain, the presence of fine sediment (silt and clay), and changes in vegetation cover. Results were used to identify active erosion zones on several riparian slopes located on the outer side of meanders. Some probable erosion zones were also observed in areas with wooded slopes over 10 m high exceeding 30% (MRC des Pays-d'en-Haut, 2005). The Rivière-du-Nord RCM includes only two landslide risk zones in Prévost along the Rivière du Nord within the ZGIE (MRC de La Rivière-du-Nord, 2017).

Several erosion and landslide events allowed the Argenteuil RCM to identify the areas most prone to soil movement in the areas around the Ruisseau des Vases and the Rivière de l'Ouest in Brownsburg-Chatham (MRC d'Argenteuil, 2009). The Rivière du Nord also has several soil movement zones within the RCM: two in Lachute and one in Saint-André-d'Argenteuil. For the Rivière du Nord, several erosion and landslide events have occurred on the concave banks of the river with generally steeper slopes. Some events are located at the confluence of a tributary and the Rivière du Nord.

2. Hypothesis of its presence

2.1 Surface deposits

Depending on the nature of its soils, the St. Lawrence Platform, located in the south, is the geologic province of ZGIE North most prone to erosion and sediment transport phenomena. The majority of these are marine surface deposits, which are fine clay-based deposits that may also contain silt and fine sand. They have a relatively flat topography gullied by watercourses during land emergence (MFFP, 2020). Along the Rivière du Nord and its main tributaries, there are also several areas with well-stratified fluvial surface deposits. They generally consist of gravel and sand, with a small proportion of silt and clay. They represent deposits that have been scoured and introduced by a watercourse and have a generally flat surface (MFFP, 2020). In the case of the Grenville geologic province, several stress zones related to shoreline erosion exist along the Rivière du Nord within the Prévost, Piedmont, and Sainte-Adèle municipalities. Surface deposits along the Rivière du Nord are also predominantly marine and fluvial within the Sainte-Adèle and Saint-Jérôme municipalities (MFFP, 2020).

Along the Rivière du Nord upstream of Sainte-Adèle, as well as along the main tributaries located in the geologic province, surface deposits are mostly fluvioglacial, glacial, or organic. These deposits are composed of heterometric sediments with subrounded to rounded forms introduced by glacial meltwater. They are stratified and may contain till pockets (MFFP, 2020). Glacial deposits are generally composed of till and are thick enough to create terrain on loose or rocky formations.

2.2 Topography

Shoreline erosion along the Rivière du Nord is observed in areas with wooded slopes over 10 m high exceeding 30% (MRC des Pays-d'en-Haut, 2005). The 30% limit also characterizes steep slopes, on which the soil must always be protected to prevent erosion (Provencher and Thibault, 1979). Around 8% of the ZGIE is made up of slopes exceeding 30%, and these are nearly exclusively located in the Laurentian Plateau on hillsides (Gouvernement du Québec, 2019).

2.3 Land use

The Rivière du Nord erosion zones located between Sainte-Adèle and Piedmont are upstream of an area with a high population density (over 400 inhabitants per km^2 according to dissemination blocks) (Statistics Canada, 2016). Another

large area with a high population density can be found just upstream of the erosion zones. A soil sealing rate evaluation by watershed and sub-watershed was carried out using the indirect measuring method described by Mason and Knight (2001). Calculations were based on land use categories (MELCC, 2018) and the rate of sealing type (e.g., open areas, agriculture, urban, transport). The results for each watershed and sub-watershed as well as the ZGIE municipalities are detailed in the tables below.

2.4 Recreation and tourism

Backwash generated by motorized watercraft creates waves that beat against shorelines, which is called wave action. Wave action from passing watercraft is a major cause of shoreline erosion. The erosion amplitude is variable and closely related to the nature of the shore substrate (Government of Canada, n.d.). Wave height depends on various factors such as speed, distance from shore, water depth, watercraft size, hull shape, and weight distribution inside the watercraft (Government of Canada, n.d.). Speeds below 10 km/h are considered reasonable when close to sensitive shores, since the wave height would not cause significant damage (Government of Canada, n.d.).

The Rivière du Nord is suitable for watercraft only in the southern portion, starting from its confluence with the Rouge River (Saint-André). Unfortunately, data on bodies of water authorized for motorized watercraft are not exhaustive, but these include:

- Lac Ludger, Lantier
- Lac Manitou – Ivry-sur-le-Lac
- Lac des Sables – Sainte-Agathe-des-Monts
- Lac Saint-Joseph – Saint-Adolphe-d'Howard
- Lac Théodore – Saint-Adolphe-d'Howard
- Lac Louisa – Wentworth
- Lac Masson – Sainte-Marguerite-du-Lac-Masson
- Lac Barron – Gore

Recreation facilities such as golf courses and ski or tubing parks may also contribute to increased erosion along nearby shorelines. Reduced vegetation cover results in lower rainwater infiltration by vegetation, thereby increasing surface runoff and disrupting the water system, particularly in ski and tubing runs.

Table 1. Soil sealing rate by watershed

Level-2 watersheds / *Level-3 watersheds*		Sealing rate (%)
Cushing		7,5
Laughren		7,7
Mcvean		7,6
Watson		3,9
Sans noms et écoulements directs		8,3
Du Nord		8,6
	Aux Mulets	8.3
	Bellefeuille	14.1
	Bonniebrook	5.3
	De l'Ouest	4.0
	Des Hauteurs	19.9
	Doncaster	4.3
	Grand Ruisseau	25.0
	La Boucane	20.4
	Lachapelle	11.7
	Lachute	7.5
	Marois	7.7
	Morand	5.9
	Noire	6.4
	Petite Rivière	4.7
	Régimbald	4.7
	Robert	5.8
	Ruisseau Doncaster	7.4
	Saint-André (Rouge)	6.0
	Saint-Antoine	29.0
	Sainte-Marie	11.1
	Saint-Louis	9.8
	Simon	7.3
	Walker	37.3
	Williams	3.8
	No names and direct flows	10.6

Table 2. Soil sealing rate by municipality

Municipality	Soil sealing (%)
Brownsburg-Chatham	5.8
Chertsey	4.3
Entrelacs	4.9
Estérel	5.5
Gore	3.2
Grenville-sur-la-Rouge	3.2
Harrington	2.2
Ivry-sur-le-Lac	4.5
Lachute	11.9
Lac-Supérieur	2.1
Lantier	5.0
Mille-Isles	4.9
Mirabel	13.0
Mont-Blanc	5.9
Montcalm	2.1
Morin-Heights	8.9
Mohawk Territory	1.6
Notre-Dame-de-la-Merci	3.1
Piedmont	13.5
Prévost	22.8
Saint-Adolphe-d'Howard	4.9
Saint-André-d'Argenteuil	7.2
Saint-Colomban	12.5
Saint-Donat	3.4
Sainte-Adèle	11.6
Sainte-Agathe-des-Monts	9.0
Sainte-Anne-des-Lacs	7.1
Sainte-Lucie-des-Laurentides	4.5
Sainte-Marguerite-du-Lac-Masson	5.4
Sainte-Sophie	14.5
Saint-Hippolyte	7.1
Saint-Jérôme	32.5
Saint-Placide	6.0
Saint-Sauveur	16.9
Val-David	13.6
Val-des-Lacs	2.9
Val-Morin	9.8
Wentworth	2.1
Wentworth-Nord	3.0

2.5 Social attitude/behavior

In agricultural areas, many natural watercourses have been adjusted with the goal of improving land drainage. The agricultural zone established in ZGIE North measures approximately 467.8 km². This zone has nearly 992 km of watercourses, including 322 km of permanent watercourses and 580 km of intermittent watercourses (Géobase du réseau hydrographique du Québec [GRHQ], 2019). However, it is currently impossible to know how many kilometres of watercourses have been linearized in this zone.

The degradation of riparian buffers, the linearization of watercourses, and the filling of topographic hollows in some agricultural zones lead to the loss of several riparian wetlands. This shoreline artificialization has caused its share of interrelated problems: vertical and horizontal bed erosion, shoreline failure, sedimentation, etc. For example, the banks of the Rouge River (Saint-André) have been highly artificialized over several decades. In 2019, during a meeting organized by the Argenteuil RCM, producers in the watershed area shared their concerns about riverbank erosion, it being so serious that some feared for their own safety.

2.6 Climate change

The rising temperatures expected in the Laurentides will reduce the presence of snow and ice, which act as a protective layer on shorelines, mitigating the impact of floods.

Increased precipitation frequencies and intensities may also have a notable effect on erosion risks. These could lead to significant changes in the water system by increasing the frequency and magnitude of peak (maximum) flows. Flow changes lead to a sedimentary imbalance that could exacerbate shoreline erosion processes (Roy, 2011).

3. General location

3.1 Total area and sub-basin areas

Table 3. Erosion and landslide zone area (km²) by level-3 and 4 watershed in the Integrated Water Management Zone (ZGIE)

Main level-3 watersheds *Level-4 watersheds*	Area (km²)	% of the ZGIE	Erosion zone area (km²)	Landslide zone area (km²)
Rivière de l'Ouest				
Ruisseau des Vases	63.5	2.8		2.3
Rivière à Simon	165.6	7.2		0.2
Ruisseau Laurin	6.8	0.3	0.6	
Ruisseau Morand	4.8	0.2	0.7	
Direct flows - Rivière du Nord	254.8	11.1	0.6	0.7

Table 4. Civil security erosion and landslide events history by level-3 and 4 watershed in the Integrated Water Management Zone (ZGIE)

Main level-3 watersheds *Level-4 watersheds*	Area (km²)	% of the ZGIE	Number of recorded erosion events	Number of recorded landslide events
Rivière de l'Ouest	369.2	16.1	3	3
Ruisseau des Vases	63.5	2.8		1
Rivière de l'Est	45.3	2.0	2	
Rivière à Simon	165.6	7.2	1	2
Rivière aux Mulets	137.7	6.0		2
Ruisseau Bonniebrook	86.6	3.8		1
Ruisseau Williams	61.8	2.7	1	
Rivière Bellefeuille	47.6	2.1		1
Ruisseau Saint-Louis	19.4	0.8		1
Ruisseau à Régimbald	17.1	0.7		1
Ruisseau Marois	13.7	0.6	1	
Ruisseau des Hauteurs	11.7	0.5		1
Others	372.1	16.2	2	4
Direct flows – Rivière du Nord	254.8	11.1		37

3.2 Physiographic borders

Table 5. Erosion and landslide zone area (km²) by physiographic region

Région physiographique	Area in the ZGIE (km²)	Erosion zone area (km²)	Landslide zone area (km²)
Canadian Shield	1,841.4	0.6	0.9
St. Lawrence Lowlands	4,578.0	1.3	3.3

Table 6. Civil security erosion and landslide events history by physiographic region

Région physiographique	Area in the ZGIE (km²)	Number of recorded erosion events	Number of recorded landslide events
Bouclier canadien	1841,4	8	42
Basses terres du Saint-Laurent	4578,0	0	8

3.3 Administrative borders

Table 7. Erosion and landslide zone area (km2) by municipality in the Integrated Water Management Zone (ZGIE)

Municipality	Area				Erosion zone area (km²)	Landslide zone area (km²)
	Total (km²)	Within the ZGIE (km²)	%	% of the ZGIE		
Brownsburg-Chatham (V)	254.8	247.8	97.2	10.8		3.3
Mirabel (V)	486.0	171.8	35.4	7.5	1.3	
Prévost (V)	35.1	35.1	100.0	1.5		0.7
Piedmont (M)	24.8	24.8	100.0	1.1	0.4	0.2
Sainte-Adèle (V)	124.8	118.8	95.2	5.2	0.2	

Table 8. Civil security erosion and landslide events history by municipality in the Integrated Water Management Zone (ZGIE)

Municipality	Number of recorded erosion events	Number of recorded landslide events
Brownsburg-Chatham	1	3
Gore	2	
Lachute		7
Mirabel		2
Piedmont		13
Prévost		11
Saint-Colomban	1	2
Saint-Jérôme		2
Sainte-Adèle	1	9
Sainte-Agathe-des-Monts	1	1
Sainte-Anne-des-Lacs	1	
Sainte-Lucie-des-Laurentides		1
Val-Morin		2
Wentworth	1	

3.4 Surface deposits and topography

Surface deposits in the Rivière du Nord erosion and landslide zones located within the administrative area of Sainte-Adèle are mostly fluvioglacial and marine (MFFP, 2020). Surface deposits in these zones within Piedmont and Saint-Jérôme are mostly fluvial and marine. The same surface deposits are found in landslide zones located in the Rivière de l'Ouest watershed (level 3) in Brownsburg-Chatham (MFFP, 2020). The granulometry of the Rivière du Nord erosion and landslide zones is generally coarse loamy.

Landslide zones located in the Rivière de l'Ouest watershed have a fine clay granulometry. They are also located in areas with slopes between 31% and 40%. Erosion zones located in the Ruisseau Morand watershed (level 3) in Mirabel have glacial and marine surface deposits. The granulometry is sandy and coarse loamy in these zones. Shore slopes in the erosion and landslide zones from Sainte-Adèle to Prévost are mostly above 51% (Gouvernement du Québec, 2019).

Landslides are also presented in the *Bank Erosion* report, as these occur on the edges of watercourses and generally result from a combination of aggravating or triggering factors, notably the presence of erosion at the base of slopes, slope incline, geological and geotechnical soil properties, groundwater conditions, etc. They happen mostly between spring and autumn when water pressure in the soil is high and detrimental to slope stability (Gouvernement du Québec, 2017). Landslides in clay soils are the most serious type, as they are more frequent and can reach large dimensions (Gouvernement du Québec, 2017).

4. Cause of the issue

The different causes of shoreline erosion are presented in Table 9 according to possible erosion processes in the ZGIE.

Table 9. Classification of shoreline erosion processes (Bernatchez et Dubois, 2004)

Type of process	Erosion process
Aerodynamic/hydrodynamic	Eolation Wave abrasion and sapping Sediment uptake by littoral ice Abrasion through water level variation Fluvial dynamics
Hydrogeologic/gravity	Landslide (rotational, abrupt, superficial) Flow (clay, mud, sand) Gully Rock fall Scree
Weathering	Cryogenics (gelifraction, solifluction) Desiccation
Anthropogenic	Construction of obstacles to sediment circulation Material excavation and sampling Construction of erosion protection structures Concentration of water drainage Denuding of surfaces Soil compaction Increased wave abrasion and sapping Water catchment Watercourse works or cleaning Absence of or poor layout (e.g., drain outlets) Destruction/degradation of wetlands Land recreation activities
Biological	Nesting Pecking Foot traffic
Chemical	Dissolution Corrosion

Additional information for certain erosion processes:

4.1 Aerodynamic/hydrodynamic

Sediment uptake by littoral ice

When ice forms at the surface of a watercourse, it traps some elements present along shorelines. In the winter, if the water level rises, ice rises along with the elements within it. Vegetation, irregular stones, and bioengineered soil structures (such as piling) can be swept away due to fluctuating water and ice levels (Agriculture and Agri-Food Canada, 2008).

Fluvial dynamics

In a meander, erosion takes place on concave shores with steep inclines where the current speed is higher, while the deposit is placed on the other convex shore where the current is weaker, forming an alluvial terrace (Université Laval, n.d.).

4.2 Hydrogeologic/gravity

Soil nature

Fine sand, silts, clays, and organic matter have a fine granulometry easily transported by water. Marine, fluvial, and organic surface deposits generally found on the edge of the Rivière du Nord and a few tributaries are composed of fine materials (sands, silts, clays) (MFFP, 2020).

Bank slope

The 30% limit is used to characterize steep slopes on which there should always be soil protection to prevent erosion (Provencher and Thibault, 1979).

4.3 Anthropogenic

Modifications to watercourse beds and banks, such as relocation, straightening, dredging, or bank stabilization, can have long-term impacts on watercourse dynamics and functioning. The watercourse will always tend to return to a state of equilibrium between sediment transport and flow. A poorly planned intervention can have long-term repercussions, as watercourses self-adjust in order to regain a stable form (Association des gestionnaires régionaux des cours d'eau du Québec [AGRCQ], 2017).

Construction of obstacles to sediment circulation

To return to equilibrium during a sediment deficit, a watercourse enters a phase of erosion, causing major morphological changes that may be extremely damaging to both human infrastructure and ecosystems (AGRCQ, 2017).

Construction of erosion protection structures

Modifications made to shorelines such as bank stabilizers can have long-term impacts on watercourse dynamics and functioning. The watercourse will always tend to return to a state of equilibrium between sediment transport and flow. Meander development in watercourses with a certain degree of power is natural and inevitable. The watercourse always strives to balance its sediment flow and liquid flow. By stabilizing a bank at one given location, banks will erode elsewhere (AGRCQ, 2017).

Concentration of water drainage

The straightening (linearization) of several segments of a watercourse can give rise to flow and sediment transport instability. A sinuous watercourse that has been straightened will therefore naturally tend to return to a sinuous form. By eliminating meanders and increasing bed slope, high-flow watercourses will erode banks to transport a larger sediment load (AGRCQ, 2017). Farming activities, the built environment, and road infrastructure contribute to limiting the creation of new meanders and therefore restricting watercourse mobility. Many human interventions have been involved in controlling the natural migration of watercourses.

Denuding of surfaces

Diminished vegetation cover (deforestation, devegetation) reduces precipitation water infiltration by vegetation and increases runoff. Runoff water (from precipitation) reaches watercourses quicker and increases flow rates, creating instability and promoting shoreline erosion. Farming activities, poorly planned forestry activities, human development, and road infrastructure development (backfill, shoreline artificialization, etc.) can diminish vegetation cover.

Soil compaction

Agricultural and construction activity can increase soil compaction and reduce its hydrological characteristics and runoff water infiltration and drainage proprieties.

Increased wave abrasion and sapping by pleasure craft

Certain pleasure craft produce eddies that generate waves which hit shorelines, disturbing them (Das and Johnson, 1970). Contrary to natural waves, those generated by watercraft exert additional pressure on shorelines, as they are intermittent, rapid, and sudden (Lindholm, Svartström, Spoof, and Meriluoto, 2001).

Water catchment
The modification of water table systems along shorelines can play a role in surface deposit stability (Roy, 2011).

Watercourse works or cleaning
Works in watercourse beds, such as maintenance, lead to increased erosion when appropriate methods are not employed to control this phenomenon.

Destruction/degradation of wetlands
Some changes in the water system are known to be caused by the loss of flood regulation by wetlands.

Land recreation activities
Repeated travel on poorly maintained trails can induce significant erosion which, when located close to a body of water, can lead to sediment input. Foot traffic may also compact soil, making it impervious and creating more runoff. The ZGIE is home to a good number of hiking and bike trails used in the summer and many cross-country ski and snowshoe trails used in the winter.

5. Main consequences

Main source : (RAPPEL, n. d.).

5.1 Environmental

- Deteriorated water quality from increased concentrations of suspended solids (SS). SS found in bodies of water may originate from soil erosion followed by sediment transportation toward bodies of water or the resuspension of sediment deposited on the bed.
- Nutrient release (phosphorous and nitrogen) that promotes the proliferation of algae and aquatic plants
- Wildlife habitats degraded by sedimentation and silting
- Reduced water transparency
- Rising water temperatures
- Reduced dissolved oxygen concentrations
- Reduced aquatic biodiversity
- Increased flood risks due to watercourse clogging
- Input of toxic products (metals) within sediments
- Accelerated aging of bodies of water

5.2 Economic

- Loss of fertile soils affecting crop yields (Agriculture and Agri-Food Canada, 2008)
- Loss of land affecting shoreline property values
- Damaged or destroyed private or public infrastructure (roads, bridges, buildings). Soil erosion can clog culverts, storm gutters, and agricultural drains.
- Increased cost of drinking water filtration
- Reduced market value of properties following water quality deterioration and plant proliferation

5.3 Social

- Loss of public or private grounds leading to safety risks
- Loss of swimming areas
- Diminished areas suitable for boating
- Loss of feeling of belonging to bodies of water or watercourses. People may find that their lake is no longer clean/beautiful because of vegetation, for example.

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