Northern Village of Puvirnituq

VULNERABILITY ANALYSIS OF THE DRINKING WATER SOURCE

WATER INTAKE N˚X2114321 OF PUVIRNITUQ

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Project 21-055

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ADVICE TO THE READER

This document was produced using data collected from municipalities, the Kativik regional administration (KRG), the Ministère de l'Environnement et de la Lutte contre les changements climatiques (MELCC), as well as from various actors involved in the protection of natural resources. water in Northern Québec. No data could be collected in the field by our own professionals due to the SARS-CoV-2 pandemic. The analyzes are based on the interpretation of the various articles of law and regulations in force.

The analyzes developed in this document are presented for information purposes only and the final decision concerning the various intervention methods and official protection zones is the responsibility of the Ministère de l'Environnement et de la Lutte contre les changements climatiques. (MELCC) or the municipality concerned.

Consequently, Nuna Resources cannot be held responsible for interventions undertaken in the environment before obtaining the necessary environmental and government authorizations.

REFERENCES FOR CITATION

Nuna Ressources. 2021. Vulnerability Analysis of The Drinking Water Source - Water Intake N˚x2114321 Of Puvirnituq. Rapport du projet 21-055. 24 pages + appendice.

ABSTRACT

The environmental firm Nuna Resources was mandated by the northern village (NV) of Puvirnituq to carry out the vulnerability analysis of its drinking water source, in compliance with article 75 of the water withdrawal and protection regulation (WWPR) and following the guidelines of the guide for carrying out vulnerability analyzes of sources intended for drinking water supply in Québec (MELCC, 2018).

The northern village of Puvirnituq is located in Nunavik, on the North shore of the river of the same name and 4 km from its mouth in Hudson Bay. Subject to an arctic climate and located in an area of continuous permafrost, the challenges of protecting the source of drinking water are particularly important. The presence of permafrost and the vagaries of the climate indeed imply development challenges specific to these latitudes.

The drinking water source for Puvirnituq is located in the Puvirnituq River, about 5 km from the heart of the village. The latter drains a watershed of some 30,000 km2, which spans almost the entire width of Nunavik. Water from the river is sent to the water treatment plant via the pumping station located immediately on the shore next to the intake. Once at the factory, located in the village, the water is filtered through several filters (carbon and cartridge filters of different porosities) before disinfection by UV light and then by the addition of chlorine. In this process, the water again passes through several cartridge filters before being stored in three indoor drinking water tanks. Finally, disinfection by adding residual chlorine takes place when drinking water is distributed by tanker.

The drinking water source protection areas, determined by mapping method, are as follows: the inner protection area rises 500 m upstream from the water intake and 50 m downstream, including riparian strips of 10 m. The intermediate protection zone rises 10 km upstream from the water intake and 50 m downstream, encompassing riparian strips of 120 m. Finally, the outer protection area corresponds to the entire watershed of the water intake, as well as the portion of the intermediate zone located downstream of the intake.

From the assessment of the six vulnerability indicators (physical integrity of sites; microorganisms, turbidity, total phosphorus, inorganic substances, and organic substances in the water), it appears that the level of vulnerability of the water source is low for all the indicators. Due to the isolated nature of the village, and the pristine nature of the surrounding areas, the drinking water source is not exposed to the risk of chemical / biological contamination from human activities, which explains the results obtained.

As the village of Puvirnituq is located downstream from the drinking water intake, very few activities are located in the water source protection areas. No activity likely to affect drinking water has been identified. In addition, the use of the "hinterland" territory, which encompasses all the water intake protection areas, contributes more to strengthening the protection of the water source than to threatening it.

Overall, this study shows that the Puvirnituq drinking water source provides the northern village with quality water, so far very little influenced by human activities. The vagaries of the northern climate are the main factors likely to compromise water installations. To further improve the monitoring and protection of the drinking water source in the future, the following recommendations have been made:

- Keep a written record of events, even minor ones, which have affected the drinking water production chain and keep this information for inter-annual monitoring. An example of such a register is provided in Annex 5;
- Create a register in which to record the values of the turbidity of the raw water, particularly during periods of flood (spring melt, heavy rains) when the turbidity is likely to increase sharply;
- Continue the analysis of raw water for the presence of coliforms as already carried out for several years;
- Apply a screen to the inlet of the water intake to prevent the introduction of debris into the pumping well;
- Visit of the drinking water sampling and treatment infrastructure by a professional over the next 5 years.

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1 INTRODUCTION

1.1 MANDATE ET OBJECTIVES

The firm Nuna Resources was commissioned to carry out a vulnerability study of the drinking water source in the northern village of Puvirnituq, which, as responsible for a category 1 surface water withdrawal (supply of more than 500 people) is obliged to provide a vulnerability report before April 1, 2021, under article 75 of the Water Withdrawal and Protection Regulation (WWPR). This report is to be updated every five years.

Also, in accordance with the guidelines of Article 75, this report combines the following information :

- The location of the withdrawal site and a description of the water treatment facilities;
- The location plan for inner, intermediate and outer protection areas;
- Water vulnerability levels according to the six indicators presented in Article 69, Annex IV of the WWPR;
- Human activities, potential events and land uses likely to affect the quantity or quality of water within the protection areas;
- An assessment of the threats that the elements listed could represent for the quality and quantity of water exploited;
- An identification of the probable causes that may explain the medium or high levels of vulnerability concerning the six indicators mentioned in Article 69 Annex IV of the WWPR.

This report presents a summary of all the information required by the Ministère de l'Environnement et de la Lutte contre les changements climatiques (MELCC), when available, for the northern village of Puvirnituq in accordance with the guidelines provided by the *guide de réalisation des analyses de vulnérabilité des sources destinées à l'alimentation en eau potable du Québec* (MELCC, 2018). Section 5.2 presents information that is missing or could not be obtained in the context of this study. If essential elements prove to be missing, this report proposes recommendations, ranked in order of priority, that the municipality could adopt to address the lack of data by 2026, the date of the next vulnerability report.

1.2 GENERAL BACKGROUND OF THE STUDY AREA

Located on the west coast of Hudson Bay, the northern village of Puvirnituq (60˚02'16.0"N, 77˚16'18"W) is situated on the north shore of the estuary of the Puvirnituq River, which flows into Hudson Bay 4 km downstream from the village. It has a population of 1,902 inhabitants over an area of 79.93 km^2 (Municipal Affairs and Housing Québec, 2020) and is part of the Kativik Regional Administration (KRG) in Nunavik, in the administrative region of Nord-du-Québec (10).

Puvirnituq is located in a continuous permafrost zone, characterized by an arctic climate and herbaceous tundra-type vegetation. The village is built on a variety of unconsolidated deposits likely to contain a lot of ice (lake sediments, marine sediments, glacial sediments), influencing the stability of the soils during periods of freezing and thawing (Annex 1; St-Amour et al. 2020). In this zone, the basement is mainly composed of granite and granodiorite, tonalite, tonalitic and granodioritic gneiss (Geology of Québec, DV2012-6, Ressources naturelles Québec, Annex 1). The average annual precipitation is around 573 mm. The annual average temperature hovers around -6.06˚C while between 2005 and 2018, the frost season extended over an average of 217 days (St-Amour et al. 2020).

Outside the village of Puvirnituq, we find:

- To the north, about 60 km away, the Monts-de-Puvirnituq National Park Reserve of 3,159 km^2;
- To the east, in the watershed of the Puvirnituq River, several advanced mining explorations (iron, gold and nickel; Séguin 2010; KRG 2008).

CARTE 1
Localisation de l'aire d'étude

Puvirnituq
Projet 21-0055-01

15 février 2021
Réalisé par: Sophie Savard
Approuvé par: Rachel Hussherr

Analyse de la vulnérabilité de la source destinée à l'alimentation en eau potable - Village Nordique de Puvirnituq

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2 CHARACTERIZATION OF WATER WITHDRAWAL

The determination of the water source protection areas, as well as the determination of the vulnerability levels of the water quality indicators presented in sections 2.3 and 2.4 (article 69, annex IV of the WWPR), were carried out by consulting the various data transmitted by the Kativik regional administration as well as the data available for the study areas in the open access databases mentioned below. The main open access data sources that were used for the preparation of the analysis are therefore as follows:

- Geobase of the hydrographic network of Québec (MERN, 2019);
- Database of hydrographic basins (MELCC, 2019);
- Topographic Data of Canada – CanVec Series (Natural Resources Canada, 2020)
- Imagery of northern villages (https://mern.gouv.qc.ca/repertoire-geographique/imagerie-villages-autroits-nord/);
- Mapping of northern villages on a scale of 1/2000 (https://www.donneesquebec.ca/recherche/dataset/cartes-topographique-des-villages-autroits-du-nord-al-echelle-de-1-2 -000);
- Historical and recent satellite images available on Google Earth Pro ©.

2.1 RAW WATER WITHDRAWAL SITE

The water withdrawal site of the Northern Village of Puvirnituq is located in the Puvirnituq River, which flows into the Hudson Bay. It drains an area of some 30,000 km^2, which crosses most of the Nunavik over its width and extends almost to Kangiqsujuaq, on the edge of Ungava Bay.

The Puvirnituq water intake is located away from the village, at the end of a road that ends in a dead end after a little less than 5 km (location map 1). The current water intake was built in 1991 and consists of a 26 m long and 400 mm diameter polyethylene supply line, with 50 mm thick polyurethane insulation. In this pipe are also installed two copper pipes of 25 mm in diameter each; connected by a copper ring in a closed loop in which a glycol solution circulates, to prevent the pipe from freezing or prevent the formation of frazil (Annex 2). The supply line is connected to a pumping station located immediately on the shore (photos 1 and 2). The latter is then itself connected to the drinking water treatment and distribution plant by two separate pipes: a polyethylene supply pipe 150mm in diameter and insulated with a 75 mm layer of polyurethane

and a recirculation pipe of 100 mm in diameter. The water circulates there continuously to prevent freezing. Heating cables are also used to prevent winter freezing.

Photo 1. Pumping station and water intake seen from the sky (from MERN online imagery)

Photo 2. Pumping station on the banks of the Puvirnituq river, in the immediate vicinity of the water intake (KRG, 2009)

The plans presented in Annex 2 describe in detail the installations at the water intake. The pumping station was upgraded in 2009 and 2013.

Table 1. Summary of the drinking water intake characteristics in the Northern Village of Puvirnituq

Sample site element	Description and details
Name of the water intake	Puvirnituq - Approvisionnement
Water intake number	X2114321
Geographical coordinates	60˚ 03’47.09’’N; 77˚ 13’21.61’’O
Type of consumption	Permanent
Type of withdrawal	In the river using an adduction pipe
Withdrawal depth	Unknown
Population deserved	1902 inhabitants
Authorized direct debit per day	Unknown
Critical water level	Unknown
Width of the stream at low water	Unknown
Number of the most recent authorization issued by the Ministry	Unknown

2.2 DRINKING WATER TREATMENT INFRASTRUCTURES

The water treatment plant in the Northern Village of Puvirnituq is located in the village, near the hospital (photo 3 and map 1), at the following geographical coordinates :

60° 2' 20.31" -77° 16' 35.31"

Photo 3. The drinking water treatment and distribution plant in Puvirnituq during its renovation in 2009 (Source: KRG)

The building, as well as the water treatment and distribution facilities, were upgraded in 2009 and 2013.

Since the completion of these upgrades, the raw water treatment steps in the plant are as follows :

- Passage of water pumped into the river through a strainer;
- Passage through three carbon filters (Hydrotech 914mmø);
- Passage through 2 cartridge filters of 20 µm porosity then two other cartridge filters of 1 µm porosity;
- UV light disinfection (3 UV reactors of the Trojan brand);
- Addition of a chlorine solution (10 %);
- Passage through a 5 µm cartridge filter then two other 1 µm cartridge filters;
- Storage of treated water in 3 interior tanks;
- Further addition of residual chlorine as the water is transferred to the tanker for distribution.

Frequent negative temperatures, as well as the geographical location in an area of continuous permafrost, make it difficult if not impossible to install an aqueduct system for the entire village (Vincent et al. 2012). Thus, once the water is treated, it is distributed by tanker truck to the various infrastructures and to the residents of the village, each with a specific water tank. Only the hospital and the group home in the immediate vicinity of the treatment plant could be connected to drinking water in 2003 thanks to a water system adapted to the conditions on the ground.

2.3 WATER SOURCE PROTECTION ZONES

Under articles 70, 72 and 74 of the WWPR, category 1 surface water withdrawals are surrounded by 3 protection areas, nested one in the other and which may overlap: the inner protection area, the intermediate protection area, and the outer protection area.

In the case of a surface water intake installed in a river, the boundaries of these protection areas follow the following criteria :

Table 2. Water source protection zones in case the intake is located in a watercourse

Type of environment	Protection areas		
	Inner	Intermediate	Outer
River	500m upstream and 50m downstream from the withdrawal site; 10m riparian strip	10km upstream and 50 m downstream from the withdrawal site; 120m riparian strip	The watershed of the withdrawal site and the portion of the intermediate protection area located downstream from the withdrawal site if relevant

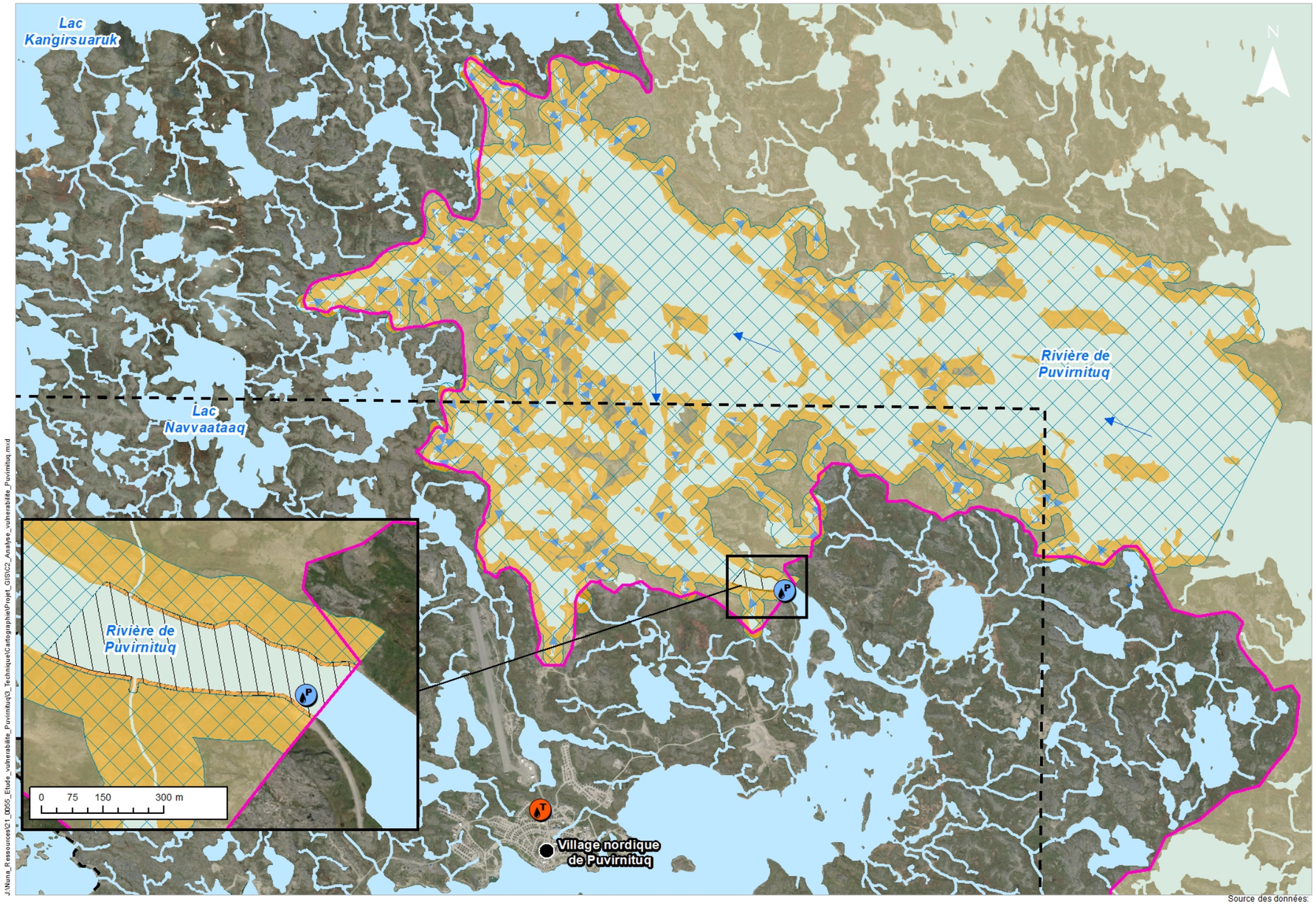
General methodology :

The watershed boundaries were drawn from hydrographic cutting units (HCU), linear geometric networks (watercourses) and surface (body of water) of the hydrographic data geobase of Québec (GRHQ, 2019). For your information, the HCUs represent a portion of a large watershed or a grouping of small watersheds delimited by the Québec Water Expertise Center (CEHQ, now assimilated into the MELCC).

On the one hand, the maximum extension of the watershed area of the water intake was determined using linear geometric networks (watercourses) and surface (lake), by checking the direction of the water flow and the classification of linear entities according to Strahler's order. This operation made it possible to validate the interconnectivity of the hydrographic network at the limits of the HCUs (watersheds) and consequently, to define the maximum extension of the watershed, ie the HCUs forming an integral part of the catchment area of the water intake.

On the other hand, when relevant, it was necessary to subtract from the watershed resulting from the previous step, the part downstream of the water intake, i.e. the part that has no influence on the exploited water. The upstream part (watershed line) was drawn using level curves lines at a scale of 1: 50,000 taken from the topographic data of Canada (CanVec Series, Natural Resources Canada, 2020) and linear geometric networks. (watercourses) and surface areas (water plan) of the GRHQ. In the end, this operation made it possible to properly delimit the water source's watershed.

Maps 2 and 3 show the drinking water source protection areas in the northern village of Puvirnituq. As high-water mark data was not available, the stream boundaries were determined from the existing hydrographic layers for the study site.



1:50 000
0 750 1 500 3 000 m

Système de projection cartographique: NAD83 (CSRS) MTM 8

Source des données:
Fond de carte, cinquième inventaire écoforestier du Québec méridional
Géobase du réseau hydrographique du Québec (GRHQ) (MERN, 2019);
Cartographie des milieux humides potentiels du Québec (CMHPQ) (MELCC, 2019);
Base de données des bassins hydrographiques (MELCC, 2019a)

CARTE 2
Aires de protection de la prise d'eau

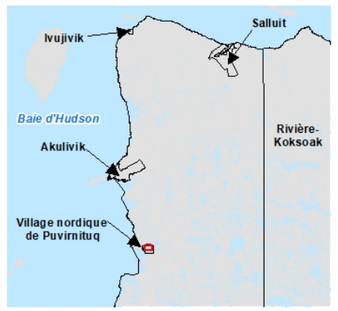
- Prise d'eau
- Station de traitement
- Limite des municipalités

Aire de protection

- Bande riveraine de 10 mètres
- Bande riveraine de 120 mètres
- Zone de protection immédiate
- Zone de protection intermédiaire
- Zone de protection éloignée
- Bassin versant de la prise d'eau

Hydrographie

- Cours d'eau
- Plan d'eau
- Sens d'écoulement



Puvirnituq
Projet 21-0055

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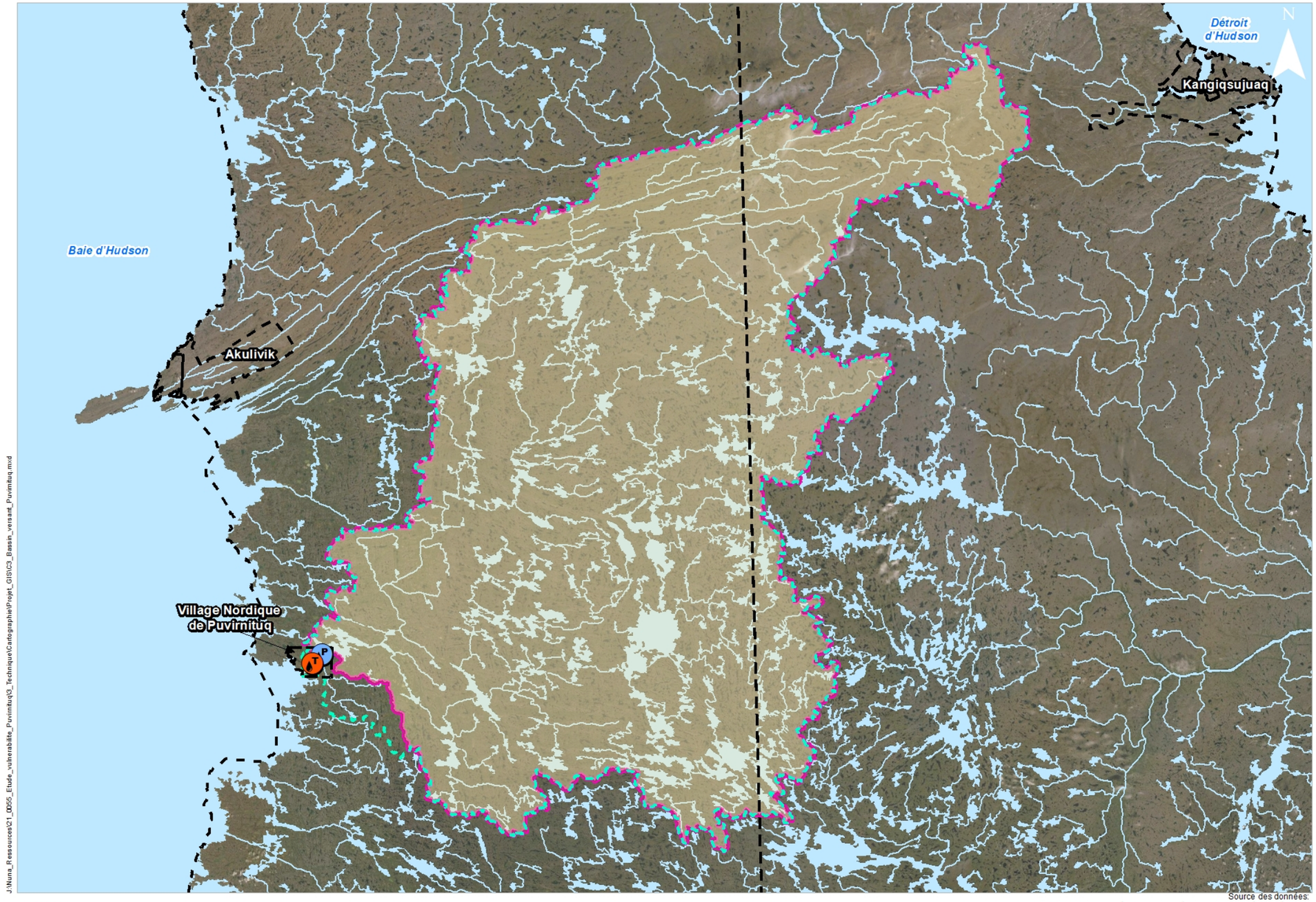
NUNA RESSOURCES

CARTE 3
Bassin versant de la rivière de Puvirnituq et de la prise d'eau



Prise d'eau

Station de traitement

Limite des municipalités

Zone de protection éloignée

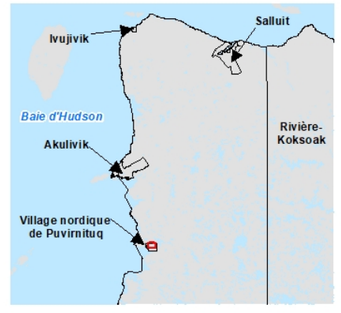
Bassin versant de la prise d'eau

Bassin versant de la rivière de Puvirnituk

Hydrpgraphie

Cours d'eau

Plan d'eau



1:1 295 000
0 10 20 40 Kilometers

Système de projection cartographique: NAD83 (CSRS) MTM 8

Source des données:
Fond de carte, cinquième inventaire écoforestier du Québec méridional
Géobase du réseau hydrographique du Québec (GRHQ) (MERN, 2019);
Cartographie des milieux humides potentiels du Québec (CMHPQ) (MELCC, 2019);
Base de données des bassins hydrographiques (MELCC, 2019a)

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2.4 VULNERABILITY INDICATORS

As required by Article 69, Annex IV of the WWPR, the vulnerability of the surface drinking water source is assessed using six indicators which are assigned a low, medium, or high level of vulnerability. These vulnerability levels are determined by following the analysis methods presented in the *guide de réalisation des analyses de vulnérabilité des sources destinées à l'alimentation en eau potable du Québec* (MELCC, 2018) and prescribed in Annex IV of the WWPR. The following sections present the results of these analyzes for each of the six indicators, as well as the methods employed based on the data available for this assessment.

2.4.1 Physical integrity of the withdrawal site

Method 1: Historical review of all events recorded. Since August 14, 2014, all those responsible for a category 1 surface water withdrawal are required to keep an up-to-date register of events that have affected, among other things, a water shortage, an obstruction, or a breakage of the water. sampling site (article 22.0.4 of the WWPR).

No such event has been reported to us.

However, as it was not possible for us to consult a register itself, we also applied method 2 to determine the level of vulnerability of this indicator.

Method 2 : Professional evaluation of the infrastructures related to the water withdrawal

Unfortunately, the pandemic context due to COVID-19 since the beginning of 2020 has not allowed our professionals to visit the Northern Village of Puvirnituq to meet the local stakeholders and to visit the infrastructures and assess their condition since their last upgrade in 2013. Having received the mandate to assess the vulnerability of the water source in November 2020, we are therefore relying on the data made available by university research teams (Center for Northern Studies, Université Laval) and exchanges of information with members of the community and the Kativik Regional Governement to issue an opinion on the state of infrastructure and the risk of damage caused by hazards of the climate. However, we recommend to validate the physical vulnerability rating assigned in this evaluation by going on site as soon as the situation will allow it.

Infrastructures conditions

According to the plans dating from the construction of the water intake, it consists of a supply pipe 400mm in diameter, which is not fitted with a device who could prevent debris from reaching the pumping well. Although this does not seem to have been a problem since 1991, it would be advisable to install a screen with openings of 37 to 50 mm at the end of the pipe to eliminate this risk.

After consulting the documents sent by the KRG, it appears that the equipment of the pumping station, as well as the drinking water treatment facilities of Puvirnituq have been regularly upgraded over the past few years, as mentioned in section 2.1, 2.2 (see also Annex 2).

Natural hazards regarding the infrastructures

As the Northern Village of Puvirnituq is located in a continuous permafrost zone, the infrastructures present are subject to ground movements during periods of frost and thaw and to the vagaries of the arctic climate.

An analysis carried out by the Center for Northern Studies of Laval University (St-Amour et al. 2020) presents the permafrost conditions according to the surface deposits on which the various infrastructures of the village were built (Annex 1). Although a significant portion of the village sits on thaw-unstable deposits, the pumping station was erected on a thick, layered sand and gravel deposit with little ice and therefore deemed thaw stable. The same goes for the land on which the drinking water treatment plant is built. Built on the bedrock, the building is not at risk of structural damage following freeze/thaw permafrost.

However, the access road of a little less than 5 km connecting the location of the drinking water intake to the rest of the village crosses land made up of unconsolidated deposits containing a lot of ice, deposits considered unstable during the thaw. Thermokarstic subsidence has already caused minor damage in the village, so it is not excluded that such an event could affect the access road to the pumping station and the supply and recirculation pipes that connects it to the pumping station. However, the amplitude of such movements is unlikely to be sufficient to cause a serious pipe break in the foreseeable future. It would be useful to reassess the situation in 5 years with the data (permafrost temperatures) that will be available for analysis at that moment.

Finally, still according to the report of St-Amour and co-authors, neither the area of the village which hosts the water treatment facilities nor the location of the water intake at the edge of the river is subject to natural and apprehended hazards that were identified by the team of scientists as part of their research (Annex 1).

In the light of this information, the location of the infrastructure for the withdrawal, treatment, and storage of drinking water in the Northern Village of Puvirnituq does not appear to be problematic for the next 5 years. The physical vulnerability of these sites is therefore **low**.

2.4.2 Vulnerability to microorganisms

The Northern Villages, because they are located north of the 55th parallel (Section 22.0.3 of the regulation respecting the quality of the drinking water – RRQDW), are not subject to the requirements of article 22.0.1 of the RRQDW, i.e. the obligation to test a sample. of raw water per

month when the distribution system serves between 1,001 and 5,000 people. This sampling aims to detect the possible presence of pathogenic microorganisms, particularly the bacterium E. Coli, which can cause gastroenteritis, the main symptoms of which are as follows: diarrhea, abdominal cramps, nausea, and vomiting (https: // www. quebec.ca/agriculture-environnement-et-ressources-naturelles/eau-potable/contamination-de-l-eau-reseau-de-distribution/e-coli-coliformes-fecaux-ou-enterocoques/). Surface water sources, compared to groundwater sources, are particularly sensitive to the risks of contamination by coliform bacteria (total, fecal) relating to the activities of the surrounding fauna and the impacts of human activities located nearby.

Raw water samples are analyzed regularly during the weekly microbiological monitoring of drinking water in the Northern Village of Puvirnituq. However, these results come from Colilert tests and therefore do not allow a precise concentration of coliforms to be determined when such microorganisms are present in the water. This tests can attest to the "presence" or "absence" of fecal and total coliforms in the water tested.

To determine the vulnerability of the water source to microorganisms, we therefore applied **method 2**. The latter is to determine if, in the area of the water source watershed, there is neither an agglomeration served by a combined sewer system or by a pseudo separate sewer system, nor an activity or an industry susceptible to contaminate the water with pathogenic microorganisms. Data from Colilert tests were also used to validate the results of method 2.

After examining the land uses and satellite imagery (MERN, Google Earth), it appears that no element likely to reject pathogenic microorganisms is present in the catchment area of the water intake (map 2 and annex 3).

In addition, the Colilert test results available between 2016 and 2020 do not indicate the presence of fecal coliforms in raw water. Of course, surface water sources remain particularly sensitive to contamination by the surrounding fauna. For this reason, it is still pertinent to monitor the raw water quality in terms of pathogenic microorganisms.

All these elements lead us to set the level of vulnerability of the water intake to microorganisms at "**low**".

2.4.3 Vulnerability to fertilizers

Villages located north of the 55th parallel (Section 22.0.3 of the RRQDW) are not subject to the requirements stated in Section 22.0.2 of the RRQDW, i.e. the obligation, for a municipal distribution system serving more than 500 people and at least one residence, to sample and quantify the total phosphorus concentration in raw surface water once a month between May and October.

Methods 2 and 3 will therefore be used for this indicator and the highest level of vulnerability obtained between the two methods will be used.

Method 2: it consists of listing all the events associated with blooms of algae or cyanobacteria in the water as well as a suspected increase in ammoniacal nitrogen.

No such event has been reported from the Northern Village of Puvirnituq. The application of this method therefore makes it possible to attribute a **low** level of vulnerability to fertilizers.

Method 3: a professional assesses all the activities that present a potential source of phosphorus or ammoniacal nitrogen in all the protection zones and judges whether they represent a risk.

No risky activity has been identified in the water source watershed.

The level of vulnerability of the water source to fertilizers is therefore set at **low**.

2.4.4 Vulnerability to turbidity

The villages located north of the 55th parallel (Section 22.0.3 of the RRQDW) are not subject to the requirements of stated in Section 22.0.2 of the RRQDW, i.e. that is the obligation to monitor the turbidity variations of the raw water at least each 4 hours and log the values in a register.

As there is no recorded dataset on the turbidity of the exploited water for the Northern Village of Puvirnituq, **method 2** is applied to determine the vulnerability rating of the water source. This method consists of issuing a professional opinion following the evaluation of the potential impacts of the characteristics of the watershed and the anthropogenic activities taking place there.

The watershed of the Puvirnituq River extends over a vast territory (approximately 30,000 km^2). It is obvious that the geological units and the surface deposits are diversified there, and that the turbidity varies according to the immediate environment of the studied portion of the river. The village's water intake is located a few kilometers before the mouth of the Puvirnituq River in Hudson Bay, at the very end of the 389 km that the river travels through Nunavik. The quantity of water drained in its watershed is therefore significant. As the water intake is located at the end of the river's course, turbidity could reach high values during flood periods (snowmelt, heavy rains). Examination of the available satellite photographs shows no distinctive water feathers as the river empties into Hudson Bay, suggesting that its waters are clear and low in suspended matter. However, a photograph only represents a single frozen moment in time, and it is difficult to extrapolate a conclusion about changes in turbidity over a long period of time. The best way to assess the drinking water source vulnerability to turbidity in the future would be to record the turbidimeter readings, so that a full dataset can be reviewed when the next report is produced in 5 years.

In parallel with these remarks, an in-depth analysis of the characteristics of the intermediate protection area carried out by the hydrogeology firm LNA[1] highlights the gentle slopes bordering the river. The analysis also established that 90% of the intermediate water intake protection area (the terrestrial part) is occupied by vegetation which contributes to the protection of the exploited water from turbidity. Likewise, 52.5 % of the terrestrial part of the intermediate area is occupied by deep water marine deposits, which do not contribute to the turbidity of the exploited waters. Full details of the analysis produced by LNA are presented in Annex 4.

Finally, given the size of the watershed and the resulting dilution factor, occasional natural or anthropogenic events outside the intermediate protection zone of the water source are not likely to affect turbidity either. Mining and quarrying activities (mining exploration, Nunanickel mine, Qullisajarniavik quarry) are not likely to have a significant impact on the turbidity of the water at the village's drinking water intake, especially given their remote location in the watershed and no risky activity has been identified in the intermediate protection zone (see also section 3 for more details on land use assignments). Given these elements, anthropogenic activities in the water source's watershed are not likely to influence the turbidity of the water exploited.

In light of this information, the level of vulnerability of the water source to turbidity is therefore low. In the future, however, it may be prudent to monitor and record changes in this parameter, particularly during the spring melt and after heavy rains. Regularly elevated turbidity readings can lead to technical failures in water treatment facilities.

2.4.5 Vulnerability to inorganic substances

The 11 inorganic substances whose concentrations are to be monitored on an annual basis in drinking water according to section 14 of the RRQDW are as follows: antimony, arsenic, barium, boron, cadmium, chromium, cyanides, fluorides, mercury, selenium, uranium. Nitrates and nitrites should be monitored on a quarterly basis.

As the available data set does not include 5 consecutive years and in accordance with the recommendations of the guide, we privileged the **second method**. The available data were used as a complement to the main method.

Method 2 aims to determine whether sectors of industrial, commercial, or agricultural activity are located within the 120 m riparian buffer of the intermediate protection zone and what percentage of this land area they occupy. The level of vulnerability is low if the percentage is less than or equal to 20 %. No activity, neither industrial, nor commercial, nor agricultural, is located in the riparian strip of 120 m.

[1] Due to the limited data available and to validate the level of vulnerability of the water intake to turbidity, an external opinion was requested from the environmental firm LNA

In addition, the concentrations of the 11 inorganic substances, available for the years 2019 and 2020; as well as the nitrate-nitrite concentrations, available in part for 2015, 2016, 2017, 2019 and 2020, are all well below the applicable standards. Following this information, the vulnerability rating of the water source to inorganic substances is set at "**low**".

2.4.6 Vulnerability to organic substances

As the drinking water system of the Northern Village of Puvirnituq does not serve more than 5,000 people, it is not mandatory for this municipality to monitor the 16 pesticides and 16 other organic substances under Section 19 of the RRQDW. **Method 2** was therefore applied to determine the level of vulnerability of this indicator. It is identical to method 2 used in section 2.4.5 for inorganic substances.

The level of vulnerability of the drinking water source to organic substances is therefore set at **low**.

2.4.7 Summary of vulnerabilities

Table 3. Synthesis of the methods that were used to determine the ratings of the six vulnerability indicators and the resulting ratings

Indicator	Main method used	Level of vulnerability
A (physical)	Method 2	Low
B (microorganisms)	Method 2	Low
C (fertilizers)	Methods 2 et 3	Low
D (turbidity)	Method 2	Low
E (inorganic substances.)	Method 2	Low
F (organic substances.)	Method 2	Low

3 INVENTORY OF THE FACTORS LIKELY TO AFFECT THE DRINKING WATER SOURCE

3.1 HUMAN ACTIVITIES

Due to the context linked to the Covid-19 pandemic, our professionals were unable to go to the Northern Village of Puvirnituq to make an inventory of human activities on the ground. The following sections were therefore carried out thanks to the consultation of the land use map, the development plan of Puvirnituq and the consultation of the members of the municipal council when details were necessary. Google Earth satellite images and imagery from northern indigenous villages (MERN) were also consulted.

The Puvirnituq drinking water intake is located 5km from the village and is not surrounded by any infrastructure or any commercial or industrial activity. Thus, very few activities take place in its watershed.

3.1.1 Human activities Inventory

The anthropogenic activities to be listed are those which, in their usual functioning, are likely to release contaminants that can affect the quantity or quality of surface water exploited.

No activity of this type was recorded during our inventory. There are several borrow pits operations in the area surrounding the village. However, none of them are located in the areas of inner or intermediate protection of the water intake. Hence, these borrow pits are unlikely to influence the water quality at the drinking water source. The same goes for mining activities: the Nunavik nickel mine in operation since 2012 is located more than 250 km as the crow flies, at the extreme limit of the watershed of the Puvirnituq River.

The raw water pumping station (and its associated oil thank) that is located in the inner protection zone is a human activity that normally poses no threat to the exploited waters.

3.1.2 Threats associated to human activities

As no threatening human activity has been reported at section 3.1.1, there is no associated threat to report here.

3.2 POTENTIAL EVENTS

Potential events linked to human activities correspond to exceptional events caused by accidents or extreme climatic events and which are likely to release contaminants into the surface water exploited or affect the quantity of drinking water available.

3.2.1 Inventory of potential events

Table 4. Potential events related to the anthropogenic activities inventoried in the watershed of the water intake

Potential event	Associated activity	Code and name CUBF	Concerned protection area	Potential contaminants
Spill at the pumping station	Electricity and Heating system at the raw water pumping station	483 – Aqueduct and irrigation	Immediate	Organic and inorganic substances (oil products)

The raw water pumping station is located on the river's shore, immediately beside the water intake. The latter is associated with an oil tank located outside the station, in a retention pond in case any spill occur (pictures 1 and 2).

3.2.2 Threats related to potential events

Table 5. Risk potential of the listed events

Potential event	Protection area	Considered contaminants	Risk potential
Spill at the pumping station	Inner	Oil products	**Low**

An oil spill at the raw water pumping station located on the shore immediately beside the water intake, is a potential event that could contaminate the exploited waters. A potential spill following either the filling/ maintenance of the oil tank or some instruments malfunctions associated to the oil tank (due to a freezing event, defective/ old parts, etc.) could have **serious** consequences on water quality (aesthetic or organoleptic water quality problem that is not acceptable for the consumer; MELCC 2018). Moreover, it is possible that such an event will occur in the next 5 years. Following the guide's criteria, the associated risk potential is therefore **low**.

3.3 LAND USES

3.3.1 Land uses inventory inside the protection zones

As the water intake is away from the village, it is part of the "hinterland" area, as defined in the development plan for the Northern Village of Puvirnituq. All the protection areas included within the municipal boundaries are therefore located in this single zone (BY-LAW No. 2007-03, Northern Village of Puvirnituq). Although the location of the water intake is beyond the limits of the land use map shown in Annex 3, the latter is still provided for information.

3.3.2 Threats associated with the land uses for the drinking water source

The following activities and developments are permitted in the hinterland: borrow pits and quarries, waste, and sewage treatment sites, drinking water supply facilities, cemetery, and temporary camps (as for the hunting, for example), telecommunications installations. Zoning also allows for traditional and recreational activities such as hunting, fishing, and trapping.

However, it should be noted that no development is allowed within a radius of 60m around the water intake. In addition, the waste treatment infrastructure is currently located opposite the water source and its watershed, on the other side of the village. They therefore pose no risk to the drinking water source as of now.

Finally, the use of these territories by the local population for their traditional and recreational activities contributes to the protection of the water source.

Although the risks of the activities mentioned in this section are quite negligible for the exploited waters, Table 6 in Annex 3 provides a summary. Activities that contribute to the protection of the water source are also presented.

4 IDENTIFICATION OF PROBLEMS AND THEIR PROBABLE CAUSES

Under Section 75 of the WWPR, this stage of the analysis seeks to identify the natural or anthropogenic causes behind the medium or high level of vulnerability identified in section 2.4 of this report.

Due to the isolated nature of the Northern Villages, and the pristine nature of the surrounding areas, drinking water sources are not exposed to the risks of chemical / biological contamination from human activities. As none of the indicators assessed in section 2.4 have a medium or high level of vulnerability, there are no issues or proven causes to be identified in this section.

5 CONCLUSION

5.1 GENERAL CONCLUSION

The Northern Village of Puvirnituq, like the other northern villages in Nunavik, is located in an isolated environment, where few industrial or commercial activities are taking places. For this reason, the drinking water source provides quality water. The main threat to water installations is the vagaries of the arctic climate, linked to the risk of freezing during the winter period and the movement of permafrost, which is undergoing profound changes with global warming.

Following the assessment of the vulnerability of the water source, none of the six indicators studied has a "medium" or "high" vulnerability level. As the Northern Village of Puvirnituq is located downstream from the drinking water intake, very few activities are located in the source protection areas, which explains these results. Likewise, no human activity is likely to affect the quality or quantity of drinking water available for the village. The "hinterland" land use, which encompasses all the intake protection zones, contributes more to strengthening the protection of the water source than to threatening it.

It emerges from this study that the drinking water source of Puvirnituq therefore provides the Northern Village with quality water and the influence of human activities is minimal.

Recommendations are made in section 5.3 to remedy to the lack of certain data and to further strengthen the monitoring and protection of the drinking water source.

5.2 MISSING INFORMATION

There are no data on low water levels and high-water mark. Riparian buffers zones were determined from the cartographic boundaries of the rivers studied, available on the databases used. The best available resolution was used.

There is no event log.

The daily water withdrawal rate, the withdrawal depth, the critical water level, the width of the watercourse at low water, as well as the number of the most recent authorization granted by the Ministry are also missing information.

A request for access to water quality data had been made to the regional office of the MELCC for Nord-du-Québec on January 6, 2021 concerning drinking water for the Northern Village of Puvirnituq. However, no data had been provided to us at the time of writing this report.

Some data on analyzes of inorganic substances are missing.

5.3 RECOMMENDATIONS

Following the drinking water source vulnerability analysis for the Northern Village of Puvirnituq, provided here is a list of recommendations sorted by priority in order to 1) validate some of the key elements discussed in the report and 2) guarantee the best possible protection of the drinking water source.

- Keep a written record of events, even minor ones, which have affected the drinking water production chain and keep this information for inter-annual monitoring. An example of such a register is provided in Annex 5;
- Create a register in which to record the values of the turbidity of the raw water, particularly during periods of flood (spring melt, heavy rains) when the turbidity is likely to increase sharply;
- Continue the analysis of raw water for the presence of coliforms as already carried out for several years;
- Apply a screen to the inlet of the water intake to prevent the introduction of debris into the pumping well;
- Visit/Evaluation of all the drinking water related installations by a professional within the next 5 years.

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ANNEX 1. GEOLOGY AND PERMAFROST

- A1.1 Geological map of Québec
- A1.2 Map of permafrost conditions (Source: St-Amour et al. 2020)
- A1.3 Map of natural hazards (Source: St-Amour et al. 2020)

Géologie du Québec

DV 2012-06

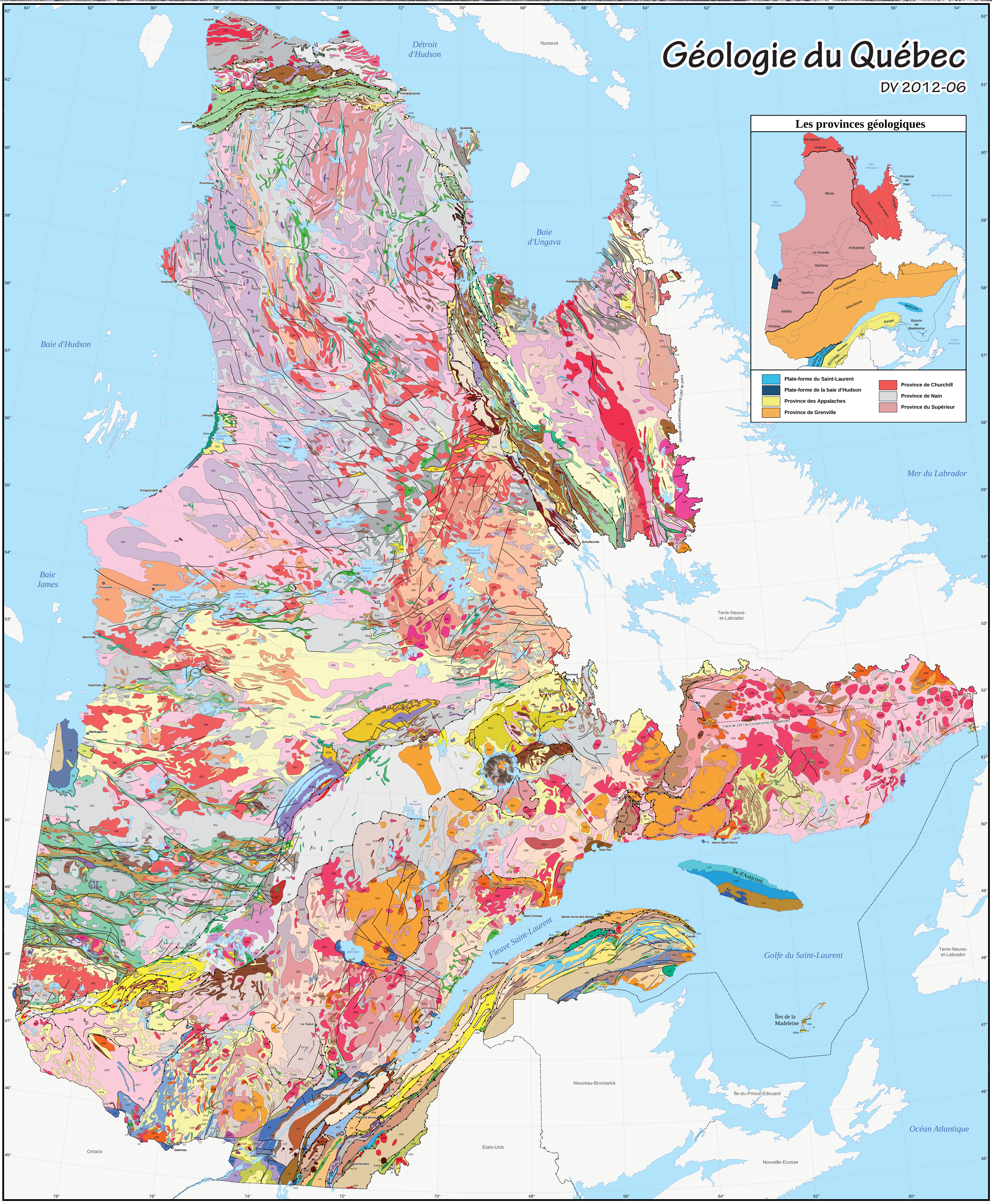


PLATE-FORME DU SAINT-LAURENT
(Plates-formes des Basses-Terres du Saint-Laurent et d'Anticosti)

MÉSOZOÏQUE

CRÉTACÉ

- **1** Roches intrusives alcalines intermédiaires à ultramafiques, brèches de diatrème associées et cornéennes (Suite des Montérégiennes)

PALÉOZOÏQUE

SILURIEN INFÉRIEUR

- **L15** Calcaire à crinoïdes et calcaire récifal (Fm. de Chicotte)
- **L14** Mudstone, calcaire et conglomérat calcaire (Fm. de Jupiter)
- **L13** Calcaire, shale, mudstone et conglomérat calcaire (Fms de Gun River, de Merrimack et de Becscie)

ORDOVICIEN SUPÉRIEUR ET MOYEN

- **L12** Calcaire, mudstone, shale et grès (Fms d'Ellis Bay et de Vauréal)
- **L11** Shale rouge, grès vert, siltstone, gypse et anhydrite (Gp. de Queenston)
- **L10** Shale gris, grès, siltstone et calcaire (Gp. de Lorraine)
- **L9** Mudrock, ardoise, dolomie et grès (Gp. de Sainte-Rosalie et Fm. de Stony Point)
- **L8** Shale noir calcareux et calcaire (Shale d'Utica et Shales de Pointe-Bleue)
- **L7** Brèche à fragments de dolomie, calcaire et grès dans une matrice carbonatée (brèches de Lacolle et de Havelock)
- **L6** Calcaire, shale, dolomie et grès (Gps de Trenton, de Black River et de Chazy; Fms de Mingan, de Tremblay, de Simard de Shipshaw et de Galets)

ORDOVICIEN INFÉRIEUR

- **L5** Dolomie, grès, calcaire et shale (Fms de Beauharnois et de Romaine)
- **L4** Grès dolomitique, grès quartzitique et dolomie (Fm. de Theresa)

CAMBRIEN SUPÉRIEUR

- **L3** Grès quartzitique, grès feldspathique et conglomérat (Gp. de Potsdam)

CAMBRIEN INFÉRIEUR

- **L2** Dolomie, calcaire et shale (Fm. de Forteau)
- **L1** Grès feldspathique, grès quartzitique et conglomérat (Fm. de Bradore)

PLATE-FORME DE LA BAIE D'HUDSON

PALÉOZOÏQUE

DÉVONIEN INFÉRIEUR

- **H4** Grès et arkose (Fm. de Sextant)

SILURIEN SUPÉRIEUR

- **H3** Mudstone gypsifère, grès, dolomie, calcaire, gypse, anhydrite et halite (Fm. de Kénogami)

SILURIEN INFÉRIEUR

- **H2** Calcaire, dolomie, chert et grès (Fms de la rivière Ekwan et de la rivière Severn)

ORDOVICIEN SUPÉRIEUR

- **H1** Calcaire, dolomie et claystone (Fm. de Red Head Rapids)

PROVINCE DES APPALACHES

PALÉOZOÏQUE

PERMO-CARBONIFÈRE

- **A30** Conglomérat, grès et mudrock rouges (formations de Bonaventure, de Cannes-de-Roches et de Cap-aux-Meules)
- **A30a** Basalte, brèche d'effondrement, roches volcanoclastiques, mudrock, grès, calcaire, gypse et anhydrite (formations du Cap au Diable et de Havre-aux-Maisons)

DÉVONIEN

- **A29** Granite, granodiorite et syénite (Suite intrusive de Lemieux; Granite des Monts Stoke; Granodiorite de Scotstown; Suite plutonique de lac aux Araignées; plutons d'Aylmer, de Winslow, d'Averill et de Saint-Sébastien - Sainte-Cécile)
- **A29a** Diorite et gabbro

SILURIEN ET DÉVONIEN

- **A28** Grès, conglomérat et mudstone vert et rouge (Fms de La Garde et de Pirate Cove)
- **A27** Grès feldspathique, conglomérat, mudrock vert et rouge et calcaire (Grès de Gaspé)
- **A27a** Basalte et rhyolite
- **A26** Calcaire, mudstone calcareux, grès, ardoise, basalte et rhyolite (Calcaires supérieurs de Gaspé)
- **A26a** Basalte et tuf mafique
- **A25** Mudrock, grès, calcaire et conglomérat (Gps de Saint-Francis et de Fortin; Fm. de Témiscouata)
- **A24** Mudrock, grès, calcaire et conglomérat (Gp. de Chaleurs)
- **A24a** Basalte
- **A23** Calcaire, siltstone, grès et conglomérat (Gp. de Glenbrooke; Fms de lac Aylmer et de Cranbourne)

ORDOVICIEN À SILURIEN INFÉRIEUR

- **A22** Mudstone, grès, calcaire et conglomérat (Gps de Matapédia, d'Honorat et de Cabano)
- **A22a** Calcaire, mudstone et grès (Fm. de White Head)
- **A21** Schiste à blocs (olistostromes de Drummondville et de la rivière Etchemin)
- **A20** Calcaire argileux, ardoise, mudrock, grès et conglomérat (Fms de Bourret, de la Ville de Québec, de Bulstrode et de Melbourne)
- **A19** Ardoise et mudrock (Gp. de Stanbridge)
- **A19a** Calcaire et ardoise
- **A18** Schiste ardoisier, grès, mudrock et roches volcanoclastiques (Gp. de Magog)
- **A17** Roches volcaniques mafiques, tuf felsique et schiste (Complexe d'Ascot)
- **A17a** Shale et ardoise
- **A16** Grès et schiste ardoisier (Fms de Frontenac et de Clinton)
- **A16a** Roches volcaniques mafiques
- **A15** Wacke lithique, mudrock, grès, conglomérat et mélange (Gp. de Mictaw; Fm. d'Arseneault)
- **A14** Mélange constitué de lithologies des formations de Rivière-Ouelle, de Tourelle et de Des Landes (Mélange de Cap-Chat)
- **A13** Roches ultramafiques (complexes du mont Albert et de La Rédemption); amphibolite (Amphibolite du Diable); mélange de roches ultramafiques et sédimentaires (Mélange du Ruisseau Isabelle)

CAMBRIEN À ORDOVICIEN INFÉRIEUR

- **A12** Mudrock, grès et calcaire (Fms de Des Landes et de Cloridorme)
- **A11** Grès, wacke, mudrock et calcaire (Fm. de Tourelle)
- **A10** Calcaire, dolomie et mudrock (Gp. de Philipsburg)
- **A9** Mudrock, grès, conglomérat et calcaire (Gp. de Trois-Pistoles; Fms de Romieu, de Rivière-Ouelle et de Sainte-Hénédine)
- **A8** Mudrock, conglomérat, grès et calcaire (Gp. de l'Île d'Orléans; Fms de Lauzon et de Lévis)
- **A7** Blocs et copeaux de grès, de roches volcaniques, de granite, de gabbro et de serpentinite (mélanges de Saint-Daniel et de Chesham)
- **A6** Grès quartzitique, mudrock, ardoise, conglomérat et calcaire (Gp. de Rosaire)
- **A5** Roches intrusives ultramafiques à mafiques, roches volcaniques mafiques et amphibolite (complexes ophiolitiques de Thetford Mines, d'Asbestos et d'Orford)
- **A4** Mudrock, ardoise verte et rouge, grès et calcaire (Gps de Saint-Roch, d'Armagh, de Sillery, de Shefford et de Trinité; Fms d'Isle-aux-Coudres et de Saint-Bernard-sur-Mer)
- **A4a** Roches volcaniques mafiques (Fm. de la Montagne de Saint-Anselme)

NÉOPROTÉROZOÏQUE À ORDOVICIEN INFÉRIEUR

- **A3** Phyllade, schiste, ardoise, grès, quartzite, dolomie et conglomérat (Gps d'Oak Hill et de Caldwell; Schistes de Bennett)
- **A3a** Roches volcaniques mafiques (Gp. de Caldwell) et schiste à chlorite (Fm. de Tibbit Hill)
- **A2** Métabasalte et roches métasédimentaires (Gps de Shickshock et de Maquereau; Unité des Pics)

PROTÉROZOÏQUE

- **A1** Paragneiss, roches intrusives granulitiques et roches métavolcaniques felsiques (Massif de Chain Lakes)

PROVINCE DE GRENVILLE

MÉSOZOÏQUE

TRIAS

- **G33** Impactite : monzonite
- **G33a** Impactite : latite et basalte sphérulitique

NÉOPROTÉROZOÏQUE TARDIF

ÉDIACARIEN

- **G32** Syénite, monzonite, monzodiorite, granite et carbonatite
- **G31** Gabbro, troctolite, anorthosite, granite et nelsonite

PALÉOPROTÉROZOÏQUE ET MÉSOPROTÉROZOÏQUE

GRANITOÏDES

- **G30** Granite, monzonite quartzifère, syénite quartzifère et pegmatite
- **G29** Syénite, monzonite, monzodiorite et autres intrusions alcalines associées
- **G28** Granitoïdes à orthopyroxène : charnockite, mangérite, jotunite et syénite à hypersthène
- **G27** Granitoïdes non subdivisés
- **G26** Migmatite
- **G25** Gneiss granitoïde
- **G24** Gneiss charnockitique et gneiss mixte
- **G23** Gneiss tonalitique et trondhjémitique; présence commune de tonalite
- **G22** Gneiss non subdivisés

ROCHES MAFIQUES À ULTRAMAFIQUES

- **G21** Anorthosite, leucogabbro, leuconorite, leucotroctolite et nelsonite
- **G20** Gabbro, norite, gabbronorite, diorite, troctolite, pyroxénite et péridotite; quantité mineure d'anorthosite
- **G19** Gneiss mafique et amphibolite

ROCHES SÉDIMENTAIRES

- **G18** Arénite, grès, wacke, quartzite, paragneiss et schiste
- **G17** Marbre, roches calco-silicatées, dolomie, schiste et quartzite
- **G16** Formation de fer
- **G15** Quartzite
- **G14** Paragneiss schisteux à graphite
- **G13** Paragneiss, gneiss pélitique, marbre, quartzite et formation de fer; présence commune de roches intrusives mafiques
- **G12** Migmatite métasédimentaire et diatexite

ROCHES VOLCANIQUES

- **G11** Roches volcaniques felsiques
- **G10** Basalte, andésite et amphibolite

ARCHÉEN

GRANITOÏDES

- **G9** Granite, granodiorite, monzonite quartzifère et pegmatite
- **G8** Tonalite, granodiorite et monzodiorite
- **G7** Migmatite
- **G6** Gneiss granitoïde
- **G5** Gneiss charnockitique et gneiss mixte
- **G4** Gneiss non subdivisés

ROCHES MAFIQUES À ULTRAMAFIQUES

- **G3** Anorthosite et gabbro

ROCHES SÉDIMENTAIRES

- **G2** Paragneiss; présence commune de diatexite, de roches intrusives mafiques et d'amphibolite

ROCHES VOLCANIQUES

- **G1** Amphibolite, métabasalte et gneiss mafique d'origine volcanique

PROVINCE DE CHURCHILL

MÉSOPROTÉROZOÏQUE

- **C27** Granite, monzonite quartzifère et syénite
- **C26** Syénite et monzonite
- **C25** Anorthosite, gabbro, gabbronorite, leuconorite et leucotroctolite
- **C24** Gabbronorite et péridotite

PALÉOPROTÉROZOÏQUE

GRANITOÏDES

Syn- à tardi-tectonique

- **C23** Granite, granodiorite, monzodiorite et tonalite
- **C23a** Monzonite et monzonite quartzifère

Pré- à syntectonique

- **C22** Granitoïdes à orthopyroxène : charnockite, opdalite, enderbite, mangérite, jotunite et gneiss granulitique
- **C21** Tonalite, diorite quartzifère et granodiorite foliées à gneissiques

INTRUSIONS MAFIQUES À ULTRAMAFIQUES

- **C20** Carbonatite et roches ultramafiques potassiques associées
- **C19** Roches intrusives mafiques : gabbro, diorite, diorite quartzifère, gabbronorite et anorthosite
- **C18** Roches intrusives ultramafiques : péridotite, pyroxénite et dunite
- **C17** Amphibolite et gneiss mafique non subdivisé; quantité mineure de métabasalte

ROCHES SÉDIMENTAIRES

- **C16** Formation de fer, mudrock et arénite quartzitique
- **C15** Dolomie, dolomie stromatolitique, grès et siltstone dolomitiques, chert et brèche de chert
- **C14** Arkose, arénite quartzitique, conglomérat, grès, mudrock rouge et dolomie
- **C13** Mudrock et wacke
- **C12** Roches métasédimentaires : paragneiss, schiste, quartzite, marbre et roches calco-silicatées
- **C12a** Quartzite
- **C12b** Marbre et roches calco-silicatées

ROCHES VOLCANIQUES

- **C11** Basalte et roches volcanoclastiques mafiques; faible quantité de roches volcaniques felsiques
- **C11a** Roches volcaniques mafiques alcalines
- **C11b** Roches volcaniques felsiques

ARCHÉEN ET/OU PALÉOPROTÉROZOÏQUE

GRANITOÏDES

- **C10** Granite et monzonite porphyrique
- **C9** Granodiorite et tonalite
- **C8** Tonalite, diorite quartzifère et granodiorite injectées de veines de composition granitique
- **C7** Migmatite de composition tonalitique à granitique; présence commune de pegmatite
- **C6** Gneiss granitoïde : gneiss tonalitique avec injections de matériel granitique; présence commune de gneiss granitique à granodioritique
- **C5** Gneiss granulitique de composition tonalitique à granitique; présence commune de granitoïdes à orthopyroxène
- **C4** Gneiss tonalitique et dioritique

ROCHES MAFIQUES À ULTRAMAFIQUES

- **C3** Amphibolite dérivée de roches intrusives et/ou extrusives mafiques à intermédiaires

ROCHES SÉDIMENTAIRES

- **C2** Roches sédimentaires : siltstone, shale, grès et conglomérat
- **C1** Roches métasédimentaires : paragneiss, schiste et quartzite

PROVINCE DE NAIN

ARCHÉEN

GRANITOÏDES

- **N2** Gneiss granulitique
- **N1** Gneiss tonalitique

PROVINCE DU SUPÉRIEUR

PALÉOZOÏQUE

PERMIEN

- **S28** Impactite, mylolisthénite, ignimbrite et brèche

ORDOVICIEN

- **S27** Calcaire, shale, grès et conglomérat

PROTÉROZOÏQUE

PALÉOPROTÉROZOÏQUE

- **S26** Syénite, carbonatite, péridotite et pyroxénite alcalins
- **S25** Grès, mudrock rouge et conglomérat
- **S25a** Basalte subaérien
- **S25b** Dolomie stromatolitique, grès et conglomérat
- **S24** Arénite quartzitique, conglomérat et mudrock
- **S23** Dolomie stromatolitique, grès dolomitique, conglomérat et brèche
- **S23a** Conglomérat et grès
- **S23b** Formation de fer à jaspilite
- **S22** Argilite, wacke, conglomérat et tillite

ARCHÉEN

NÉOARCHÉEN

GRANITOÏDES

Tardi- à post-tectonique

- **S21** Granite alcalin et monzogranite
- **S20** Granite et granodiorite; quantité mineure de diatexite
- **S19** Granite et granodiorite à orthopyroxène et/ou clinopyroxène

Syntectonique

- **S18** Diatexite
- **S17** Monzonite, monzonite quartzifère, syénite, monzodiorite, monzodiorite quartzifère et diorite
- **S16** Granite et granodiorite
- **S15** Granite et granodiorite à orthopyroxène et/ou clinopyroxène
- **S14** Tonalite et granodiorite à orthopyroxène et/ou clinopyroxène
- **S13** Tonalite, diorite, diorite quartzifère et granodiorite; gneiss tonalitique

Pré-tectonique ou synvolcanique

- **S12** Tonalite, granodiorite et granite; gneiss tonalitique et granodioritique

INTRUSIONS MAFIQUES À ULTRAMAFIQUES

- **S11** Complexes stratiformes : anorthosite, gabbro, pyroxénite et péridotite
- **S10** Roches intrusives mafiques : gabbro, gabbronorite et diorite
- **S9** Roches intrusives ultramafiques : pyroxénite, péridotite, dunite, hornblendite, serpentinite, carbonatite et filons-couches ultramafiques et mafiques

ROCHES SÉDIMENTAIRES

- **S8** Roches sédimentaires : wacke, mudrock, conglomérat, formation de fer et arénite quartzitique
- **S8a** Conglomérat polygénique; localement roches volcaniques alcalines
- **S8b** Formation de fer
- **S7** Roches métasédimentaires : paragneiss, schiste, formation de fer et marbre; quantité mineure de diatexite

ROCHES VOLCANIQUES

- **S6** Roches volcaniques felsiques : rhyolite, rhyodacite, dacite, roches volcanoclastiques et intrusions porphyriques felsiques synvolcaniques
- **S6a** Roches métavolcaniques et métavolcanoclastiques felsiques
- **S5** Roches volcaniques mafiques et intermédiaires : basalte, andésite et roches volcanoclastiques
- **S5a** Roches métavolcaniques mafiques et intermédiaires; amphibolite
- **S4** Roches volcaniques ultramafiques : komatiite et basalte magnésien

MÉSOARCHÉEN

- **S3** Gneiss tonalitique; tonalite et diorite foliées
- **S2** Roches métavolcaniques et métasédimentaires

ÉOARCHÉEN

- **S1** Roches métavolcaniques et métasédimentaires

FRONTIÈRES

- Frontière internationale
- Frontière interprovinciale ou interétatique
- Frontière Québec — Terre-Neuve-et-Labrador (cette frontière n'est pas définitive)

SYMBOLES

- Discordance
- Faille de chevauchement
- Faille de type indéterminé

Métadonnées

Surface de référence géodésique :	Ellipsoïde GRS 80
Système de référence géodésique :	NAD 83 compatible avec le système mondial WGS 84
Projection cartographique :	Conique de Lambert
Méridien central :	68° 30' ouest

0 50 100 150 km

1/2 000 000

Sources

Données	Organisme	Année
Géologie :	Ministère des Ressources naturelles Direction de l'information géologique du Québec	2012
Topographie :	Ministère des Ressources naturelles Direction générale de l'information géographique	2010

Réalisation

Compilation géologique :	Robert Thériault
Assistance technique :	Stéphane Beauséjour, André Tremblay
Production :	Ministère des Ressources naturelles Direction générale de Géologie Québec
Diffusion :	Ministère des Ressources naturelles Direction de l'information géologique du Québec

Dépôt légal - Bibliothèque et Archives nationales du Québec

Localisation

Ressources naturelles
Québec

Résumé

Cette carte présente les conditions de pergélisol de la région de Puvirnituq. Ce village se situe au Nunavik, sur la rive est de la baie d'Hudson, à l'embouchure de la rivière Puvirnituq (60.05° N ; 77.32° O).

Note

Cette carte a été compilée principalement par photo-interprétation et validée avec un nombre limité d'observations de terrain, de sondages et de forages dans le pergélisol. Toute information pouvant en améliorer la précision et éventuellement conduire à la production d'une mise à jour sera appréciée.

Abstract

This map shows the permafrost conditions of the Puvirnituq region. This Nunavik village is located on the east shore of the Hudson Bay at the mouth of the Puvirnituq River (60.05° N ; 77.32° W).

Note

This map was compiled mainly by air photo interpretation and validated by a limited number of terrain observations, probing and drill holes in the permafrost. Any information leading to an improvement of precision and, eventually, an update of the map will be received with thanks.

Système national de référence cartographique

RNCan, gouvernement du Canada, centre d'information topographique (2006). Index vectoriels du système national de référence cartographique du Canada.

Illustration de couverture :
Puvirnituq, Nunavik, Québec. Photographie par Chantal Lemieux

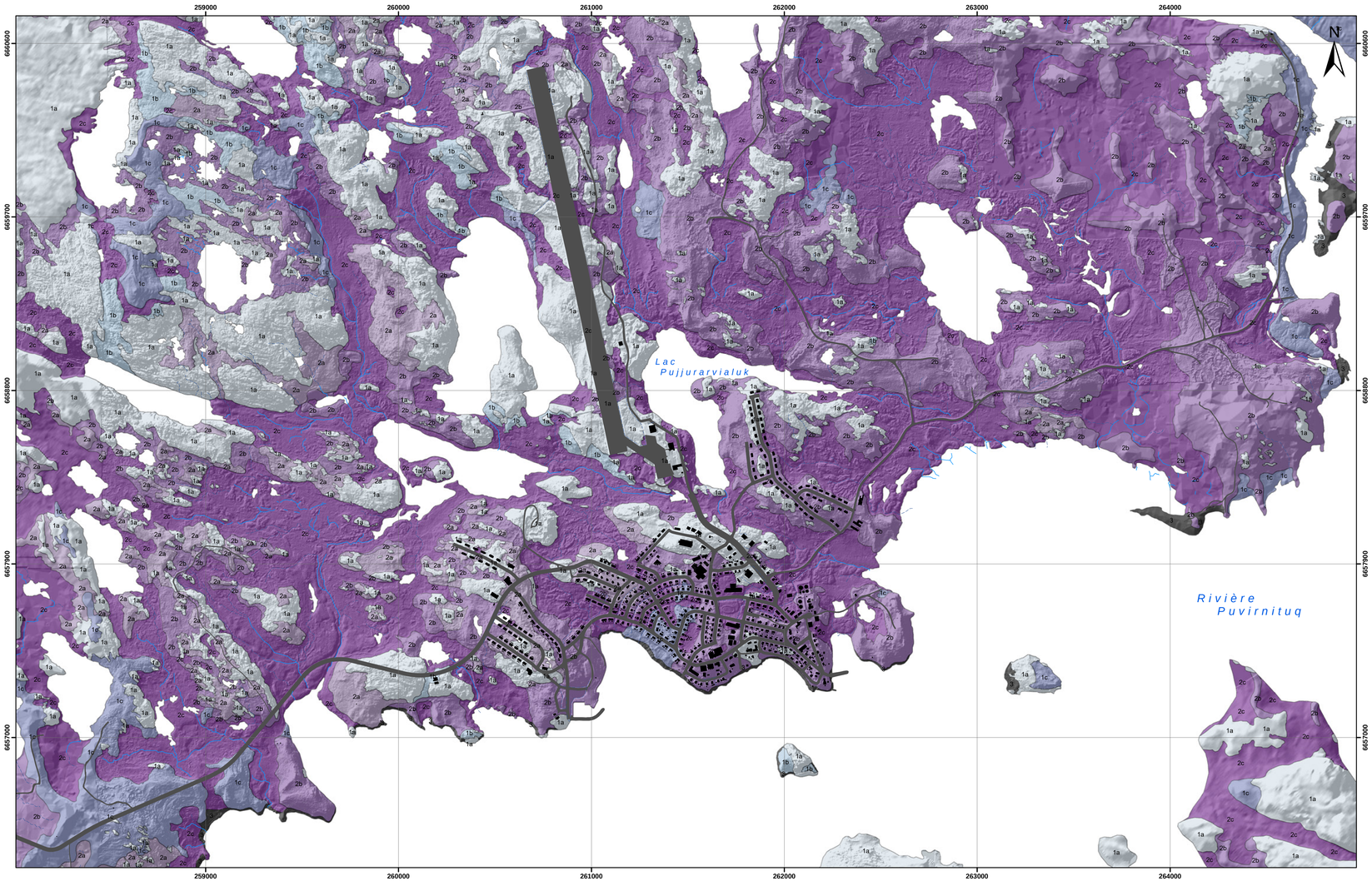
Centre d'études nordiques, Québec, 2018

CONDITIONS DE PERGÉLISOL

PUVIRNITUQ

Québec, Nunavik

1 : 12 000



Dépôts stables au dégel : roc et dépôts meubles contenant très peu ou pas de glace

1a Socle rocheux.
La couche active atteint une épaisseur comprise entre 4,5 et 6 m. Seule sa structure de joints et de diaclases est susceptible de contenir une faible quantité de glace.

1b Dépôt de sable et gravier en couverture mince (< 2 m) sur socle rocheux.
La couche active atteint une épaisseur comprise entre 1,5 et 2,5 m. Contient de la glace interstitielle poreuse dont le contenu volumique en glace est généralement inférieur à 10 %.

1c Dépôt de sable et gravier stratifié épais (> 2 m).
La couche active atteint une épaisseur comprise entre 1,5 et 2,5 m. Contient de la glace interstitielle et possiblement de la glace sous forme de lentilles dans les couches de matériau à granulométrie fine. Présence probable de réseaux de polygones à coins de glace bien développés.

Dépôts instables au dégel : dépôts meubles contenant beaucoup de glace

2a Dépôt glaciaire (till) en couverture mince (< 2 m) sur socle rocheux.
La couche active atteint une épaisseur comprise entre 2,5 et 3 m. Contient de la glace interstitielle et sous forme de lentilles dans les couches de matériau à granulométrie fine. Le contenu volumique en glace est généralement inférieur à 30 %. Présence d'ostioles et de coulées de gélifluxion sur les versants. Matériau sujet au fluage et à des tassements différentiels limités lors de sa fonte en raison de sa faible épaisseur.

2b Dépôt glaciaire (till) en couverture épaisse (> 2 m) sur socle rocheux.
La couche active atteint une épaisseur comprise entre 2,5 et 3 m. Contient de la glace interstitielle et sous forme de lentilles dans les couches de matériau à granulométrie fine. Le contenu volumique en glace est généralement inférieur à 30 %. Présence d'ostioles et de coulées de gélifluxion sur les versants. Matériau sujet au fluage et au tassement différentiel lors de sa fonte.

2c Couvertures minces de sols organiques, de sédiments alluviaux, de sédiments littoraux ou de sédiments lacustres sur des sédiments marins fins d'eau profonde (sable fin, silt et argile). Dépôts mal drainés pouvant atteindre plus de 7 m d'épaisseur. La couche active atteint une épaisseur comprise entre 0,5 et 1,5 m. Contient beaucoup de glace de ségrégation dont le contenu volumique dépasse régulièrement 30 % et peut atteindre près de 100 %. Surface fréquemment recouverte d'ostioles. Matériau sujet à des tassements différentiels importants et à des ruptures de pente sur les versants lors de sa fonte.

Contraintes sévères : processus périglaciaires et de versants dynamiques, littoraux et plaines alluviales actuelles

3 Contraintes sévères : processus périglaciaires et de versants dynamiques, littoraux et plaines alluviales actuelles.

BÂTIMENTS

INFRASTRUCTURES DE TRANSPORT

RÉSEAU DE DRAINAGE - ruisseaux permanents

RÉSEAU DE DRAINAGE - ruisseaux intermittents

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Image en relief ombragé préparée par L'Hérault, E. dérivée des données LIDAR 2010 (MRNF 2010, gouvernement du Québec). Illumination : azimuth 315°, altitude 45°, exagération verticale 1x

Projection : MTM zone 9, NAD83

CONDITIONS DE PERGÉLISOL

PUVIRNITUQ

Québec, Nunavik

1 : 12 000

0 250 500 750 1 000 1 250 1 500 Mètres

Auteurs : M. Allard., E. L'Hérault., J. Doyon et T. Gibéryen
Centre d'études nordiques, Université Laval, décembre 2018.

Citation recommandée :
Allard, M., L'Hérault, E., Doyon, J. et Gibéryen, T., 2018. Conditions de pergélisol, Puvirnituq, Québec, Nunavik; Centre d'études nordiques, échelle 1: 12 000.

Résumé

Cette carte présente les risques naturels actuels et appréhendés de la région de Puvirnituq. Ce village se situe au Nunavik, sur la rive est de la baie d'Hudson, à l'embouchure de la rivière Puvirnituq (60.05° N ; 77.32° O).

Note

Cette carte a été compilée principalement par photo-interprétation et validée avec un nombre limité d'observations de terrain, de sondages et de forages dans le pergélisol. Toute information pouvant en améliorer la précision et éventuellement conduire à la production d'une mise à jour sera appréciée.

Les risques naturels sont représentés par un symbole ponctuel, linéaire ou zonale, en fonction de leur échelle et de leur géométrie.

Abstract

This map shows the actual and potential natural hazards of the Puvirnituq region. This Nunavik village is located on the east shore of the Hudson Bay at the mouth of the Puvirnituq River (60.05° N ; 77.32° W).

Note

This map was compiled mainly by air photo interpretation and validated by a limited number of terrain observations, probing and drill holes in the permafrost. Any information leading to an improvement of precision and, eventually, an update of the map will be received with thanks.

Natural hazards are presented according to their scale and geometry: polygons, lines or points.

Système national de référence cartographique
The National Topographic System of Canada

RNCan, gouvernement du Canada, centre d'information topographique (2008). Index vectoriels du système national de référence cartographique du Canada.

Vector indexes of the National Topographic System of Canada. Government of Canada, Natural Resources Canada, Earth Sciences Sector, Mapping Information Branch, Centre for Topographic

Illustration de couverture / Cover illustration:
Puvirnituq, Nunavik, Québec.
Photographie par Chantal Lemieux / Photocredits: Chantal Lemieux

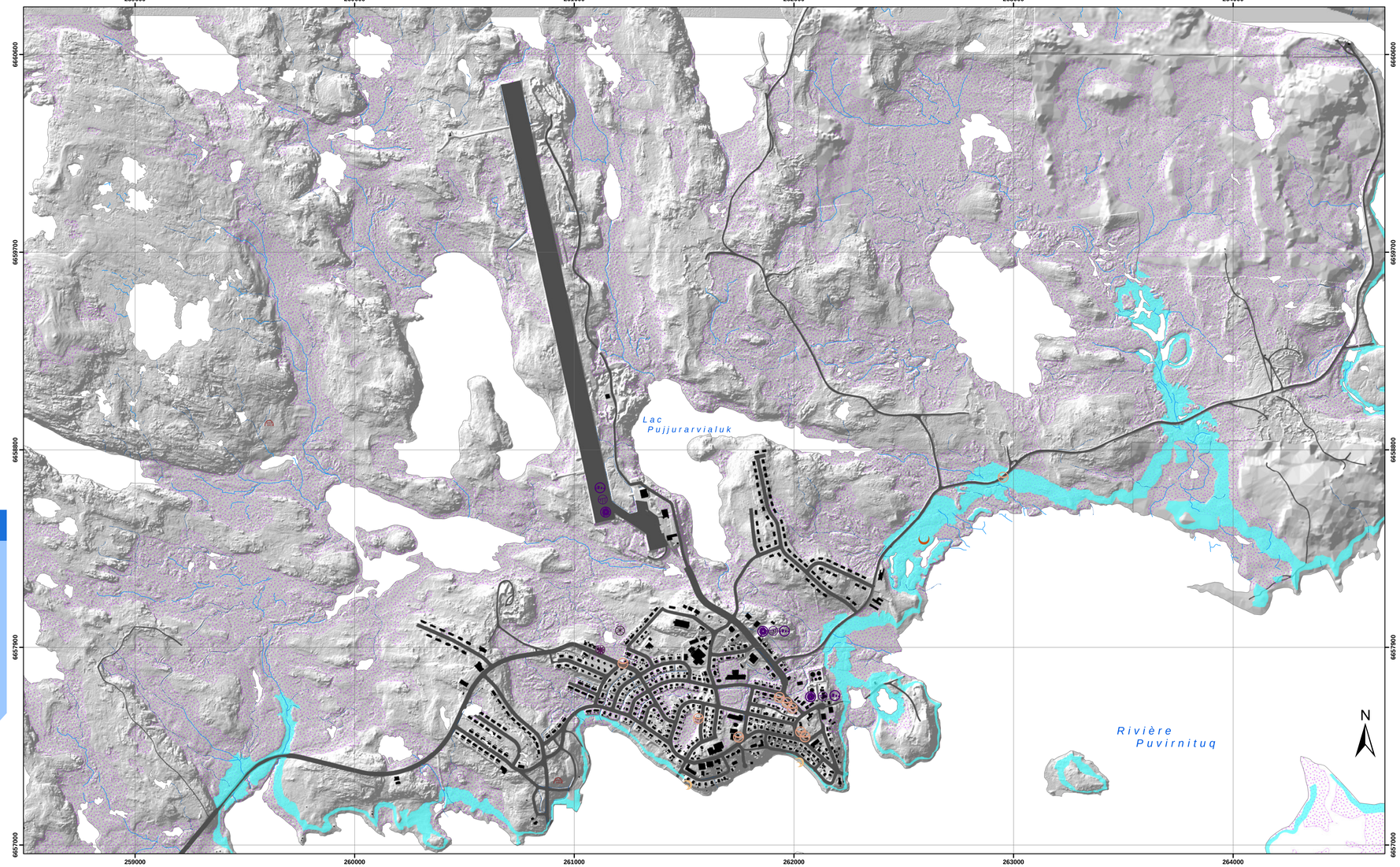
Centre d'études nordiques, Québec, 2016

ALÉAS NATURELS ACTUELS ET APPRÉHENDÉS
ACTUAL AND POTENTIAL NATURAL HAZARDS

PUVIRNITUQ

Québec, Nunavik

1 : 10 000



MOUVEMENT DE MASSE / MASS WASTING

AVALANCHE DE NEIGE / SNOW AVALANCHE

1/100
1/1000

GLISSEMENT DE TERRAIN / LANDSLIDE

GÉLIFLUXION / GELIFLUCTION

COULÉE / FLOW

ÉBOULIS / FALLS

ÉROSION / EROSION

ÉROSION CÔTIÈRE ET FLUVIALE / COASTAL AND FLUVIAL EROSION

ÉROSION PAR LE VENT / WIND EROSION

CLIMATIQUE / CLIMATIC

FEU / WILDFIRE

TEMPÊTE DE VENT / WIND STORM

BLIZZARD / BLIZZARD

VERGLAS / ICE STORM

PROCESSUS PÉRIGLACIAIRES / PERIGLACIAL PROCESSES

PERGÉLISOL RICHE EN GLACE / ICE-RICH PERMAFROST

GLAÇAGE / ICING

BUTTE SAISONNIÈRE À NOYAU DE GLACE / FROST BLISTER

PROCESSUS LIÉS AU DÉGEL / THAW-RELATED PROCESSES

AFFAISEMENT THERMOKARSTIQUE / THERMOKARST SUDSIDENCE

ÉROSION THERMIQUE/ THERMAL EROSION

PROCESSUS HYDROLOGIQUES / HYDROLOGICAL PROCESSES

DRAINAGE D'UN LAC / LAKE DRAINAGE

SURCOTE / STORM SURGE

CRUE SOUDAINE ET INONDATION / FLASH

EMBÂCLE ET DÉBÂCLE GLACIELS / ICE-JAM AND BREAK-UP

POUSSÉE GLACIELLE / ICE-PUSH

TREMBLEMENT DE TERRE / EARTHQUAKE

TREMBLEMENT DE TERRE / EARTHQUAKE

HYDROLOGIE / HYDROLOGY

RÉSEAU DE DRAINAGE - ruisseaux permanents
RILLS AND WATERTRACKS - running throughout all arctic summer

RÉSEAU DE DRAINAGE - ruisseaux intermittents
RILLS AND WATERTRACKS - running occasionally during spring melt

INFRASTRUCTURES / INFRASTRUCTURE

BÂTIMENTS / BUILDING

INFRASTRUCTURES DE TRANSPORT / TRANSPORT

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Image en relief ombragé préparée par L'Hérault, E. et Doyon, J. dérivée des données LIDAR 2010 (MRNF 2010, gouvernement du Québec).
Illumination : azimuth 315°, altitude 45°, exagération verticale 1x

Hillshade created by L'Hérault, E. and Doyon, J. from LIDAR data (MRNF 2010, gouvernement du Québec).
Illumination: azimuth 315°, altitude 45°, vertical exaggeration 1x

Projection : MTM zone 9, NAD83

ALÉAS NATURELS ACTUELS ET APPRÉHENDÉS
ACTUAL AND POTENTIAL NATURAL HAZARDS

PUVIRNITUQ

Québec, Nunavik

1 : 10 000

0 250 500 750 1 000 1 250 1 500 Mètres

Auteurs : S. Aubé-Michaud, M. Allard et E. L'Hérault, Centre d'études nordiques, Université Laval, décembre 2016.

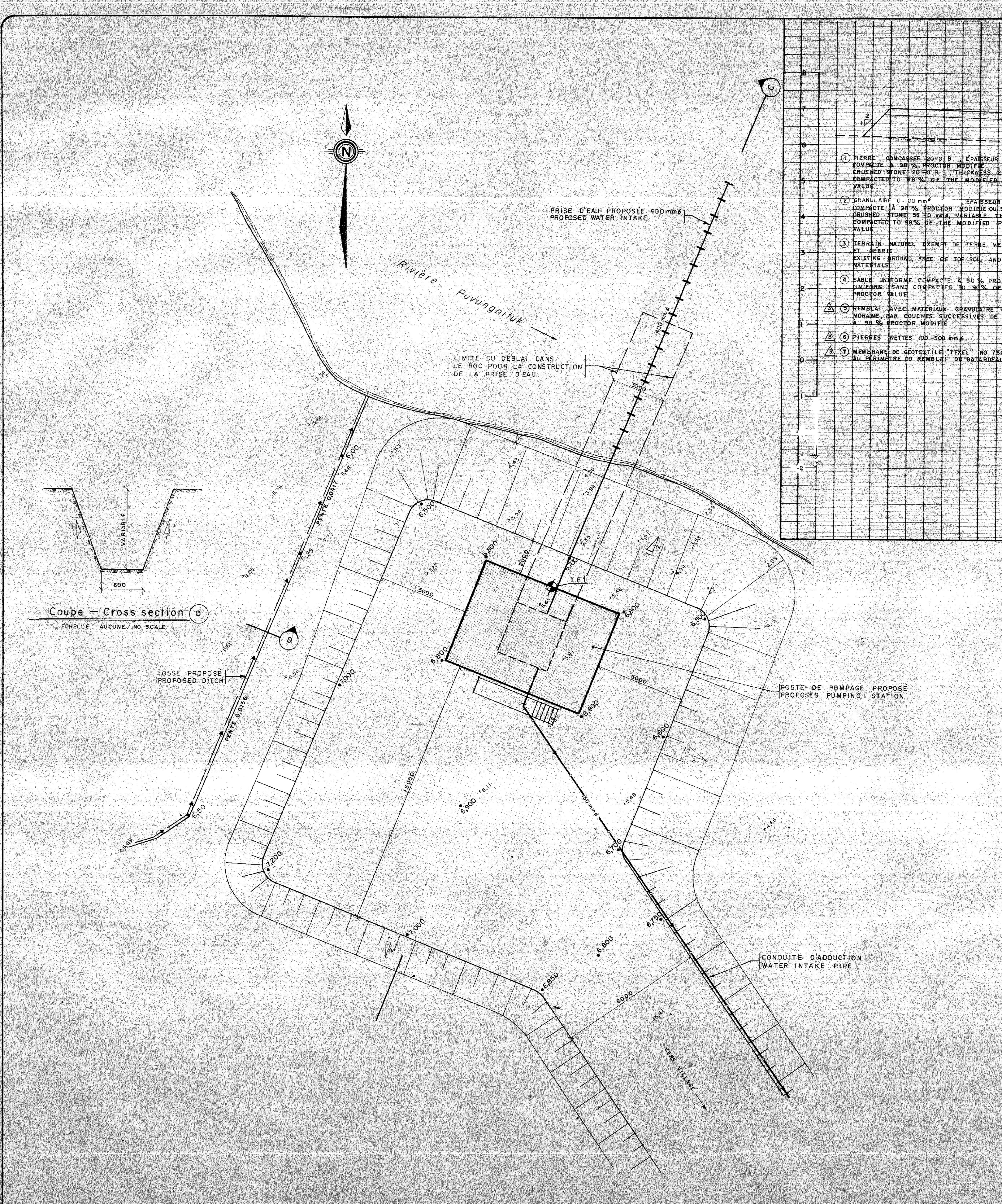
Authors: S. Aubé-Michaud, M. Allard and E. L'Hérault, Centre d'études nordiques, Université Laval, December 2016.

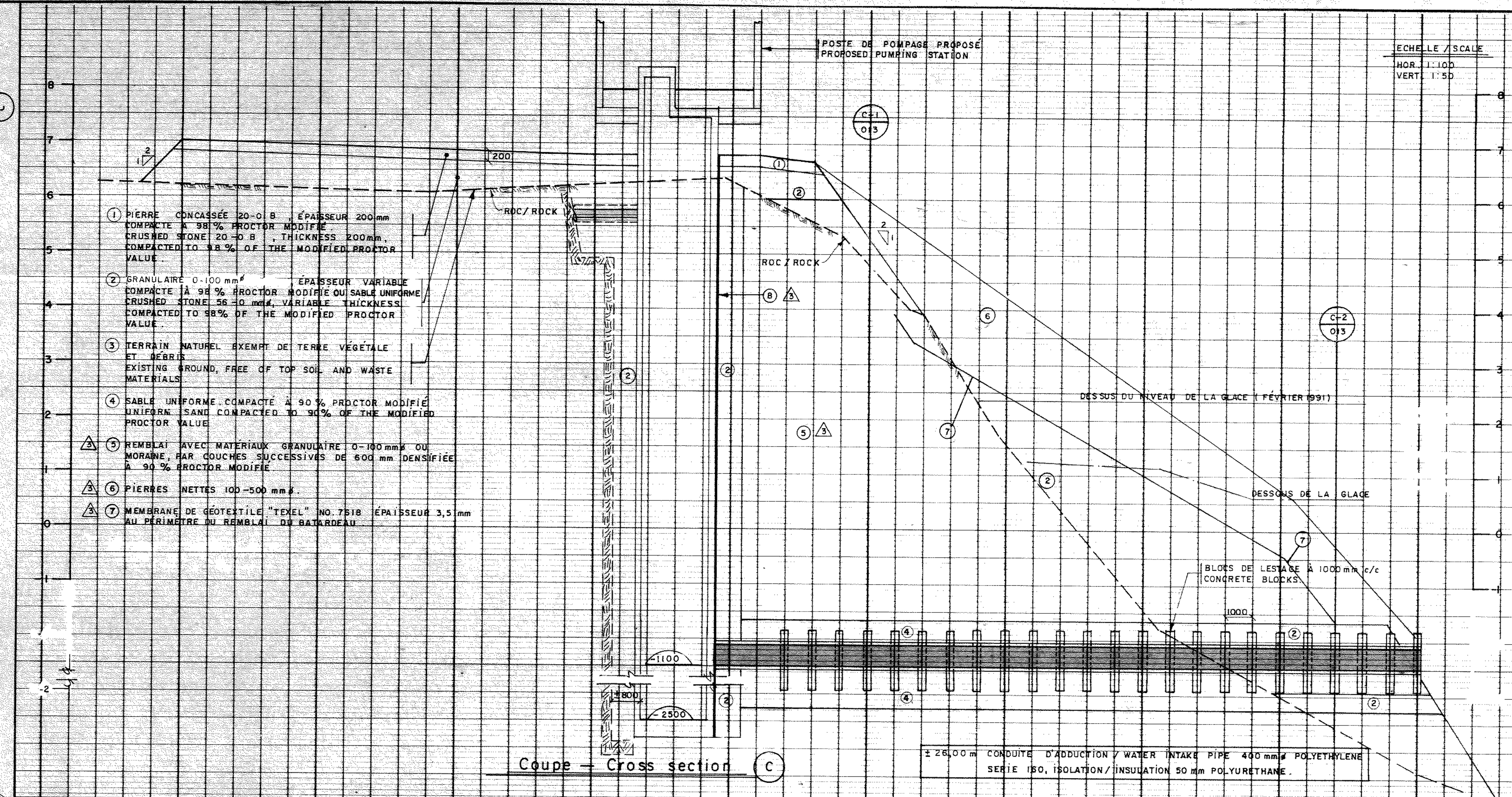
Citation recommandée :
Aubé-Michaud, S., Allard, M. et L'Hérault, E., 2016. Aléas naturels actuels et appréhendés, Puvirnituq, Québec, Nunavik, Centre d'études nordiques, échelle 1: 10 000.

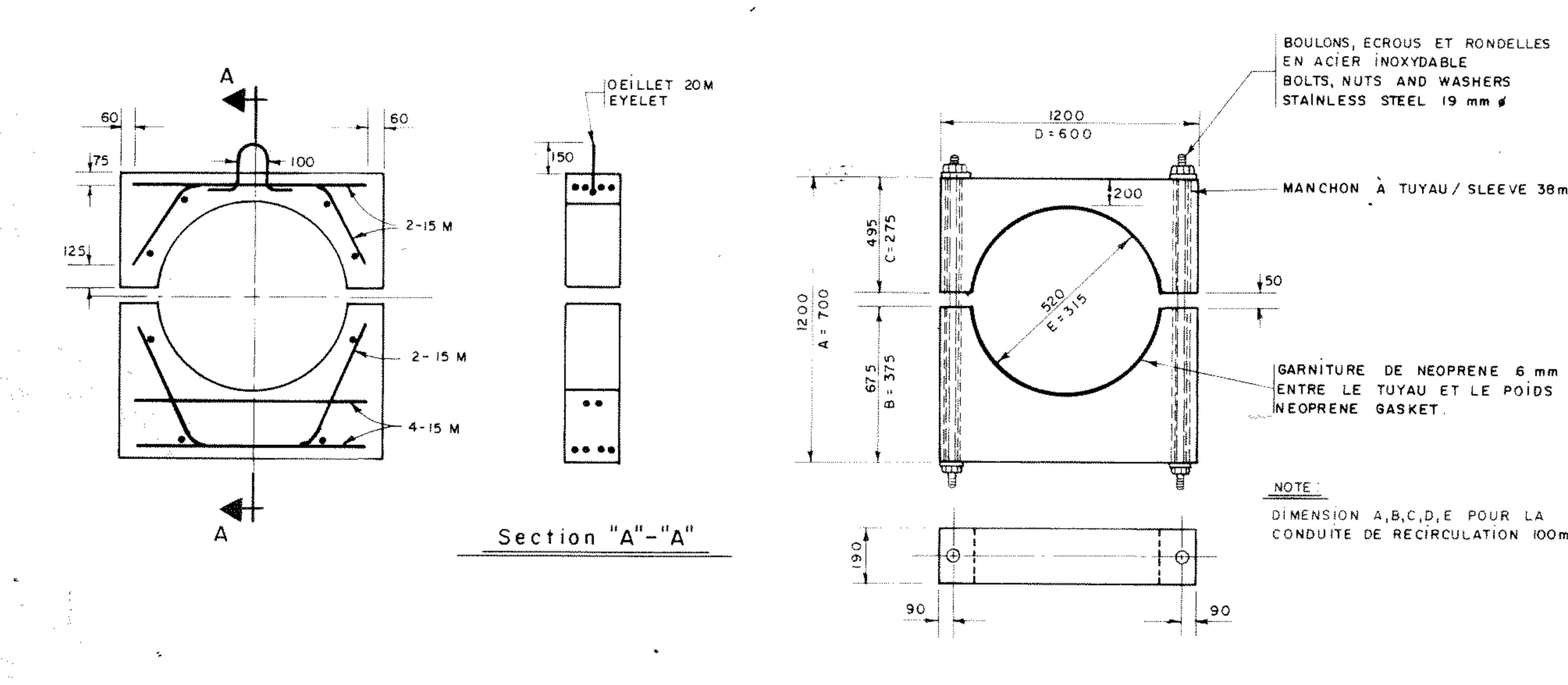
Recommended citation:
Aubé-Michaud, S., Allard, M. and L'Hérault, E., 2016. Actual and potential natural hazards, Puvirnituq, Québec, Nunavik, Centre d'études nordiques, scale 1: 10 000.

ANNEX 2. CONSTRUCTION SCHEMATICS OF THE INSTALALTIONS AT THE WITHDRAWAL SITE

- A2.1, A2.2 Schematics of the installations destined to the withdrawal and treatment of the Northern Village of Puvirnituq drinking water

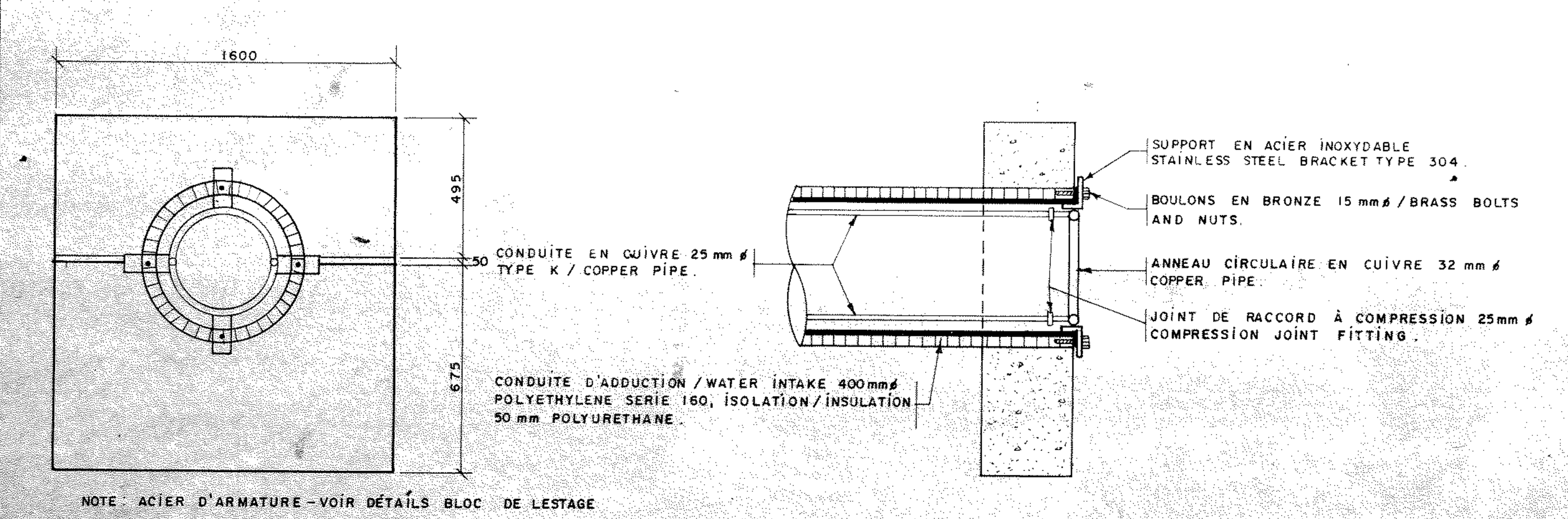






Bloc de lestage / Concrete ballast weight

ÉCHELLE : AUCUNE / NO SCALE



Extrémité de la prise d'eau — Détails

End of water intake pipe — Details

ÉCHELLE : AUCUNE / NO SCALE

NOTE : LA MISE À JOUR DES PLANS TELS QUE CONSTRUITS A ÉTÉ RÉALISÉE SELON LES INFORMATIONS FOURNIES PAR LE CONSULTANT BPR, RESPONSABLE DE LA SURVEILLANCE EN CHANTIER DES TRAVAUX.

Rev. No	Description	Date
4	TEL QUE CONSTRUIT	94-11-03
3	MODIFICATION POUR REMBLAI DE LA TRANCHÉE	92-09-10
2	ÉMIS POUR SOUMISSION	91-04-08
1	POUR APPROBATION	91-02-28

Administration régionale KATIVIK
KATIVIK Regional Government
ᑲᑎᕕᒃ ᓄᓇ ᓕᓕᒫᑦ ᑲᕙᒪᖓ

POVUNGNITUK

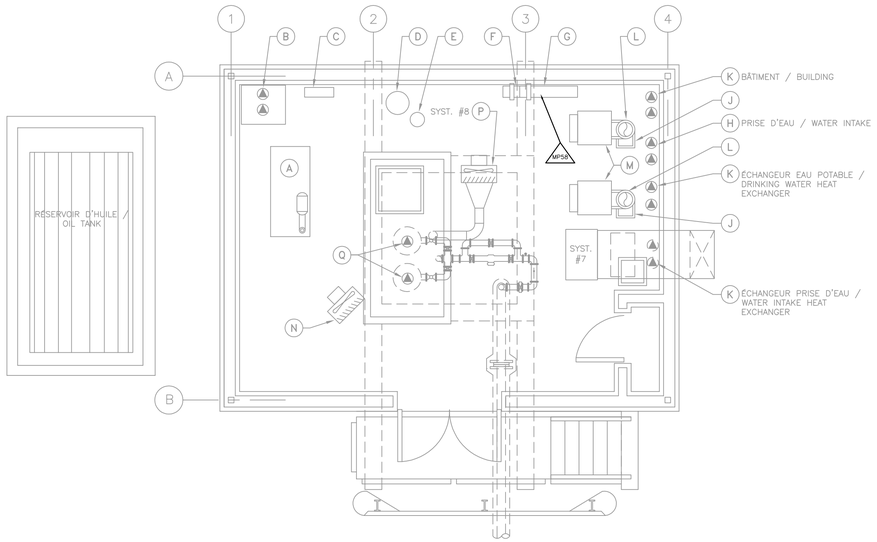
Consultant:
St-Amant, Vézina, Vinet, Brassard,
Ingénieurs-Conseils
1271, 7e rue Val d'Or, Qué. J9P 3S1
Tél. (819) 825-2233

Titre du plan:
Poste de pompage — Plan d'aménagement / Landscaping site
Water pumping station

Préparé par: L. Lévesque ing.	Échelle: 1:100
Dessiné par: Y. Boisvert T.Sc.A.	Date: Janvier 1991
Approuvé par: G. Marcotte ing.	Dossier No: V-061 / Plan No: V-061-011

Gilles Marcotte 30623 QUÉBEC

no du dessin	no de feuille	rév
MP–007		00



VUE EN PLAN – POSTE DE POMPAGE EXISTANT
TOP VIEW – EXISTING PUMPING PLANT

ÉCHELLE : 1:50

ÉQUIPEMENTS DE MÉCANIQUE / MECANICAL EQUIPMENTS

(A) GÉNÉRATRICE / GENERATOR

(B) POMPES D'HUILE / OIL PUMPS

(C) RÉSERVOIR INTÉRIEUR 100 GALLONS / INSIDE TANK 100 G

(D) RÉSERVOIR D'EXPANSION / EXPANSION TANK

(E) ALIMENTATION D'EAU AUTOMATIQUE / AUTOMATIC WATER SUPPLY

(F) ÉCHANGEUR DE CHALEUR DE LA PRISE D'EAU / WATER INTAKE HEAT EXCHANGER

(G) ÉCHANGEUR DE CHALEUR DE L'EAU POTABLE / DRINKING WATER HEAT EXCHANGER

(H) CIRCULATEUR DE LA PRISE D'EAU / CIRCULATOR FOR WATER SUPPLY

(J) RÉGULATEUR DE TIRAGE / DRAFT CONTROL

(K) CIRCULATEUR DE CHAUFFAGE / HEAT CIRCULATOR

(L) CHEMINÉE DU TOÎT 250ø / CHIMNEY TO ROOF 250ø

(M) CHAUDIÈRE / BOILER

(N) AÉROTHERME MODÈLE R–188, MOTEUR 50W, CAPACITÉ 13210W / UNIT HEATER MODEL R–188, MOTOR 50W, CAPACITY 13210W

(P) CONVECTEUR À AIR PULSÉ R–50–1 MOTEUR 12W, CAPACITÉ 7685W / CABINET UNIT HEATER R–50–1, MOTOR 12W, CAPACITY 7685W

(Q) POMPES "P1" ET "P2" / PUMPS "P1" & "P2"

LISTE DES TRAVAUX À EXÉCUTER / JOB TO BE DONE LISTING

MP50

FOURNIR ET REMPLACER L'ECHANGEUR DE CHALEUR D'EAU POTABLE PAR:
QUANTITÉS :
– 1 X ÉCHANGEUR ARMSTRONG, CRN–OH–480, W64–23–1
– 150 PSI @ 375 DEG F
– L'ENTREPRENEUR DEVRA FOURNIR TOUS LES PIÈCES ET ÉQUIPEMENTS NÉCESSAIRES A L'INSTALLATION DE L'ÉCHANGEUR DE CHALEUR
– FOURNIR LA TUYAUTERIE POUR MARIER AVEC L'EXISTANT

SUPPLY AND INSTALLATION OF DRINKING WATER HEAT EXCHANGER BY :
QUANTITY :
– 1X HEAT EXCHANGER, ARMSTRONG, CRN–OH–480, W64–23–1
– 150 PSI @ 375 DEG F
– CONTRACTOR MUST SUPPLY ALL EQUIPMENT AND PARTS NECESSARY FOR HEAT EXCHANGER INSTALLATION.
– SUPPLY ALL PIPING TO CONNECT WITH THE EXISTING PIPING.

MP51

FOURNIR ET REMPLACER L'ECHANGEUR DE CHALEUR D'EAU POTABLE PAR:
QUANTITÉS :
– 1 X ÉCHANGEUR ARMSTRONG, CRN–OH–481.5, W48–23–1
– 150 PSI @ 375 DEG F
– L'ENTREPRENEUR DEVRA FOURNIR TOUS LES PIÈCES ET ÉQUIPEMENTS NÉCESSAIRES A L'INSTALLATION DE L'ÉCHANGEUR DE CHALEUR
– FOURNIR LA TUYAUTERIE POUR MARIER AVEC L'EXISTANT

SUPPLY AND INSTALLATION OF DRINKING WATER HEAT EXCHANGER BY :
QUANTITY :
– 1X HEAT EXCHANGER, ARMSTRONG, CRN–OH–481.5, W48–23–1
– 150 PSI @ 375 DEG F
– CONTRACTOR MUST SUPPLY ALL EQUIPMENT AND PARTS NECESSARY FOR HEAT EXCHANGER INSTALLATION.
– SUPPLY ALL PIPING TO CONNECT WITH THE EXISTING PIPING.

MP52

FABRIQUER 2 PLAQUES EN ALUMINIUM ANTIDÉRAPANT TYPE "5 BAR" POUR FERMER TROUS EXISTANTS LAISSÉS PAR DÉMANTÈLEMENT DES ANCIENNES POMPES. CHAQUE PLAQUE DOIT MESURER 406X406MM AVEC UN TROU AU CENTRE POUR TUYAU DE 4" SS. CHAQUE PLAQUE DOIT ÊTRE COUPÉE EN DEUX POUR PERMETTRE SON INSTALLATION. 4 TROUS PAR PLAQUE POUR LES BOULONS SERONT PERCÉS SUR PLACE. LES BOULONS SONT EXISTANTS DANS LE BÉTON. FOURNIR DES ÉCROUS POUR BOULONS DE 1/2" ET DE 3/8".

FABRICATE 2 ANTI–SKIDDING ALUMINIUM PLATES, TYPE "5 BAR" FOR CLOSING THE EXISTING HOLES LEFT BY THE DISMANTLING OF OLD PUMPS. EACH PLATE MUST MEASURE 406MM X 406MM, WITH A HOLE IN THE CENTER FOR THE 4" SS PIPE. EACH PLATE MUST BE CUT IN HALF TO HELP INSTALLATION. 4 HOLES FOR THE BOLT WILL BE DRILLED IN PLACE. THE BOLTS ARE EXISTING IN THE CONCRETE. FURNISH THE NUTS FOR BOLTS OF 1/2" AND 3/8".

MP53

INSTALLER ET FIXER CORRECTEMENT L'ENTONNOIR SITUÉ DESSOUS LE BACK FLOW PREVENTER.

MP54

INSTALLER UN OPÉRATEUR A VOLANT SUR LA VANNE PAPILLON KEYSTONE F1000 ø100MM EXISTANTE.
QUANTITÉS :
– 1X OPÉRATEUR A VOLANT POUR UNE VANNE PAPILLON KEYSTONE F1000 ø100MM.
– LA VANNE EXISTANTE NE DOIT PAS ÊTRE REMPLACÉ.

MP55

REMPLACER ET INSTALLER LES NOUVEAUX PURGEURS D'AIR.
QUANTITÉS :
– 2X PURGEUR VALMATIC MODÈLE 15A ø25MM
– 4X PURGEURS VALMATIC MODÈLE 15A ø25MM
– 2X PURGEURS WATTS SERIES FV–4M1 ø18MM A INSTALLER AU DESSUS DES RÉSERVOIRS

MP56

REMPLACER ET INSTALLER LES CHECK VALVES, VANNES MANUELLES ET RACCORDS SUR CERTAINE POMPE DE CIRCULATION QUI COULE :
QUANTITÉS :
– vANNE MANUELLE : CRANE 9171 SERIE, ACIER INOXYDABLE 304,
– CHECK VALVES : ALOCOY FIGURE 2370, ACIER INOXYDABLE 304/316
– COUDE 90
– TEE

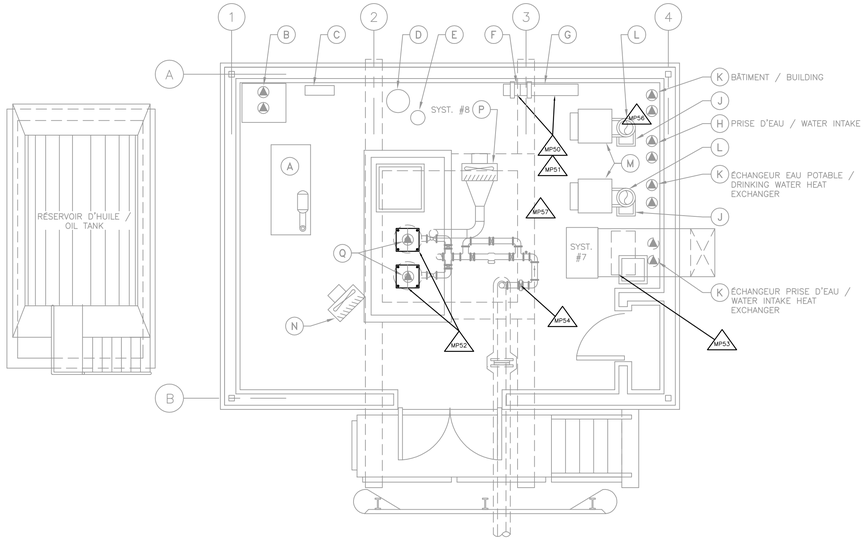
MP57

REMPLACER ET INSTALLER TUYAU, COUDE 90, COUPLING ET RACCORD A L'ÉCHANGEUR :
– CIRCUIT DE RECIRCULATION
– TUYAUX TRÈS ROUILLÉS

MP58

DÉMANTELER LES ÉCHANGEURS DE CHALEUR EXISTANTS

DISMANTLING OF EXISTING HEAT EXCHANGER



VUE EN PLAN – POSTE DE POMPAGE PROJETÉ
TOP VIEW – PROJECTED PUMPING PLANT

ÉCHELLE : 1:50

rév	no de feuille	no du dessin
00		MP–007

client

Administration régionale KATIVIK Regional Government
P.O. Box 9 KUUJJUAQ (QUÉBEC) CANADA J0M 1C0
Service des travaux publics municipaux
Tél.: (819) 964–2961 Fax: (819) 964–0306

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ELECTROSULT INC.
EXPERTS CONSEILS
CONSULTANTS
1, Waterman, Saint-Lambert, Québec J4P 1R7
Tél.: (450) 466-2227
Fax.: (450) 466-0267
www.electrosult.com

architecte

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Montréal (Québec) H2C 1R5
Tél. et fax (514) 858-9229
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consultant – mécanique de procédé

Rousseau, Salvas inc.
1991, Boul. de Périgny, suite 109
Chambly (Qc) J3L 4C3
450-572-0880

consultant – mécanique de bâtiment

LAFRANCE m+e inc.
mécanique + électricité
3502, de Lorimier, Montréal, Qc. H2K 3X6
Tél.: (514) 525–9888 – Fax: (514) 526–9888
COURRIEL: lafrance@lrme–inc.com

consultant – structure

COMTOIS–BLOUIN ET ASSOCIÉS INC.
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internet: mcblouin@oiz.videotron.ca
5112 Boulevard Bourque
Sherbrooke, Qc J1N 2K7

sceaux

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rév		révision	date
2	00	CONSTRUCTION KRG 20 (1085)	09.03.20
1	00	APPEL D'OFFRES KRG 20 (1085)	09.02.09
émis	rév	registre d'émission	date

Détail Numéro De Sur — DÉTAIL, COUPE, ÉLÉVATION
ÉCHELLE:

projet

MISE AUX NORMES USINE D'EAU POTABLE
POTABLE WATER PLANT STANDARDIZATION

PUVIRNITUQ

titre

POSTE DE POMPAGE
DIAGRAMME MÉCANIQUE DE PROCÉDÉ
VUE EN PLAN & DÉTAILS
PUMPING STATION PROCESS FLOW DIAGRAM,
TOP VIEW & DETAILS

concu	dessiné
C. ROUSSEAU, ING	C.R.
vérifié	
B. ROUSSEAU, ING	
échelle	date
	26–11–2008

numéro du projet: 510–040

numéro du dessin	numéro de feuille	rév
MP–007		00

ANNEX 3. LAND USES

PUVIRNITUQ

Land use designations and zoning
Affectations du sol et zonage

- Residential: maximum height 1 story / Résidentiel: hauteur maximale 1 étage
- Residential: maximum height 2 stories / Résidentiel: hauteur maximale 2 étages
- Public and institutional use / Public et institutionnel
- Commercial and services / Commercial et services
- Industrial use / Industriel
- Special use area / Aire réservée aux usages spéciaux
- Airport and communication / Activités aéroportuaires et communication
- Beaching and unloading / Débarcadère et plage
- Conservation / Conservation
- H — Hinterland / Arrière-pays
- Future development area / Aire de développement futur
- Buffer zone / Zone tampon
- Road network / Réseau routier

0 100 200 300 Meters
0 250 500 750 1 000 Feet

Prepared by / Préparé par
KATIVIK REGIONAL GOVERNMENT
Renewable Resources
Land Use Planning Section
KATIVIK

Date of last update January 26, 2007

Appendix 'A' to the Master-plan by-law No.:
Annexe 'A' du règlement de plan directeur no: ___________

Date : ____________________

____
Mayor, Maire

____
Secretary-Treasurer, Secrétaire-Trésorier

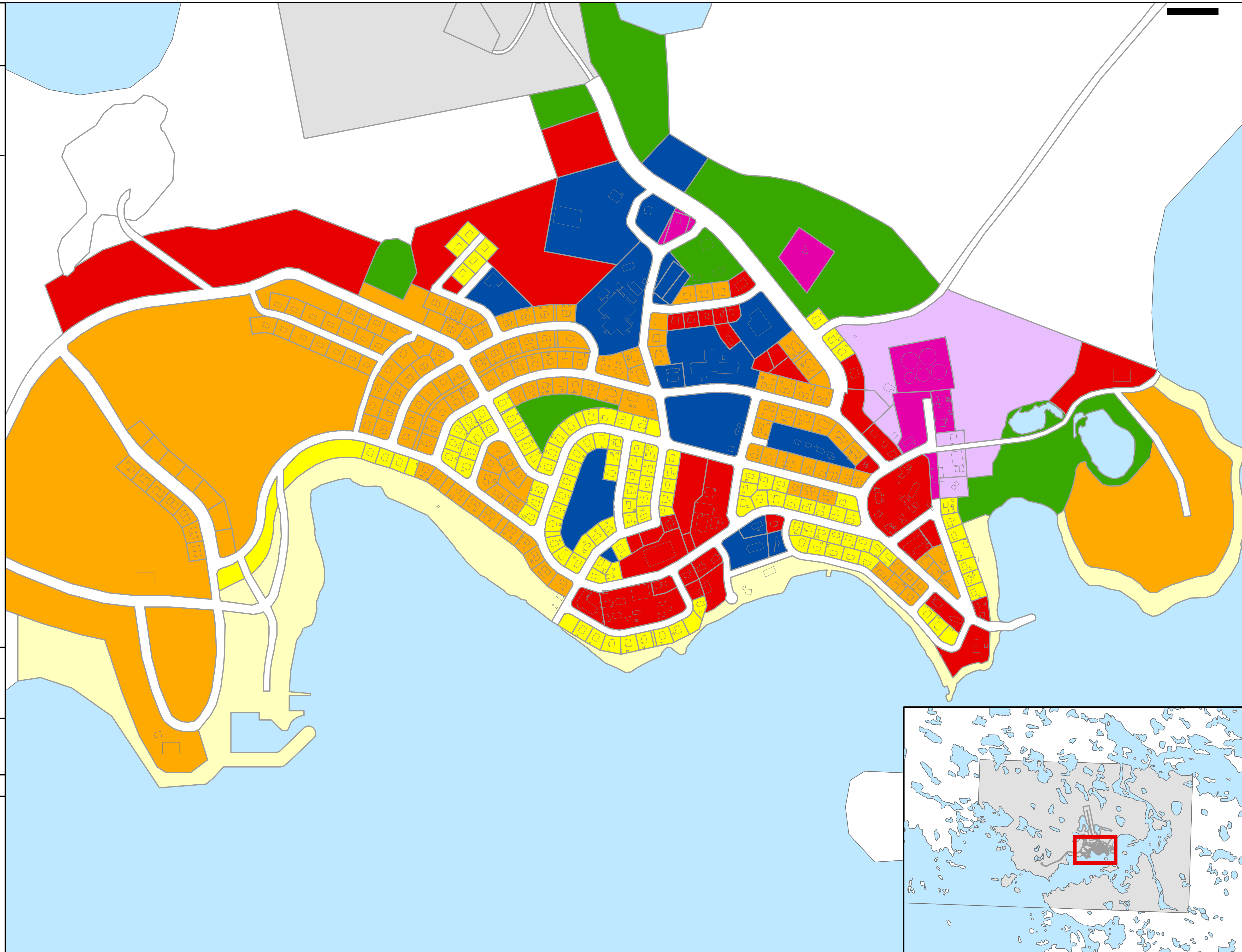


Table 6. Inventory of land uses likely to impact in a positive or in a negative way the drinking water source

Name of condition	Protection areas concerned	Condition representing risk/protection	Activity representing a risk / protection	Potential contaminants and associated risk
Hinterland	All areas	Risk	Operation of borrow pits	Inorganic matter and sediment **Negligible risk**
Hinterland	All areas	Risk	Cimetery	Organic matter, micro-organisms **Negligible risk**
Hinterland	All areas	Risk	Sewage ponds	Organic matter, micro-organisms **Negligible risk**
Hinterland	All areas	Risk	Landfill site	Organic and inorganic materials, microorganisms **Negligible risk**
Hinterland	All areas	Protection	Hunting, fishing, trapping	-
Hinterland	All areas	Protection	Outdoor activities	-

— A3.1 Land use plan for the northern village of Puvirnituq (Source: KRG)

ANNEX 4. DETAILS AND PRECISIONS ON TURBIDITY VULNERABILITY

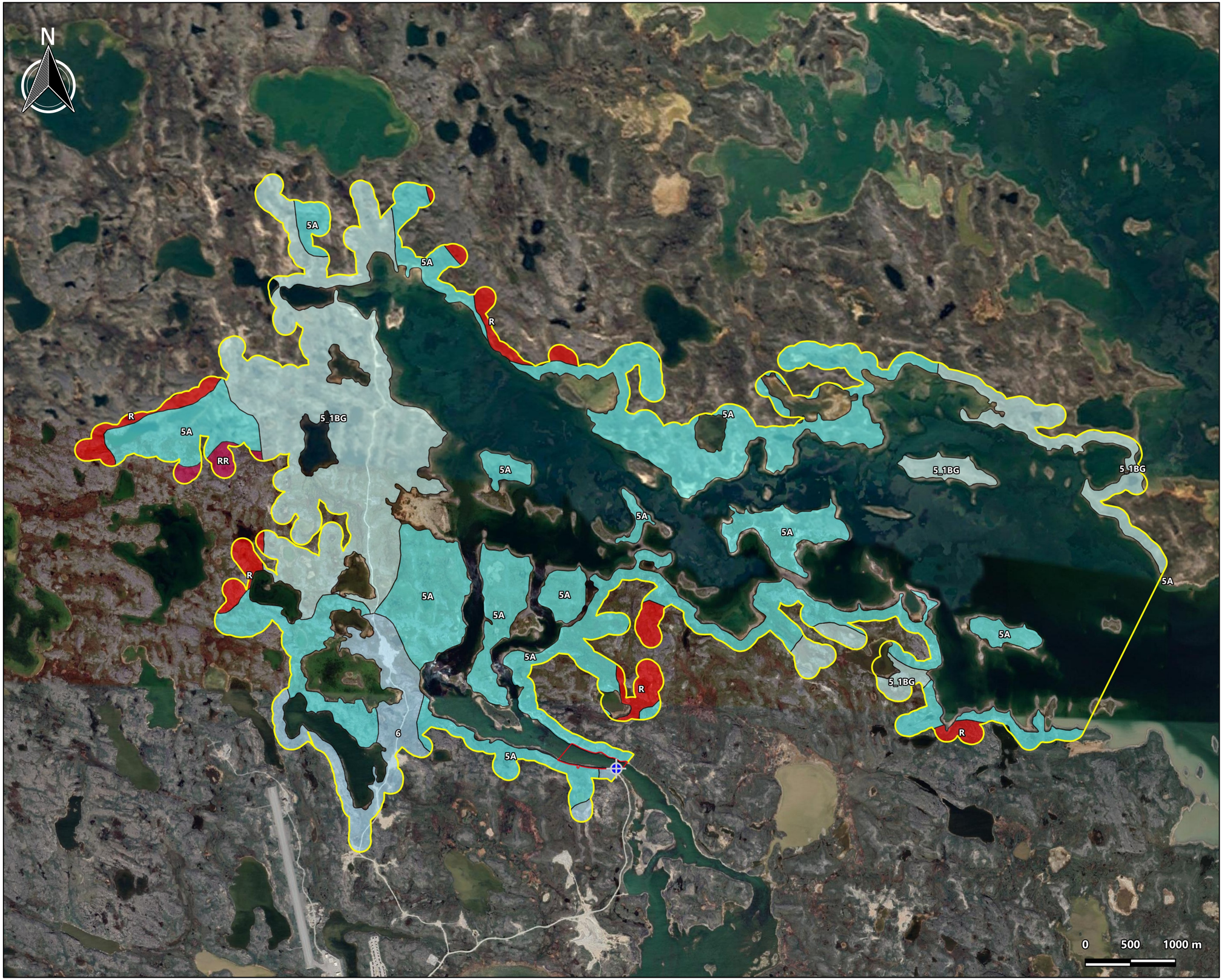
- A4.1 Pdf provided by LNA (4 pages: 1 table et 3 maps)

Tableau 1 : Détermination de la vulnérabilité des eaux exploitées à la turbidité
Client : Groupe Synergis
Projet : Accompagnement technique pour l'analyse de vulnérabilité des sources d'eau potable du village nordique de Puvirnituq
N/Réf. : 20-6867-4663

Au vu de la taille du bassin versant de la rivière Puvirnituq (28 000 km²), l'analyse de la vulnérabilité à la turbidité des eaux exploitées a été effectuée sur l'aire de protection intermédiaire. Le facteur de dilution résultant de la taille du bassin versant permet d'affirmer que les conditions situées relativement loin de la prise d'eau n'impactent pas de manière notable la turbidité des eaux exploitées

Caractéristique du milieu	Description	Source des données	Risque associé pour la turbidité
Pédologie	Absence de donnée permettant de conclure dans le rapport car ce dernier se concentre sur le secteur habité du village et peu de sondage ont été effectués.	Rapport "Caractérisation géotechnique et cartographie améliorée du pergélisol dans les communautés nordiques du Nunavik - Puvirnituq"	N/A
Géologie	Environ 52,5% de la partie terrestre de l'aire de protection intermédiaire de la prise d'eau est occupée par des dépôts marins d'eau profonde (dépôts silteux/argileux). Ces derniers ne constituent pas une source de turbidité pour les eaux exploitées. Le reste de l'aire (48,5%) est occupée par des dépôts marins littoraux (sableux) ou des affleurements rocheux, pouvant apporter des particules en suspension aux eaux de surface.	Ministère des Forêts, de la Faune et des Parcs	Moyen
Relief	Utilisation du MNT pour calculer les pentes dans un logiciel SIG. La valeur de pente moyenne pour l'aire de protection intermédiaire du site de prélèvement est de 3%. Cependant, cette valeur est à consiérer avec précaution car une grande partie de l'aire de protection est occupée par une étendue d'eau de pente nulle. Malgré cela, la majorité des pentes de la partie terrestre de l'aire de protection sont nulles ou faibles (inférieures à 8%).	MNT (MERN)	Faible
Couvert végétal	Les données de végétation au sein de l'aire de protection intermédiaire autour de la prise d'eau ont été divisées en deux catégories : couvert végétal représentant une protection vis-à-vis de la turbidité ou non. Ainsi, il apparaît que 90% de la partie terrestre de l'aire de protection intermédiaire est occupée par un type de végétation participant à la protection des eaux exploitées par rapport à la turbidité.	Ministère des Forêts, de la Faune et des Parcs	Faible
Affectation du territoire	L'aire de protection intermédiaire de la prise d'eau appartient à la zone "arrière-pays". Le plan de développement autorise notamment les activités suivantes au sein de cette affectation : carrières, sablières, décharges, équipements associés à l'approvisionnement en eau et au traitement des eaux usées, chalets, bâtiments liés à la chasse, à la pêche et au piégeage, campements de pourvoirie, cimetières, bases d'hydravions, équipements de télécommunication. Cependant, aucune activité à risque n'est observable sur les images satellites. De plus, il est à noter qu'aucun développement n'est permis dans un rayon de 60m autour de la prise d'eau. Enfin, les infrastructures de traitement des déchets se trouvent actuellement à l'opposé de la source d'eau et de son bassin versant, de l'autre côté du village.	Affectations du territoire du village nordique de Puvirnituq	Faible

Vulnérabilité retenue pour l'indicateur D	Faible



Groupe Synergis

Accompagnement technique pour l'analyse de vulnérabilité des sources d'eau potable du village nordique de Puvirnituq

Géologie des dépôts de surface

LÉGENDE

Prise d'eau

Aires de protection

- Immédiate
- Intermédiaire

Dépôts de surface

- 5A — Dépôts marins - Faciès d'eau profonde
- 5_1BG — Dépôts marins
- 6 — Dépôts littoraux
- R — Roc
- RR — Roc à nu

Nom du fichier :
20-6867-4663_fig1_depots_surface_Puvirnituq
Fond cartographique : Google satellite
Projection NAD83 MTM9

Échelle :	1 : 40 000	**Date :**	2021-02-18
Figure :	1	**Dossier :**	20-6867-4663
Approuvé par :	Jean-Philippe Tremblay, géo., hydrogéologue		
Préparé par :	Jérémy Targosz, chargé de projet		
Dessiné par :	Jérémy Targosz, chargé de projet		

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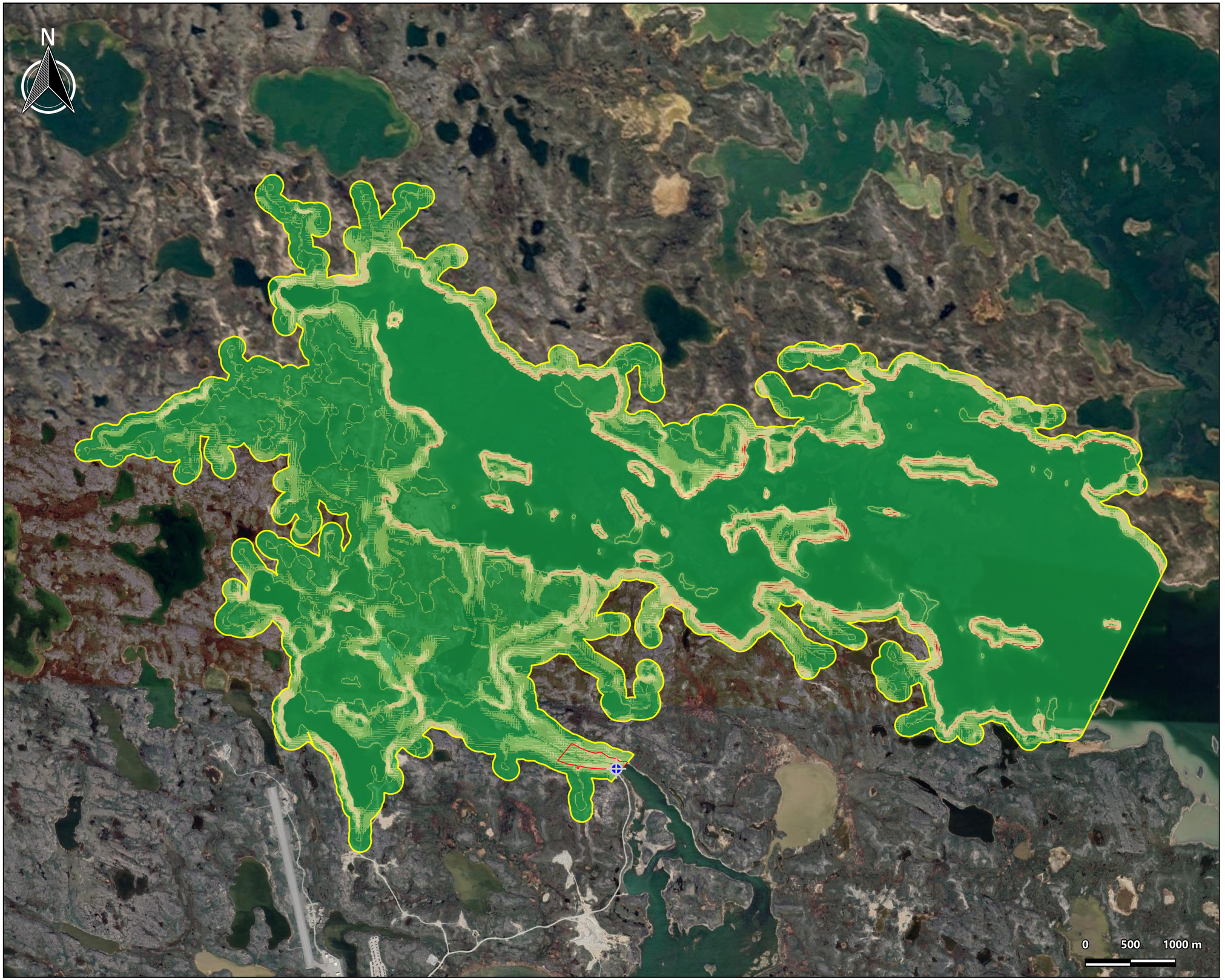

Groupe Synergis

Accompagnement technique pour l'analyse de vulnérabilité des sources d'eau potable du village nordique de Puvirnitug

Carte des pentes au sein des aires de protection

LÉGENDE

Prise d'eau

Aires de protection

Immédiate

Intermédiaire

Classes de pente

Pente nulle 0 à 3%

Pente faible 4 à 8%

Pente douce 9 à 15%

Pente modérée 16 à 30%

Pente forte 31 à 40%

Pente excessive 41% et plus

Nom du fichier :
20-6867-4663_fig2_pentes_Puvirnituq
Fond cartographique : Google satellite
Projection NAD83 MTM9

Échelle :	1 : 40 000	**Date :**	2021-02-18
Figure :	2	**Dossier :**	20-6867-4663
Approuvé par :	Jean-Philippe Tremblay, géo., hydrogéologue		
Préparé par :	Jérémy Targosz, chargé de projet		
Dessiné par :	Jérémy Targosz, chargé de projet		

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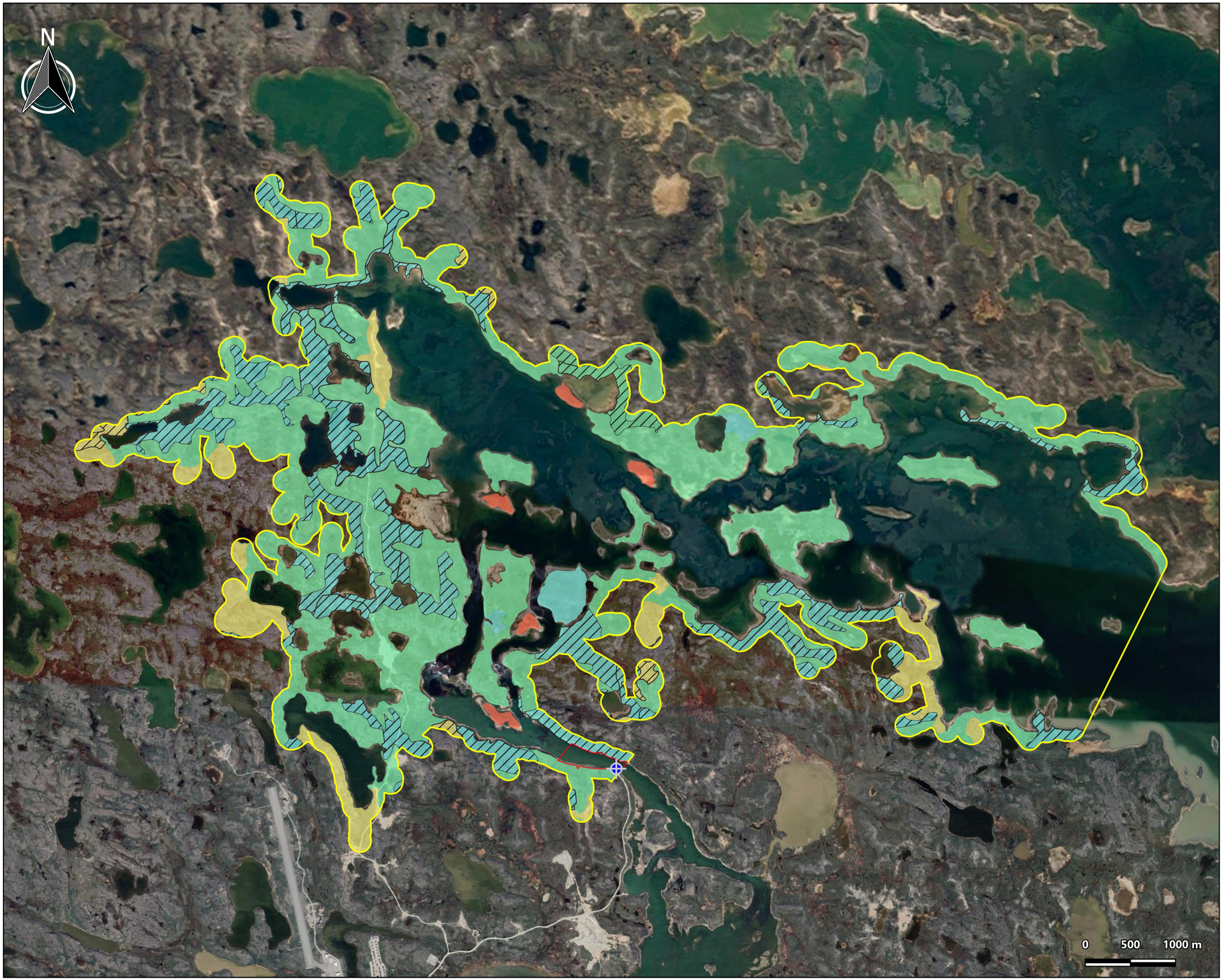

Groupe Synergis

Accompagnement technique pour l'analyse de vulnérabilité des sources d'eau potable du village nordique de Puvirnituq

Cartographie du couvert végétal au sein des aires de protection

LÉGENDE

Prise d'eau

Aires de protection

- Immédiate
- Intermédiaire

Végétation cartographiée

- Île de moins de 8 ha
- Toundra à arbustes dressés
- Toundra à arbustes dressés avec 30 à 70 % d'arbustes dressés
- Toundra à arbustes dressés avec 10 à 50 % de substrat rocheux
- Toundra à arbustes dressés dominée par le substrat rocheux
- Tourbière arctique avec 30 à 70% d'arbustes dressés
- Tourbière arctique ou toundra humide

Nom du fichier :
20-6867-4663_fig3_vegetation_Puvirnituq
Fond cartographique : Google satellite
Projection NAD83 MTM9

Échelle :	1 : 40 000	**Date :**	2021-02-18
Figure :	3	**Dossier :**	20-6867-4663
Approuvé par :	Jean-Philippe Tremblay, géo., hydrogéologue		
Préparé par :	Jérémy Targosz, chargé de projet		
Dessiné par :	Jérémy Targosz, chargé de projet		

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ANNEX 5. MODEL/TEMPLATE OF EVENTS LOG

* *Adapted from the model provided by the MELCC at the following link:*
http://www.environnement.gouv.qc.ca/eau/potable/registre/modeles-source-approvision.htm

Développement durable, Environnement et Lutte contre les changements climatiques
Québec

Events log occurring throughout the procurement supply chain (Section 22.0.4 of RRQDW)*

Identification of the withdrawal site

Location of the potable water production facility: Northern Village of Puvinituq
Identification of the withdrawal site:

Name : Puvirnituq – Approvisionnement
Number : X2114321

Event details

Description of event: _____
_____
_____
_____

Start date: _____ End date: _____

Types of problem encountered:

- ☐ Water shortage (strictly linked to a drying up of the water source)
- ☐ Obstruction or breakage at the withdrawal site
- ☐ Malfunction of the screening, filtration, disinfection system or the entire treatment (validate whether MDELCC must be advised in vertu of Article 35.1)
- ☐ Other: _____

Affected equipments or processes :

Equipment: ☐ Strainer ☐ Water pipes ☐ Pumping system
Processes: ☐ Screening ☐ Filtration ☐ Disinfection
☐ Entire treatment system
☐ Others: _____
☐ None

Location of occurrence (note if necessary): _____
_____

Categories of events to which the observations refer:

- ☐ Natural or anthropogenic events that affected the physical integrity of the withdrawal site ☐
- ☐ Suspected or measured increases in ammoniacal nitrogen
- ☐ Others

Observations inscrites par (name) :
Position :
Signature :
Date :

_____
_____
_____
_____

NUNA RESSOURCES

* Reminders :

- A separate register must be kept for each withdrawal site, ie for each separate water withdrawal installation;
- Each event must be listed separately (one event per page), even if two events occur simultaneously;
- An event whose effect extends over several consecutive days should be recorded as a single event. However, a similar event that occurs periodically must be recorded separately at each occurrence.

Details of some of the information to be entered in the register

Event information

Types of problem encountered: Check all types of applicable problems according to the classification established in section 22.0.4 of RRQDW.

Types of problems encountered	Examples
Water shortage (strictly linked to a drying up of the water source)	Low flow leading to an exposure of the water intake
	Drainage due to the breaking of a retention dam
Obstruction of the Withdrawal site	Silting up
	Frazil
	Proliferation of aquatic plants or zebra mussels
	Accumulation of coarse debris
Breakdown of the Withdrawal site	Damaged caused by ice
	Subsidence of a retaining wall
	Tearing off / removing of the supply line
Malfunction of the screening, coagulation, settling, filtration, disinfection system or of the entire treatment system	Overgrowth of algae, cyanobacteria or other microorganisms causing taste and odor problems in treated water
	Proliferation of aquatic plants or zebra mussels causing problems with the screening system
	Presence of a contaminant in raw water (for example, ammoniacal nitrogen) which increases the consumption of chemicals (eg. chlorine) and prevents the achievement of treatment goals
Others (any other problem that does not belong to one of the three previous types of problems)	Presence of a contaminant in the raw water which does not affect the operation of existing treatment processes, but which cannot be treated by these processes (eg. chlorides in high concentrations or hydrocarbons). Note: Depending on the nature of the contaminant and the risks it represents for human health, its presence could lead to the temporary closure of the water intake.

Place where the event occurred: in some cases, it may be relevant to note the location of the event (eg. the location of the cyanobacteria bloom or the location of a spill).

Categories of events to which the observations refer/relate: Check all the categories concerned.

- Natural or anthropogenic events that have affected the physical integrity of the withdrawal site include events associated with a water shortage, an obstruction or breakage of the withdrawal site.

The "other" category includes all events that do not correspond to one of the first three categories.


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