Bois Noirs Limouzat

Loire - France

Presentation of compliance with the GISTM standard

BES-DT-003297-AMF-ENV

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Preamble

By the prefectorial letter of December 04, 2008, the Bois Noirs Limouzat (BNL) dam is classified as category A pursuant to article R.214-112 of the French Environment Code. These works constitute the physical barrier of the facility for uranium mine tailings, classified ICPE 1735, from the former mine.

Orano Mining, member of the ICMM (International Council on Mining and Metals), agreed to apply the GISTM (Global Industry Standard on Tailings Management). The analysis of the consequences of a failure of the works, although extremely unlikely, pursuant to the GISTM, led to considering the works as “extreme.”

Orano agreed to apply the standard starting on August 05, 2023, for works facilities for which the consequences of a failure are classified in the “very high” or “extreme” categories. This commitment concerns the BNL site.

This note constitutes the official publication in compliance with principle 15.1. Here are the specifications required for the publication:

Since point A of the 15.1 requirement concerns exclusively new projects on the tailings storage area, we will focus on points B and C of the requirement relative to existing mine tailings storage areas:

B. For each existing *mine tailings storage area* and compliant with principle 21 of the United Nations Guiding Principles (UNGP), the operator publishes and updates the following information at least once a year:

1. A description of the *mine tailings storage area* (some of the information can be obtained from elements resulting from Requirements 5.5 and 6.4);
2. The consequential classification (Requirement 4.1);
3. A summary of the results of the assessment of the risks relates to the *mining tailings storage area* (some information can be obtained from the elements resulting from Requirement 10.1);
4. A summary of *impact assessments* and exposure assessments and of the vulnerability of the populations to *credible failure scenarios* at *mine tailings* (some information can be obtained from the elements resulting from Requirements 2.4 and 3.3);
5. A description of the design for all the *lifecycle* steps of *the mine tailings storage area*, including the current and final height (this information can be obtained from the elements resulting from Requirement 5.5);
6. A summary of the main conclusions of the annual performance reviews and the *dam safety review (DSR),* including the implementation of mitigation measures to reduce the risk *at the AFQRR level* (some information can be obtained from the elements resulting from Requirements 10.4 and 10.5);
7. A summary of the main conclusions of the environmental and social monitoring program, including the implementation of mitigating measures (Review 7.5);
8. A summary version of the *Emergency Preparedness Response Plan* (*EPRP)* of the *mine tailings storage area* for storage areas that have one or more credible failure modes that could lead to a flow failure. This summary must: (i) be based on *credible failure scenarios* involving flowrate

taken from the *breach analysis* of the *mine tailings storage area*; (ii) include emergency preparedness, which applies to *populations affected by the project,* as identified in the *breach analysis* of the *mine tailings storage areas*, and that require cooperation with *public sector agencies*; and (iii) exclude the details of the preparatory measures for emergency situations that apply to the assets of the *operator* confidential information (Requirements 13.1 and 13.2);

9. Dates of last and next independent reviews (Requirement 10.5); and
10. Annual confirmation that the *operator* has sufficient financial capacity (including proof that it is commercially reasonable) to cover the estimated costs of the planned closure, an anticipated closure, *restoration* and post-closure management of the *mine tailings storage area* and its ancillary structures (Requirement 10.7).

These declarations are issued directly unless they are subject to requirements of regulatory authorities.

C. Provide local authorities and emergency services sufficient information taken from the *breach analysis* to enable efficient scheduling of catastrophe management (some information can be obtained from the elements resulting from Requirement 2.3);

Introduction

The former uranium mining site of Bois Nois Limouzat is located in the Saint-Priest-la-Prugne municipality in south-central France (Figure 1).

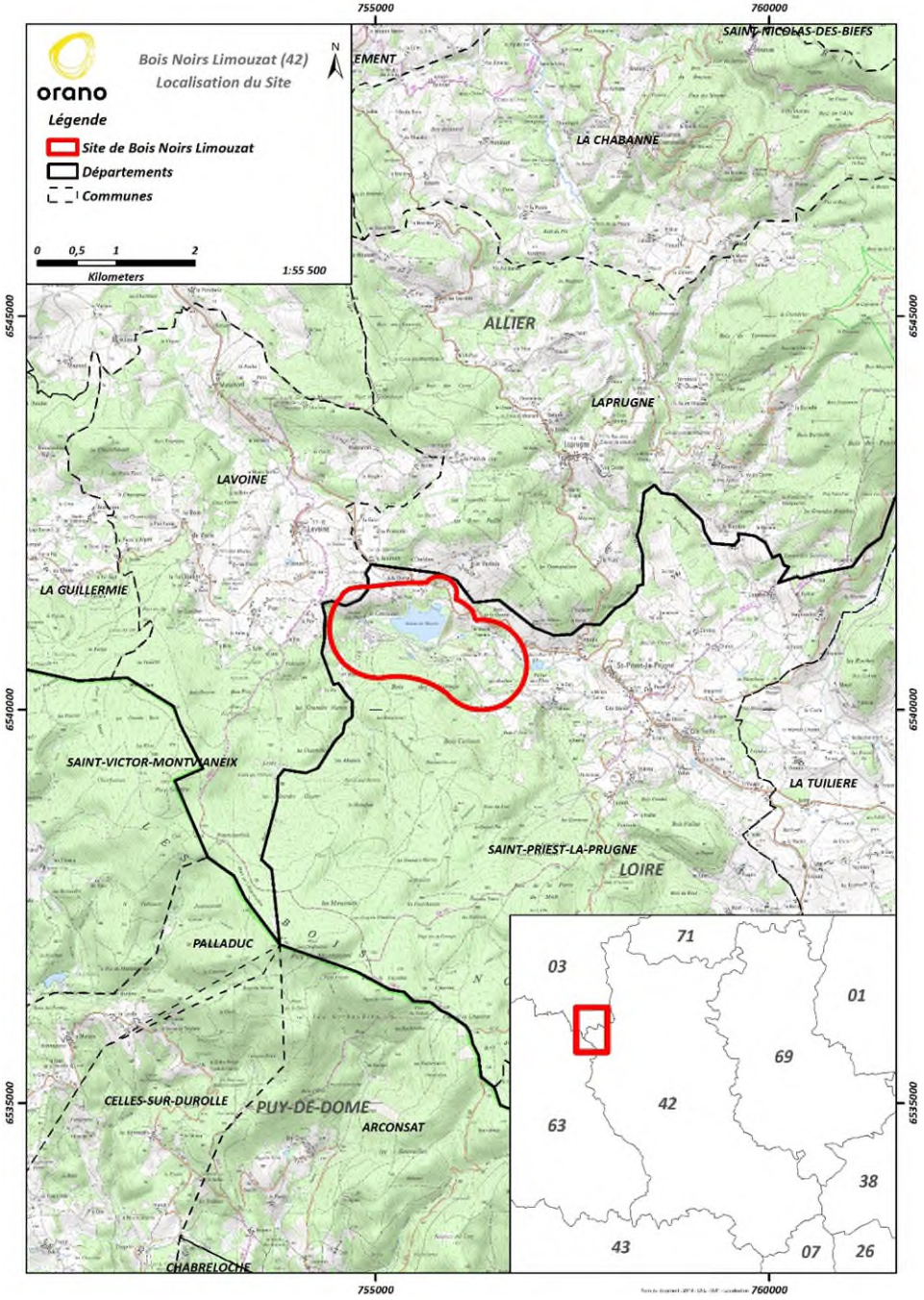


Figure 1 - Location of the Bois Noirs Limouzat site.

The general organization for monitoring the Bois Noirs dam is as follows:

- Orano Mining is the owner and operator of this dam.
- Orano Mining calls on external companies for maintenance and for monitoring the site, works, and examination system. These companies follow the guidelines put in place.
- An Expert Surveyor is in charge of all topographical measurements.
- An Engineer of Record (EOR) is in charge of applying monitoring measures and of civil engineering expertise.
- An Independent Technical Review Board or Senior Reviewer (ITRB), analyzing and making suggestions as necessary for the entire monitoring and operating plan, but also providing an outside perspective on the technical proposals and opinions of the EOR.

La Figure 2 below, situates the various works mentioned in this document and described in section 1Description of the works and their design (Points B.1 & B.5):

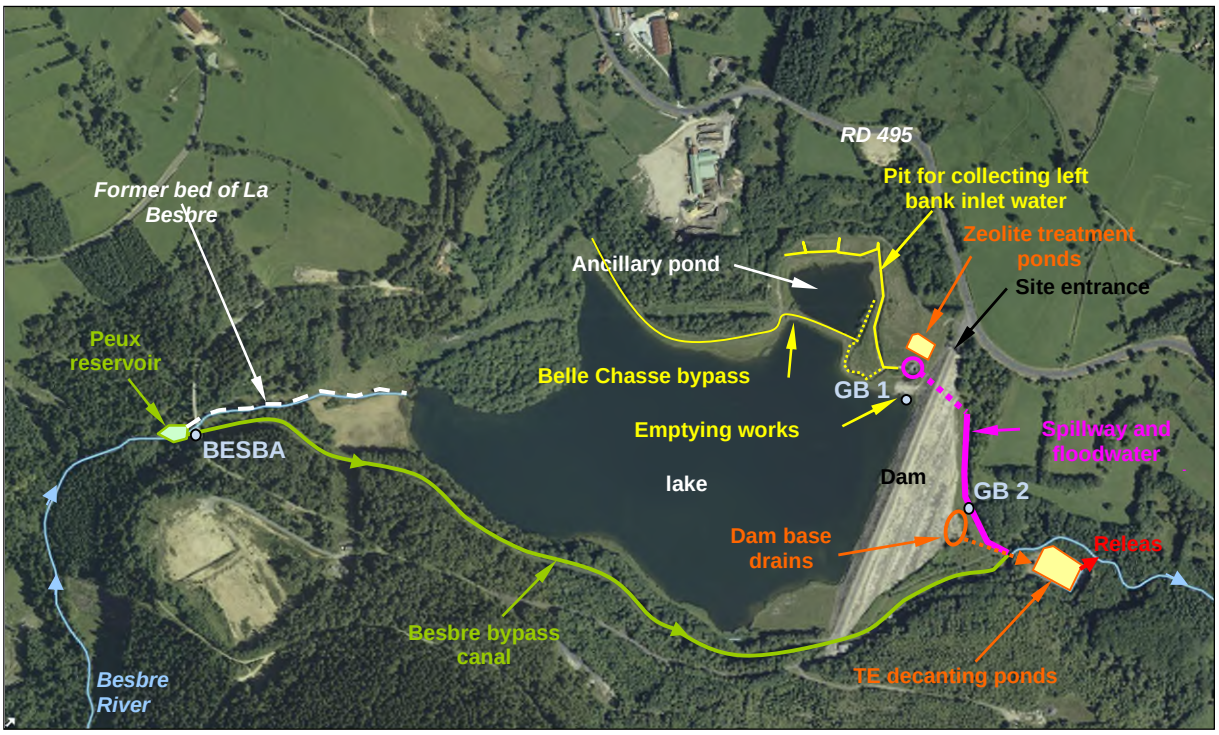


Figure 2 – Bois Noirs site map and location of various works

1. Description of the works and their design (Points B.1 & B.5)

1.1. Dam

The dam was built between 1959 and 1962, perpendicular to the Besbre valley, to enable the decanting and disposal of tailings from the processing plant for uranium ore extracted from the Bois Noirs deposit and neighboring mines.

The Bois Noirs works consist in a homogeneous backfill dam made up of waste rock with maximum height of 42 m and built on the natural terrain with a crest length of 508 m.

Before the backfill was created, the foundation soil was cleaned up and the following work was performed:

- general stripping of the footprint and uncovering of an alluvial layer left in place;
- a cutoff wall 2.5 to 8.5 m wide, filled with compacted argillaceous materials, cutting the alluvial layer from 0.30 to ± 2.0 m, set up on a granite substratum. Situated around 30 m upstream of the longitudinal axis of the dam at the bottom of the valley, it lengthens as it draws close to the dam on the flanks;
- 1 main drain 140 m long with 3.0 to 6.5 m in width and 2.0 m maximum depth along the axis of the valley, leaving from the cutoff wall to reach the downstream base of the dam;
- other less important drains, single or ramified, not connected to the cutoff, ensuring the capture of the sources observed on the flanks of the valley.

The filling of various drains consists in three distinct layers:

- Lower: 200/500 mm rough blocks;
- Intermediary: 40/60 mm stones;
- Upper: 15/17 mm rough gravels to 5/8 mm fine gravels.

All of the drains empty out into the concrete ponds equipped with standardized gages and reservoirs making it possible to measure flowrates at the dam base.

The dam's main characteristics are shown in Table 1below.

Table 1 - Main characteristics of the Bois Noirs dam.

Type	Homogeneous backfill dam
Position	Disposal of discharges of the uranium ore concentration plant FOREZ
Construction period	1959-1962
Height above TN	42 m
Crest length	508 m
Dimension of the crest	from 771.27 NGF to 772.27 NGF at construction
Normal level	761,97 NGF

Volume of the lake at the normal operating lake elevation (RN)	2,1 hm^3
Highest water table (PHE)	764,71 NGF
Surface area of catchment basin	10,9 km^2
River	Besbre
Upstream thinning of facing	2H/1V average
Downstream thinning of facing	2H/1V average

The dam remains continually in the water to limit the releases of radon generated by tailings.

The main characteristics of the large pond (lake) are presented below in Table 2:

Table 2 - Characteristics of the large pond.

Volume of decanted processing tailings	1,360,000 m^3
Average height reached by the tailings	± 758.17 m
Maximum height reached by the tailings	759.77 m
Minimum height reached by the tailings	754.77 m
Maximum reservoir height in normal operation	761.93 m
Surface area of the pond at elevation 761.93 m	21 ha
Volume of the reservoir at elevation 761.93 m	2,100,000 m^3
Exceptional maximum reservoir height	764.71 m
Capacity of the reservoir at the height 770.17 m	4,300,000 m^3

The minimal operating elevation (CME) is 759.87m NGF. It corresponds to the maximum elevation reached by the tailings to which are added 10 cm to ensure a minimum water thickness serving as radiological shielding.
The RN is 761.93 m NGF.

1.2. Emptying system

These works, built in 1986 between the lake and the floodwater evacuator, consist in a submersible dike (see Figure 3) crossed by pipes opening onto an airlock followed by pumping works. This dike includes:

- Compacted sand in which a trench of 1.60 m deep and 0.80 m wide was filled in with concrete;
- A layer of 150/250 mm riprap on the upstream facing;
- A 0/60 mm filter layer and two layers of riprap including the top layer is concreted on the downstream facing;
- A reinforced concrete slab on which is mounted a spilling threshold at the dimension 761.93 NGR by wave-barrier low walls of which the crest is set at the dimension 762.63 NGF.

This dike is crossed by two concrete pipes (18.5 m in length and 0.80 m in diameter) closed by two wall-mounted flat valves at an airlock arranged immediately downstream from the pipes. The airlock

is also equipped with an emptying valve. Pumping works, equipped with three submerged pumps and an emptying valve, were installed in 2019 as an extension of the existing safety airlock (Figure 3 and
Figure 4) to be able to manage the water level in the pond.

Each of the two upstream valves is controlled by a rack using a lever. The intermediary valve is maneuvered along a threaded rod using a manual jack. The wall flat valve downstream from the pumping works is maneuvered by a handwheel. To prevent any malicious acts, the wheel is equipped with a padlocked anti-theft device hindering its movement.

A grid was installed at the opening between the airlock and the pumping works to prevent fish from nearing the pumps and allowing them to be released in the natural environment in case all valves are opened.

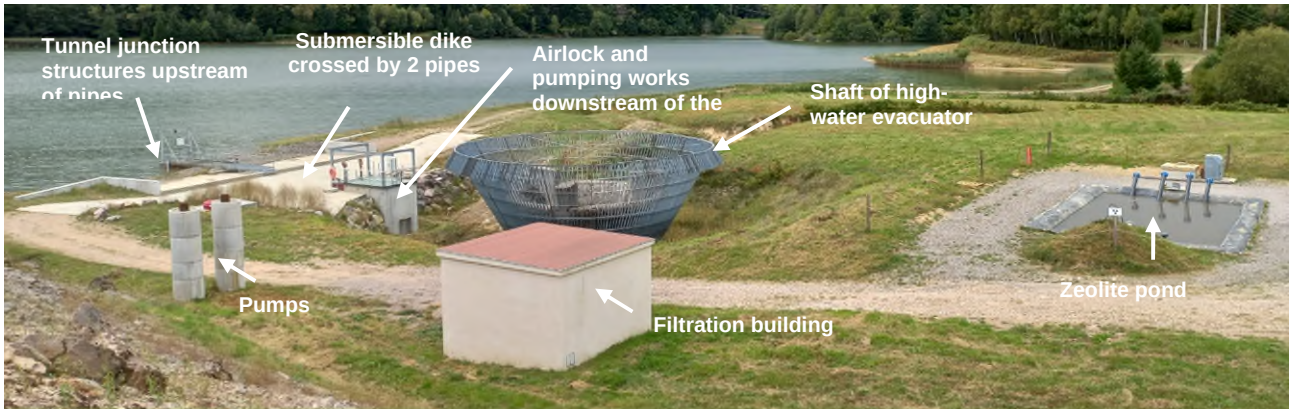


Figure 3 – Photo illustrating the site on the left bank upstream of the dam

In normal situations, only the emptying valve of the pumping system is closed. The other valves remain open to allow water to be pumped from the large pond to the station of filtration using zeolites, to prevent any spillage outside of flooding periods.
The water of the lake, since it contains radon, cannot be massively discharged in the natural environment, except in the case of emergency measures. The emptying system cannot be used as a flooding regulator, but only as safety equipment that rapidly lowers the body of water in case of severe failure of the dam.
In case of emergency, the maximum evacuation flowrate with the four valves entirely raised is 3 m^3/s.

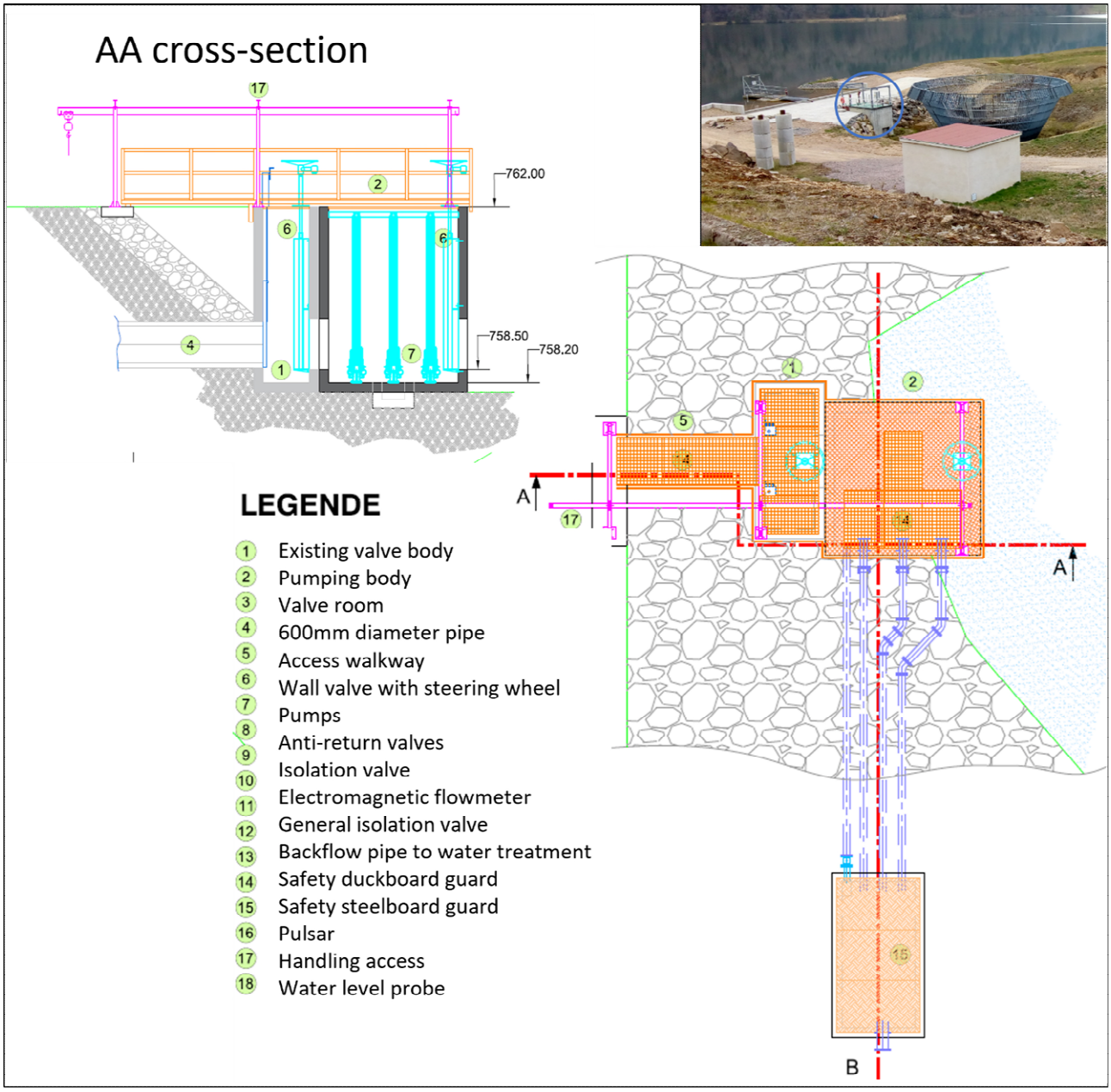


Figure 4 – Sluice and pumping works

The invert at the pipe intake is set at 759.17 m NGF; the works with their valves thus do not amount to in-depth emptying. If the valves are all opened, the major part of the lake volume will not be emptied.

1.3. Floodwater evacuator

The floodwater evacuator on the left bank (Figure 2) consists of:

- A threshold at the elevation 763.67 NGF

- A vertical concrete shaft (Figure 5)
- A circular concrete drift 118 m long passing under the dam (Figure 6)
- A concrete open-air channel opening out downstream of the dam base on the left bank

Three waterways were set up for evacuating waters coming from the emptying works, the bypass of ru de Bellechasse, and inlets on the left bank. The dewatering outlets are set at the elevation of 758.67 m NGF and are 0.80 m wide and 0.60 m high (Figure 5).

The tunneling of the shaft involved creating a spillway equipped with piles to avoid vortexes and grids to avoid ice jams.
A level detector is installed on the masonry of the shaft of the floodwater evacuator. It raises the alarm in case of a rise in the water level at the base of the shaft to the elevation 758.97 m NGF.

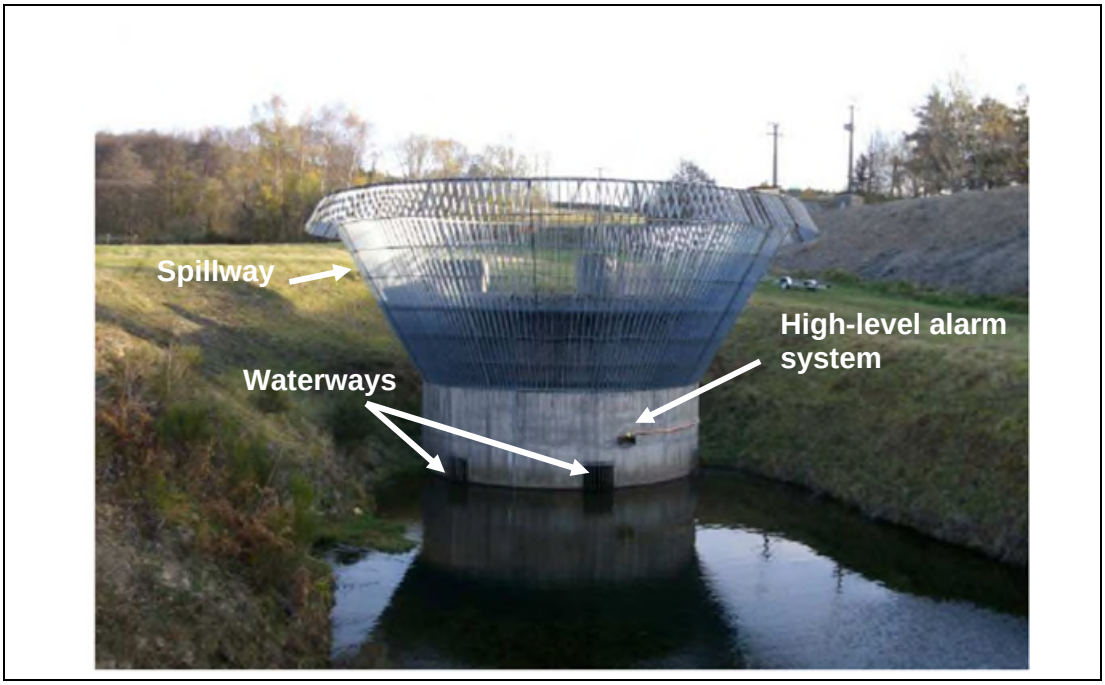
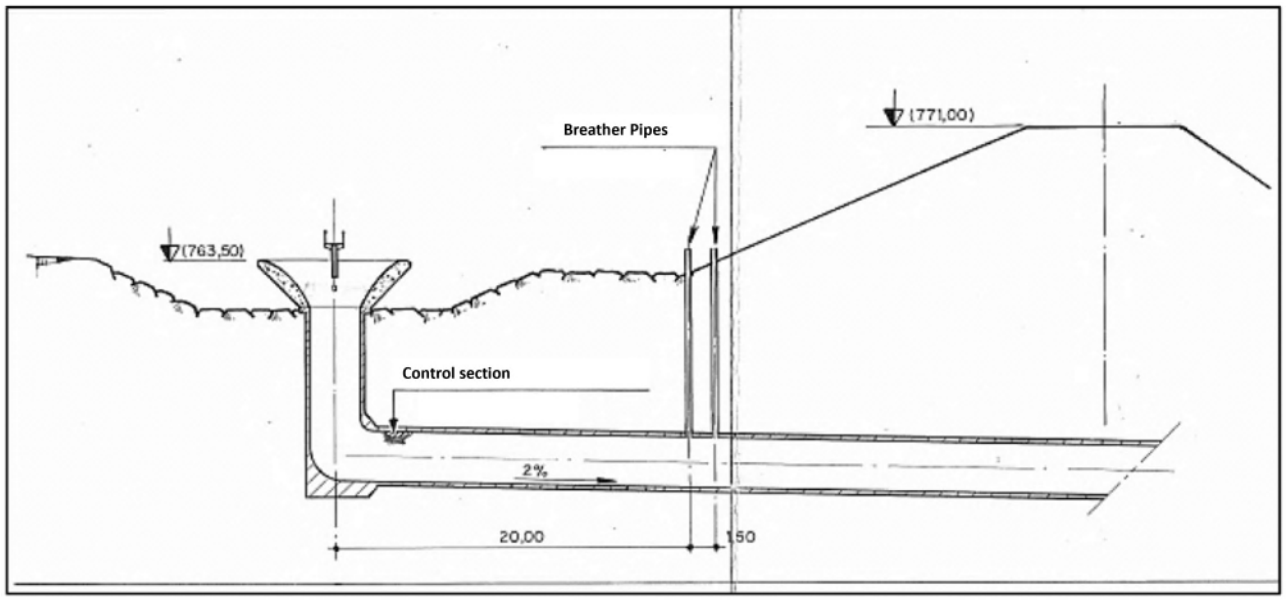


Figure 5 – Flooding evacuator shaft

On the drift roof, two pumps evacuate air in case of sudden emptying (see Figure 3 and Figure 6).



*Note: The dimensions indicated on the 1985 diagram above are in the historical geographical system; since 2013, topographical measurements have been carried out in Lambert 93, leveling IGN 1969

Figure 6 – Drawing of the drift (file CTPBOH of 1985)

The open-air channel, with total length of 148 m is composed of 8 pads divided into 2 sections with different slopes (5% - length of around 30 m, 16% - length of around 118 m) and ends with a downstream scoop anchored in the rock to eliminate the risks of erosion (8 m in length).

These works are liable to evacuate 50.7 m^3/s under 764.71 mNGF for an episode of extreme flooding with an occurrence every 10,000 years.

2. Analysis of risks and consequences of failure (Points B.2 & B.3 and B.4)

2.1. Analysis of risks and failures

Relative to regulations applicable to category A, Orano Mining had to conduct a danger study, updated in 2019. This study is a complete risk analysis that identifies causes of a failure of the works and their safety features (notably the submersible dike) and assesses the probability of the event and the human, environmental, social, and economical consequences of the failure.

7 central postulated events (ERCs) were identified:

- ERC 1: Partial or total failure of the dam
- ERC 2: Failure of the dam following rapid emptying;
- ERC 3: Failure of the floodwater evacuator shaft during flooding;
- ERC 4: Failure of the submersible dike;
- ERC 5: Failure of the submersible dike following rapid emptying;

- ERC 6: Accidental opening of emptying system;
- ERC 7: Inadvertent opening of the emptying system following a malicious act.

A danger study conducted in 2019 led to the 3 corrective measures listed below:

Table 3 – Recommended measures to reduce risk (RRM) following the 2019 EDD.

Study / Action		Priority level	Timing
RRM 1	Updating operation guidelines and monitoring by integrating the operating procedures, in case of emergency, to prevent the drying of tailings	1	2020
RRM 2	Setting up an alarm in case of rapid reduction in the body of water with a monitoring procedure in case of confirmed emptying of the body of water	2	2022
RRM 3	Setting up a protective system against overflow of the submersible dike	2	2020

These three measures were carried out according to the pre-established schedule. It was thus possible to update the risk analysis

2.1.1. ERC1 – Dam failure

Hydraulic consequences

The populations potentially impacted were assessed using the IRIS database of INSEE:

- Between the Bois Noirs dam and the upstream area of Saint Clément, around 25 people impacted by the flood wave in less than an hour without taking the ERPs (French public buildings) into account.
- Taking into account the flood wave of the Mayet of Montagne dam, 934 people impacted by the flood wave without taking ERPs from Saint Clément into account.
- Two ERPs were identified that were concerned by the flood wave:
    - the Paradou campsite located immediately downstream of the dam and whose capacity is estimated to be 115 people;
    - the Plans de Saint Clément campsite, whose capacity is estimated to be 109 people, is located downstream of Saint Clément.

Thus, 140 people potentially in the area of rapid kinetics and 1043 people in the area of slow kinetics.

Unfortunately, the flood wave downstream of Mayet de Montagne hydroelectric power plant cannot be produced without the characteristics of these works of which Orano is not the owner.

The hydraulic consequences of ERC 1 are catastrophic. The kinetics of these events are extremely rapid. Monitoring and examination measurements nevertheless show the behavior of the dam and anticipate severe accidents liable to occur.

Given the rarity of the event identified in the risk analysis, the author proposes qualifying ERC1h **in the green area** in the **"Frequency: Extremely rare - Severity: catastrophic"** case in the criticality matrix.

Radiological consequences

The failure of the dam induces liberation of water with rapid kinetics and liberation of radiologically marked tailings. This event has a radiological impact on the surrounding populations, notably downstream of the dam (Moulin Thiennon, Moulin Poyet, Moulin St Priest, Laprugne) but also nearby (sawmill, Bellechasse) due to:

- Internal exposure (gamma radiation) notably due to the liberation of water and radiologically marked tailings downstream of the dam and to the irrigation of plants.
- Internal exposure due to inhalation of radon and dust following the emptying of the lake and the drying of the lake.
- Internal exposure due to ingestion following the liberation of water and radiologically tailings deposited on plants and crops

This scenario conservatively increases the radiological consequences and in terms of severity.
In such a scenario, the largest dose for the public would be that due to ingestion and that due to the inhalation of dust (average activity in radium-226: 33 Bq/g).

The background noise of the region (uranium mining) and the gamma radiation due to radon from stripping of the tailings would not be very significant.

The dosimetric impact calculation was performed for Orano by ARCADIS as part of an impact study sent to the DREAL in 2018, considering for one of the studied scenarios a stripping of tailings. Such a scenario is very conservative in terms of the inhalation dose compared to ERC1. The calculated doses are as follows (during passive monitoring):

Note: the results correspond to all exposure routes possible.

Table 4 - Inhalation dose per reference group (extract of the 2018 Study of Dosimetric Impact).

Scenario 4: Effective Dose for non-guaranteed monitoring								
Location	Concerned Individual	Referenced group	External Dose	222Rn Inhalation Dose	Dust Inhalation Dose	Soil Dose	Ingestion Dose	Total Dose
Belle Chasse	Retraité	SC4n-GR2-c	0.14	0.23	0.0011	0.0002	0	**0.38**
Moulin de Thiennon		SC4n-GR2-t	0,0004	0,036	0,0002	0	2,74	**2,7766**
Moulin de Poyet		SC4n-GR2-p	0,0002	0,014	0,0001	0	2,74	**2,7543**
Moulin de St-Priest		SC4n-GR2-s	0,0002	0,012	0,0001	0	2,74	**2,7523**
Belle Chasse	Enfant de 5 ans	SC4n-GR3-c	0.13	0.25	0.0007	0.0002	0	**0.38**
Moulin de Thiennon		SC4n-GR3-t	0,0004	0,0384	0,0001	0	2,9	**2,9389**
Moulin de Poyet		SC4n1-GR3-p	0,0002	0,015	0	0	2,9	**2,9152**
Moulin de St-Priest		SC4n1-GR3-s	0,0002	0,013	0	0	2,9	**2,9132**

Concerning the exposure of the public (the site – Dam and OPM (open pit mine) – is closed to the public), the first site to be opened to the public is Belle Chasse (upstream) and Verse du Jot (downstream). The inhalation dose exceeded the regulatory threshold at Moulin Thienon (2.77 mSv/year), Moulin de Poyet (2.75 mSv/year), and Moulin de St-Priest (2.75 mSv/year). For reference the added maximum dose for the public is 1 mSv/year and 20 mSv/year for nuclear workers.
Also, for comparison, the estimation of ionizing radiation[1] calculated for the Saint Priest la Prugne municipality is 14.4 mSv/year. The total dose calculated for the degraded scenario above corresponds to around 20% of the locally estimated dose.

As for the Dam and OPM points, the time of presence is low, 400 h/year instead of 4,000 h/year for the residing population). Consequently, its exposure will be strongly reduced (coefficient 10).
The radiological consequences of ERC 1 are thus classified as “significant”.

Given the rarity of the event identified in the risk analysis, the author proposes qualifying ERC1h **in the green area** in the **“Frequency: extremely rare - Severity: significant”** case in the criticality matrix.

2.1.2. ERC2– Failure of the dam following rapid emptying

Rapid emptying may lead to instability of upstream backfill and dam failure.

ERC2 has an extremely rare probability.

This event results in sudden overflow downstream in limited proportions because the level of the lake is low and a flowrate is already released downstream (emptying underway). While it cannot be excluded that this flowrate augmentation may surprise some people downstream on the banks of the river, this event can be anticipated as part of the dam’s monitoring. The number of people impacted in the rapid kinetics area is thus estimated not to exceed 10 people and the total number of impacted people is estimated to remain below 100.

The hydraulic consequences are thus qualified as “significant.”

The failure of the dam following rapid emptying would have the same radiological consequences as ERC 1, but with different kinetics of water liberation and distance at which the tailings would be entrained insofar as in this scenario part of the water is being emptied.

The radiological consequences of ERC 2 are “moderate.”

2.1.3. ERC3 – Failure of the shaft of the floodwater evacuator during flooding

[1] Calculation carried out on July 17, 2023 on the IRSN site https://expop.irsn.fr/ - Commune of Saint Priest la Prugne, for a single-family home, without taking into account medical exposure, air travel, consumption of seafood and for a non-smoker.

ERC3 results from a failure of the shaft's civil engineering concomitant to a millennial flood. It is assigned a probability E. The critical path leading to this ERC is related to the usual degradation of the shaft concrete.

This event leads to a sudden over-flowrate (gradient around +10 m^3/s for the millennial flood) downstream but in proportions comparable to a rare natural flood and to a time where the intensity of the flood is already significant downstream (pre-existing flowrate of around 35 m^3/s by the floodwater evacuator and 10 m^3 by the bypass channel). While it cannot be excluded that this augmentation of flowrate surprises some people downstream on the banks of the waterway, this event can be anticipated as part of the dam's monitoring in a flooding situation. The number of people impacted in the rapid kinetics area is estimated to not exceed 10 people and the total number of impacted people is estimated to remain below 100.

The hydraulic consequences are thus qualified as "significant."

The radiological consequences of such a scenario would be the release of a quantity of water slightly radiologically marked. Given the radiological activity of the water in the large pond (2 Bq/l), and given that the phenomenon does not last a long time and that no catchment of drinking water exists downstream of the site, such a scenario would not lead to exceeding the threshold of 1 mSv/year.

The radiological consequences of ERC 3 are "moderate."

2.1.4. ERC4 – Failure of the submersible dike

ERC4 results from failure of the submersible dike located between the lakeand the evacuator. This dike underwent renovation and complete reinforcement in 2020.

ERC4 is assigned a probability C (unlikely). The critical path leading to this ERC is related to the external erosion linked to the overflow of the pond following very intense precipitation.

The flowrate released in case of failure of the submersible dike during a centennial flood is 8.6 m^3/s or an overflow of 2.6 m^3/year compared to the flowrate already released during a centennial flood (6 m^3/s by the flood evacuator and 10 m^3/s by the bypass channel).

The hydraulic consequences are thus qualified as "significant."

Such a scenario would lead to the liberation of slightly radiologically marked water potentially containing a low quantity of tailings and partial drying of the lake. , Such a scenario would not lead to exceeding the threshold of 1 mSv/year.
The radiological consequences of ERC 4 are "moderate."

2.1.5. ERC5 – Failure of the submersible dike following rapid emptying

Rapid emptying may lead to instability of upstream backfill of the dike and thus its failure. Rapid emptying is triggered in case of a significant anomaly on the main dam.
ERC5 is assigned a probability of E ("extremely rare")

This event results in sudden overflow downstream in limited proportions because the level of the lake is low and a flowrate is already released downstream. While it cannot be excluded that this flowrate augmentation may surprise some people downstream on the banks of the river, this event can be anticipated as part of the dam's monitoring. The number of people impacted in the rapid kinetics area is estimated to not exceed 10 people and the total number of impacted people is estimated to remain below 100.

The hydraulic consequences are thus qualified as "significant."

Such a scenario would lead to the liberation of slightly radiologically marked water in moderate quantities due to the fact that the event occurs with emptying; there is thus little water in the lake. In the long term, a drying of the lake is possible.

The radiological consequences of ERC 5 are similar to those of ERC4 or "moderate."

2.1.6. ERC6 – Accidental opening of the emptying system

This event may be caused by:

- the concomitance of the non-closure of the upstream valve and an inadvertent opening of the valve downstream of the airlock;
- the concomitance of inadvertent opening of the upstream valve and an inadvertent non-closure of the valve downstream of the airlock;
- a civil engineering failure of the airlock.

ERC6 is assigned probability B (probable).
This event leads to sudden over-flowrate but one that is very slight (gradient of around +3 m^3/s) downstream.

The hydraulic consequences are thus qualified as "moderate."

Such a scenario would lead to the liberation of slightly radiologically marked water with low flowrate. Given the low flowrate and the presence of the lake it is likely that the entering flowrate is sufficient to compensate for the water discharged by emptying. This scenario will not lead to the stripping of tailings.

The radiological consequences will thus be "moderate."

2.1.7. ERC7 – Inadvertent opening of the emptying system following a malicious act

Following an act of vandalism of occurrence A, an upstream valve and a downstream valve may be opened simultaneously. However, maneuvering the valves is difficult and involves a particular system not described in this document for safety reasons. Considering the precautionary measures concerning the use and maneuvering of the valves, the occurrence is thus declassified as B.
ERC7 is assigned probability B (probable).
This event leads to sudden over-flowrate but one that is very slight (gradient of around +3 m^3/s) downstream.

The hydraulic consequences are thus qualified as “moderate.”

Such a scenario would lead to the liberation of slightly radiologically marked water with low flowrate. Given the low flowrate and the presence of the lake, it is likely that the entering flowrate is sufficient to compensate for the water discharged by emptying. This scenario will not lead to the stripping of tailings.

The radiological consequences will thus be “moderate.”

2.1.8. Criticality matrix

The classification in the criticality matrix takes account of the application and reliability of the protection barriers.

(1) Hydraulic risk

Table5: Criticality matrix resulting from the risk analysis (with active protection barriers) relative to the hydraulic risk

		Probability				
		Extremely rare (> 10^{-5})	Rare (10^{-4}–10^{-5})	Unlikely (10^{-3} – 10^{-4})	Probable (10^{-2} – 10^{-3})	Usual (< 10^{-2})
		E	D	C	B	A
Severity	Disastrous					
	Catastrophic	ERC1h				
	Severe					
	Significant	ERC3h ERC2h ERC5h		ERC4h		
	Moderate				ERC6h, ERC7h	

	Unacceptable risk
	Risk to be monitored
	Acceptable risk

(2) Radiological risk

Table6: Criticality matrix resulting from the risk analysis (with active protection barriers) relative to the radiological risk.

		Probability				
		Extremely rare (> 10^{-5})	Rare (10^{-4} – 10^{-5})	Unlikely (10^{-3} – 10^{-4})	Probable (10^{-2} – 10^{-3})	Usual (< 10^{-2})
		E	D	C	B	A
Severity	Disastrous					
	Catastrophic					
	Considerable					
	Significant	ERC1r				
	Moderate	ERC3r ERC2r ERC5r		ERC4r	ERC6r, ERC7r	

	Unacceptable risk
	Risk to be monitored
	Acceptable risk

Following the implementation of three priority measures identified in the 2019 Danger Study, the site no longer presents events classified as "risk to be monitored," but only events classified as "acceptable risks," and is considered non-critical and satisfactory relative to public safety, whether in terms of hydrology or radiology.

The analysis conducted in 2023 of the consequences of failure according to the GISTM requirements confirms the 2019 analysis and adds details for each challenge in compliance with appendix 2 of the standard.
It is important to add the GISTM standard approach does not take into account occurrence probability. As a reminder the probability of Dam break down is evaluated are "Extremely rare" rare (10^{-5}).

The consequences of the Bois-Noirs dam failure relative to the population, the environment, health, society, and the economy are assessed as follows:

- Extreme for the potentially at-risk population;
- Extreme for the potential loss of human life;
- High for the impacts on the environment;
- Very high for the impacts on health and society;
- Very high for the impacts on infra-structures and the economy.

It should be noted that this analysis was based on a flood wave study of the dam taking into consideration worst scenario flood failure at the highest-water elevation (764.71).

Concerned stakes located in the low kinetic were evaluated with highly conservative approach regarding the Mayet de Montagne hydroelectric dam plant if it would be impacted

by a flood wave induced by BNL failure, as Orano was not allowed to be provided with the hydroelectrical facility technical characteristics.

A failure by an internal erosion mechanism for a body of water at a normal reservoir elevation (761.93) would present, at least to the Saint-Clément reservoir, a lower impact due to the lower volume of released water. However, it is likely that the Paradou campsite immediately downstream would be significantly impacted in the same way, even though the potential risk of loss of human life is considered as unchanged.

3. Conclusions of yearly internal and external reviews (Point B.6 & B.9)

3.1. In-Depth Technical Visit (VTA)

Annually and with the help of its associated service provider, Orano Mining conducts an in-depth technical visit.
This visit, conducted in parallel to the annual analysis of the examination data for the works, covers the entire monitoring plan, but also and especially to observe any possible damage and establish an action plan validated by the EOR and reviewed (only since 2023) by the ITRB which did not exist up until then.

The last VTA took place on June 29, 2023, but the report is not yet available at the time of publication of this report. The previous VTA took place on September 14, 2022. Here are the conclusions and recommendations:

"The condition of the Bois-Noirs dam is still satisfactory overall and does not show significant change from one year to another. No major anomalies were observed during the VTA of September 14, 2022.
The site and works are still maintained with care and regularity.
The equipment operates correctly: submersible dike valves, level sensors, alarms, and examination systems.
As was already mentioned last year, the main types of damage affect the Besbre canal. A greater number of damages were easily identified during this visit due to a very low water level in the canal. Certain areas are changing (e.g., pads 7–8). Similarly, the low level made it possible to carry out an observation of the condition of the upstream rectangular section. The concrete presents numerous signs of aging.
The Bellechasse water uptake has been cleaned since the last visit but is to be regularly monitored to check for the absence of leaking along the length of the works.
The systems for collection and measurement of the downstream base drains and the wetlands on the berms downstream of the dam, without significant change compared to earlier observations, remain to be improved. A renovation project was submitted to Orano for implementation in 2023. It is important to continue to check that the water taken into the drains remains clear, without entrainment of dam materials.

The particular monitoring measures and the corrective measures to bring to bear are summarized in the tables below:

	Particular monutoring actions	Frequency
A	Gallery: Leaks and concrete visual monitoring	Bi-annual
B	Submersible dam: Valves inspection and alarms tests	Yearly
C	Upstream canalised Besbre section: Control water inflows along Besbre channel	During bi-monthly visits under high flow conditions

D	Upstream canalised Besbre section: Control channel concrete and structure aspects especially after flood episod	Bi-montly
E	Bellechase stream: Check water inflows along concrete channel	Bi-montly
F	Visual check along fishway	Bi-montly

	Corrective actions	Deadline
1	Remove pine trees from dam upstream side	before end 2023
2	Remove concrete chips from gallery roof	before end 2023
3	Remove vegetation fromp downstream Besbre section	before end 2023
4	Refilled training wall crack (downstream flood channel)	2023
5	Improve and renovate dam downstream drainage system	2023
6	Re-work punctual tarmac defaults along dam ridge road	2023
7	Renovate Besbre channel	2027 or earlier if important default noticed

3.2. DREAL inspections

The services of the Loire prefecture represented by the DREAL, the Polluted Soils and Sites Waste center, for the part Classified Facility for the Protection of the Environment (ICPE) and the Natural and Hydraulic Risk Prevention Department (SPRNH), and the Hydraulic works Center for the dam part, leading to a shared yearly inspection on site in the presence of the operator and the associated engineering office. The last inspection was conducted on July 06, 2023, without “non-conformities” identified, but the report is not available at the time of publication of this report.

The previous inspection was conducted on September 26, 2022. Here are the conclusions:

“The inspection performed today including a visit of the easily accessible parts of the arranged works, as well as a meeting on the results of the maintenance and monitoring of said works and intersecting with the documents sent to the inspection department or presented by the operator during the meeting, did not show any evident information that could challenge the favorable judgment previously reached on safety of the arrangement.
This inspection led to three requests, and non-satisfactory requests from previous inspections were revised. The following was requested of Orano Mining:

- *Improve the drain system on the downstream facing and at the base of this wall by 12/31/2023*
- *Show the detection sensor for rapid decrease in the body of water before the 12/31/2022*
- *Set up monitoring of one-off types of damage in the bypass channel of the Besbre and define the operation conditions until 2024."*

During the July 6, 2023inspection, the examining department was told that the improvement of the drain system would not be conducted in 2023 even though a previous visit took place on March 27 with two potential service providers. The technical specifications were subject to added details and will be submitted shortly to the service providers. The contract should be drawn up before the end of 2023 so that the work will be carried out between August and October 2024.

The two other requests were fulfilled and described in the monitoring report for the works for 2022, and observed by the examining department during the July 6, 2023, inspection.

The next inspection should take place between September and October 2024

4. Monitoring plan for normal operation (Point B.7 and Point C)

4.1. Systems for measuring and managing the body of water (lake)

The water cover (lake) is measured using four systems:

- A level scale attached to the concrete of the tunnel junction structures upstream of the pipes of the emptying works;
- Two stations for the continuous measurement of water level attached to the walkway above the large pond:
    - An analog level sensor (ultrasound) sending daily levels of the large pond to a remotely accessible server via a GSM transmitter;
    - A radar probe connected to the controller;
- A level sensor (radar probe) located above the emptying works and connected to the controller of the water treatment station.

Since the valves between the large pond and the emptying works are constantly open, the level measured in the large pond is the same as that measured in the emptying works.

The level of the large pond measured by the radar probe on the large pond side is fed back to the controller of the water treatment station. If there is a rapid drop in the body of water dimension of more than 2 cm in an hour, an alarm is sent to the on-call technical service.

The level of water measured in the emptying works is collected by a controller of the station and serves the following purposes:

- trigger or stop the pumping of the water in the large pond to the water treatment station that uses zeolites;
- send level alarms to the on-call technical service for control via the controller of the treatment station.

In normal situations, the level of the body of water is between the dimensions 759.87 and 761.93 m NGF. Depending on the rainfall and the season, the pumping system located in the emptying works guarantees that the water level is maintained in this value interval.

The large pond level changes according to rainfall and the seasons. In general, the water level in the large pond decreases between June and September and increases between October and May.

To avoid overflow of the large pond, outside the flood period but during intense rain episodes between October and May, the water of the large pond is pumped according to the dimension of the large pond in compliance with the guideline below:

- The first pump (average flowrate of 50 m^3/h) is triggered when the level of the large pond reaches the dimension 761.40 m NGF;
- The second pump begins to support the first (average flowrate of 100 m^3/h) when the level of the large pond reaches the dimension of 761.50 m NGF;

- The third pump begins to support the first two (average flowrate of 150 m^3/h) when the level of the large pond reaches the dimension 761.60 m NGF.

The flowrate of the pumps is also adapted according to the clogging of the filter and the zeolite treatment pond.

4.2. Systems for examination measurements

4.2.1. Description

The system for examining the Bois Noirs dam includes the system for managing the body of water level and consists of:

- a level scale on the pipe tunneling works at the lake, measured twice a month;
- 2 level scales for measuring the flowrates of the bypass works:
  - in the Besbre bypass canal;
  - in the energy dissipation scoop at the extreme downstream of the floodwater evacuator canal;
- 2 stations of continuous measurement of the large pond level;
- A large pond level sensor at the emptying works connected to the controller of the water treatment station;
- pumping works consisting of 3 pumps, each with a capacity of 50 m^3/h;
- a station for continuous measurement of the Besbre flowrate;
- 20 survey markers, measured once a year:
  - 10 survey markers, installed along the pavement, at the summit of the downstream facing (B2 to B11), measured since 1960;
  - 10 planimetrical markers, installed in the axis of the pavement, at the crest (R2 to R11), measured since 1984;
  - spacing between these two types of markers has been measured for informational purposes since 2004;
- 30 piezometers (P0 to P13, P5b, P7b, P8b, P14 to P26) divided into 8 upstream/downstream profiles situated on the crest and the berms of the downstream facing + 1 (PZMA) for monitoring of the level of the right bank perched water table, measured twice a month using a sonic probe;
- 9 flowrate measurement points for the drains in contact with the core of the works and the foundation (D1 to D6 + D1.1 to D1.3), their grouping making up D1, measured twice a month;
- 14 measurement points for the wetlands, measured twice a month:
  - 2 at the dam base (E4 and E4b);
  - 11 on the berms (E1, E2, E3, E5, E7, E8, E9, E10, E11, E12, and E13);
  - 1 near the “dam/right bank TN” contact between the lower and intermediary berms (E6);
- An onsite rainfall measurement is performed continuously and recorded every 15 days. The raingauge is installed on the walkway above the pumping works. It sends data on the managing controller of the water treatment station.

NB: The level scale indicating the level of the lake is set on the local baseline to which 17 cm must be added to obtain the value in NGF Lambert 93.

4.2.2. Frequency of measurements

The frequency of measurements is presented in the table below.

Frequency	Type of measurement
Continuously	Rainfall Besbre flowrate Lake water level
Twice monthly	Lake water level (at the level scale) Flowrate of drains and wetlands Piezometric levels Flowrates of bypass works
Yearly	Elevation measurements on the crest of the works Measurements of spacing between the R / B markers on the crest of the works Planimetrical measurements on the crest of the works

Table 7 - Frequencies of examination measurements of the dam

4.3. Servicing and maintenance

Servicing and maintenances of the examination system consists of:

- Replacing the level scales if they are broken or illegible;
- Every 15 days, checking the proper operation of the continuous measurement stations at the lake, the Besbre flowrate, and rainfall;
- Performing yearly maintenance on these continuous measurement stations (battery check and replacement, if necessary; functional test; calibration, etc.);
- Using the 3 pumps on an alternating basis according to the flowrate necessary for maintaining the level of the water in the lake in the abovementioned interval;
- Checking every 3 months that the pumps are operating properly in the low water period;
- Repairing the survey markers when they are broken;
- Repairing the bases of the piezometers when they are broken;
- Conducting an endoscopic inspection of the piezometers if the level measurements are inconsistent;
- Cleaning the tanks and the ponds for collecting water from the drains at the dam base when there are algae that prevent correctly measuring drain flowrates.

4.4. Rounds for monitoring and examination in normal operating situations

The rounds described below for monitoring and measurement are performed by a qualified service provider on behalf of the operator.
The elevation and planimetrical inspections are carried out yearly by an Expert Surveyor.
The data collected during the rounds and inspections are sent to the Engineer of Record (EOR).
The site is maintained by a qualified service provider.

4.4.1. Normal operating situation

The normal operating situation is defined by:

- A Besbre flowrate of less than 5 m^3/s;
- An oscillation of the body of water level between 759.87 m NGF, corresponding to the minimum operating dimension (CME), and 761.93 m NGF, corresponding to the lake normal level (RN) and to the lake elevation overflow.
- Closure of the emptying valve of the pumping works, since the valves of the works remain open for pumping the lakewater to regulate the lake level;
- Blocking of the main reservoir feed valve via the old natural bed of the Besbre by a plate.

Maintaining the lake level in the abovementioned interval is carried out by a pumping system interlocked with the water level measured in the drain works.

The following sections describe the examination and monitoring rounds performed in normal operating situations.

4.4.2. Twice-monthly round

(1) Monitoring the right bank works

It consists in moving along the path from the Peux reservoir to the dam base to inspect the Besbre bypass canal and to:

- Measure the Besbre flowrate at the BESBA (located Figure 2);
- Check the proper operation of the station that continuously measures the Besbre flowrate;
- Measure the damage to the concrete of the Besbre bypass canal, notably the absence of separation of the coating;
- Monitor the appearance of water seepage along the slope below the path that runs the length of the canalized Besbre during high flowrate periods;
- Check for the absence of bodies liable to generate overflow and remove them if necessary.

(2) Monitor the left bank works

This consists of moving along the path from the water uptake of the Bellechasse canal to the facing base downstream of the dam, and to:

- Check for the absence of debris in the Bellechasse canal that could lead to overflow, removing it if necessary;
- Check for changes in the wetlands between the water uptake and the extremity upstream of the canal;
- Check for the absence of floating bodies in the large pond that are significant enough to block the floodwater evacuator and remove them if necessary;
- Check for the absence of overflow in the accessory pond in the pit for collecting left bank inlet water;
- Check for proper leaktightness of the emptying valve in the pumping airlock and the absence of leaking at the submersible dike;
- Check for the proper operation of the raingauge;
- Check for the proper operation of measuring stations at the large pond;
- Examine the dewatering outlets of the evacuator and clean them to avoid any accumulation of plant debris that could lead to their total clogging;
- Check for the absence of bodies in the floodwater evacuator canal that could block water flow. If there are any ice jams, they are removed.

(3) Monitoring and management of the large pond level

In normal situations, the level of the large pond is between 759.87 NGF and 761.93 NGF.

During the twice-monthly round, the large pond level is measured using the level scale at the GB 1 (shown in Figure 2).

The level of the large pond is maintained in the value interval, defined above, through the pumping system installed on the emptying works. This system, composed of three 50 m^3/h pumps, sends large pond water to the water treatment station (over zeolites) to avoid potential overflows in the large pond outside flooding periods

According to the water level measured by the pumping works sensor, the 3 pumps are started and stopped successively.

The dimensions of the successive start and stop of the pumps may vary according to the following parameters:

- Season: low water / high water
- Weather: precipitations, storms, drought

As a reminder, the dimensions for pump start are currently the following:

- 761.40 m NGF: triggering the first pump;
- 761.50 m NGF: triggering the second pump to support the first;
- 761.60 m NGF: triggering the third pump to support the first two.

(4) Dam monitoring

Visual examination

During examination of the dam facings, special attention must be paid to:

- Any sign of mechanical changes in the works (crevice, flaw, bulge, perceptible settling, significant drop of the blocks, etc.);
- Any wet spot on the slope or berms, or dam/natural terrain contact. In case of persistence, as soon as possible each point of seepage will be equipped with a sensor and measurement system similar to those already produced to quantify the point's flowrate.

All visual observations are recorded in the observation sheet.

Performing flowrate measurements

As part of monitoring the Bois Noirs dam, flowrate measurements are performed as defined in the following table:

Table 8 - Measurements of flowrates as part of monitoring the Bois Noirs dam.

Location	Names of measurement points
Dam base drains	D1, D2, D3, D4, D5, D6
14 wetlands of the dam	E1, E2, E3, E4, E4B, E5, E6, E7, E8, E9, E10, E11, E12, E13
Besbre upstream of the site	BESB A
Left bank	GB 2

Performing piezometric level measurements

Water level measurements are performed on the 31 dam monitoring piezometers.

The piezometric level is obtained by subtracting the raw measurement (at the known elevation dimension) from the top of the piezometer (summit of the tubing).
During raw measurements, the recording sheet for water levels in the piezometers includes the following, for immediate response: the headrooms corresponding to the alert dimensions defined by the Engineer of Record (EOR) for the piezometers downstream from the crest.

4.4.3. Monthly round

It consists of:

- Performing the same examinations as those performed during the twice-monthly round;
- Performing the examination of the drift and floodwater evacuator canal to check for the absence of deterioration of the masonry, accumulation of plant debris, and dead animals. These potential accumulations are removed and any deterioration noted;
- Monitoring the changes in the sealant cord at the vertical connection between the right bank training wall of 2017 and the original wall;
- Checking the proper operation of the pumps of the pumping works during the low water period;

It should also be noted that during the round in March (high water) and September (low water), the following will be performed: visual monitoring of the leak areas and the potential damage to the lining of the floodwater evacuator drift.

4.4.4. Yearly round

It consists of:

- Performing the same examinations as those performed during the monthly rounds;
- Inspecting the condition of the masonry and any seals between the elements:
  - the section of the Besbre canal into steps;
  - the fish scale;
  - the "Belle Chasse" canal and its water uptake.

  Any deterioration must be handled as soon as possible;
- Inspecting the proper water flow in the canals as well as the left bank pits, since the latter may be damaged by significant accumulation of mud, sand, or gravel and by the proliferation of plants. If necessary, these works and the evacuator pond must be cleaned as soon as possible;
- Maintaining (cleaning and lubrication) the racks and screw pitch to enable moving the emptying valves;
- Maneuvering the emptying valves and maintaining them;
- Testing the level alert floats (large pond and spillway base).

In addition, an Expert Surveyor will perform the following yearly: elevation and planimetrical inspections as well as the inspection of spacing between elevation and planimetrical markers.

The site is maintained yearly or twice a year if needed. This maintenance consists in:

- Removing vegetation:
  - Yearly at the old bed of the Besbre, the dam, and the dam base; around the large pond and the accessory pond; and around the works of the water treatment station;
  - Twice a year: trails, paths, fish passages, dam base drains, and the water treatment station.
- Cleaning the pits and the outlets yearly.

4.4.5. Reporting on observations and measurements following the rounds

Following each round, a report including observation sheets as well as flowrate and piezometric level measurements is sent to the designated engineer (Engineer of Record, EOR). This engineer prepares a succinct interpretation report by email of the observations collected and measurements performed during the round and compares them to the expected normal measurements.

In addition, the observations concerning the dam are recorded in the dam register. This register is handwritten by the service provider assigned to the monitoring, in a notebook kept in the Bois Noirs water treatment station. A copy of the register is regularly sent to the operator.

In case of leaktightness defects in the valves or significant damage to the dam facings, the Engineer of Record (EOR) will be informed immediately.

In case of confirmed abnormal measurements, the results will be sent immediately to the Auvergne – Rhône-Alpes DREAL and to the designated engineer (Engineer of Record/EOR) who, working with the Orano Mining operator, will decide on the provisions to be made.

5. Emergency Preparedness Response Plan (Point B.8 and C)

The credible failure scenarios are described in the risk analysis and provided below:

- ERC 1: Partial or total failure of the dam
- ERC 2: Failure of the dam following rapid emptying;
- ERC 3: Failure of the floodwater evacuator shaft during flooding;
- ERC 4: Failure of the submersible dike;
- ERC 5: Failure of the submersible dike following rapid emptying;
- ERC 6: Accidental opening of emptying system;
- ERC 7: Inadvertent opening of the emptying system following a malicious act.

An emergency plan was prepared by the department Après Mines France (AMF) of Orano Mining to cover a failure of the works, be it major (large dam) or accessory (submersible dike). The following mimic diagram shows the procedure to follow (Figure 7). **The telephone numbers of the people in charge have been deleted on purpose but are, of course, included and up to date in the Emergency Preparedness Response Plan (EPRP). Government services are sent the updated version of the works monitoring guidelines as soon as a modification is necessary.**

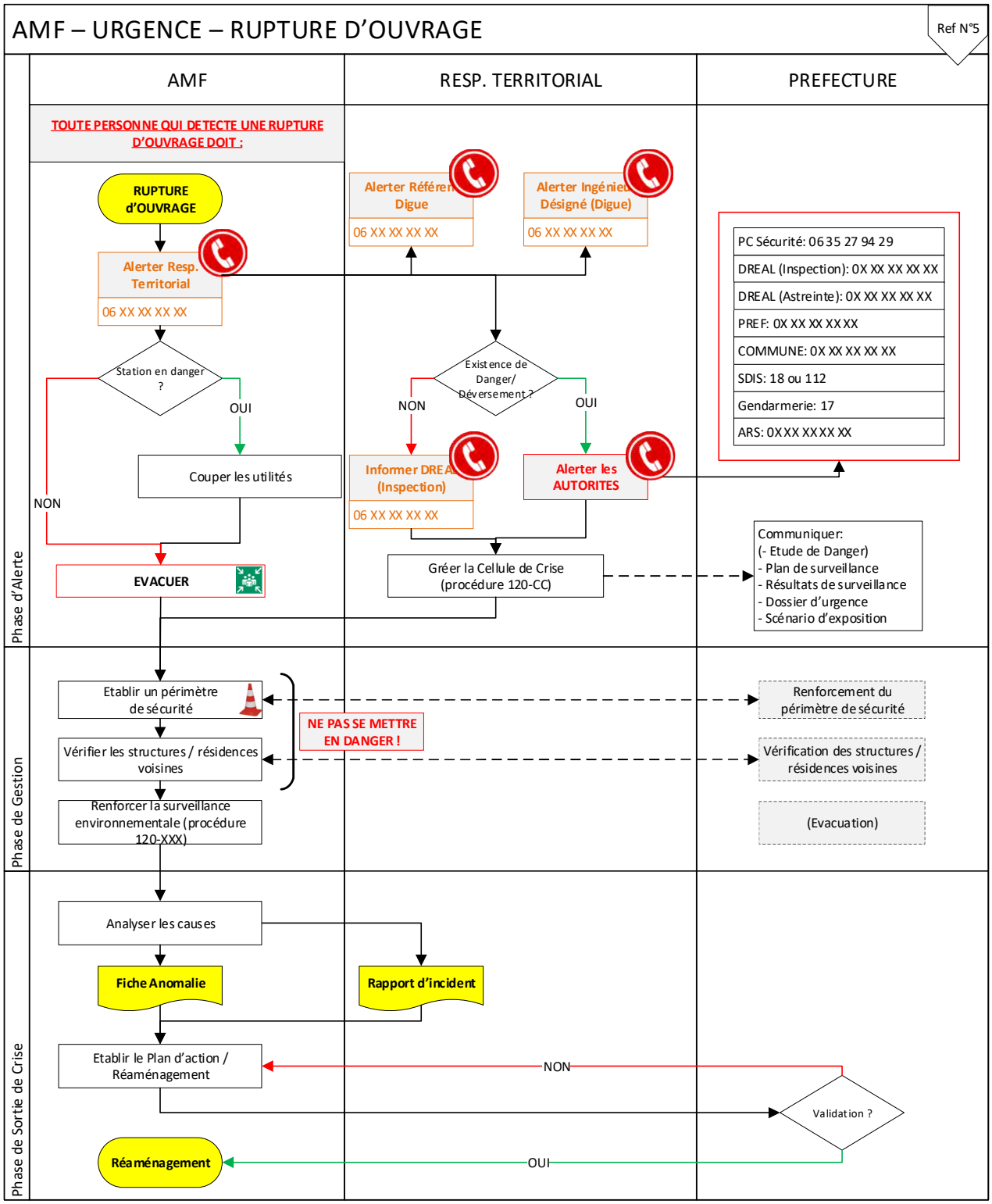


Figure 7 - Emergency procedure in case of failure of the works.

The last two central postulated events were malicious acts and are also covered by the emergency plans illustrated below (Figure 8 & Figure 9).

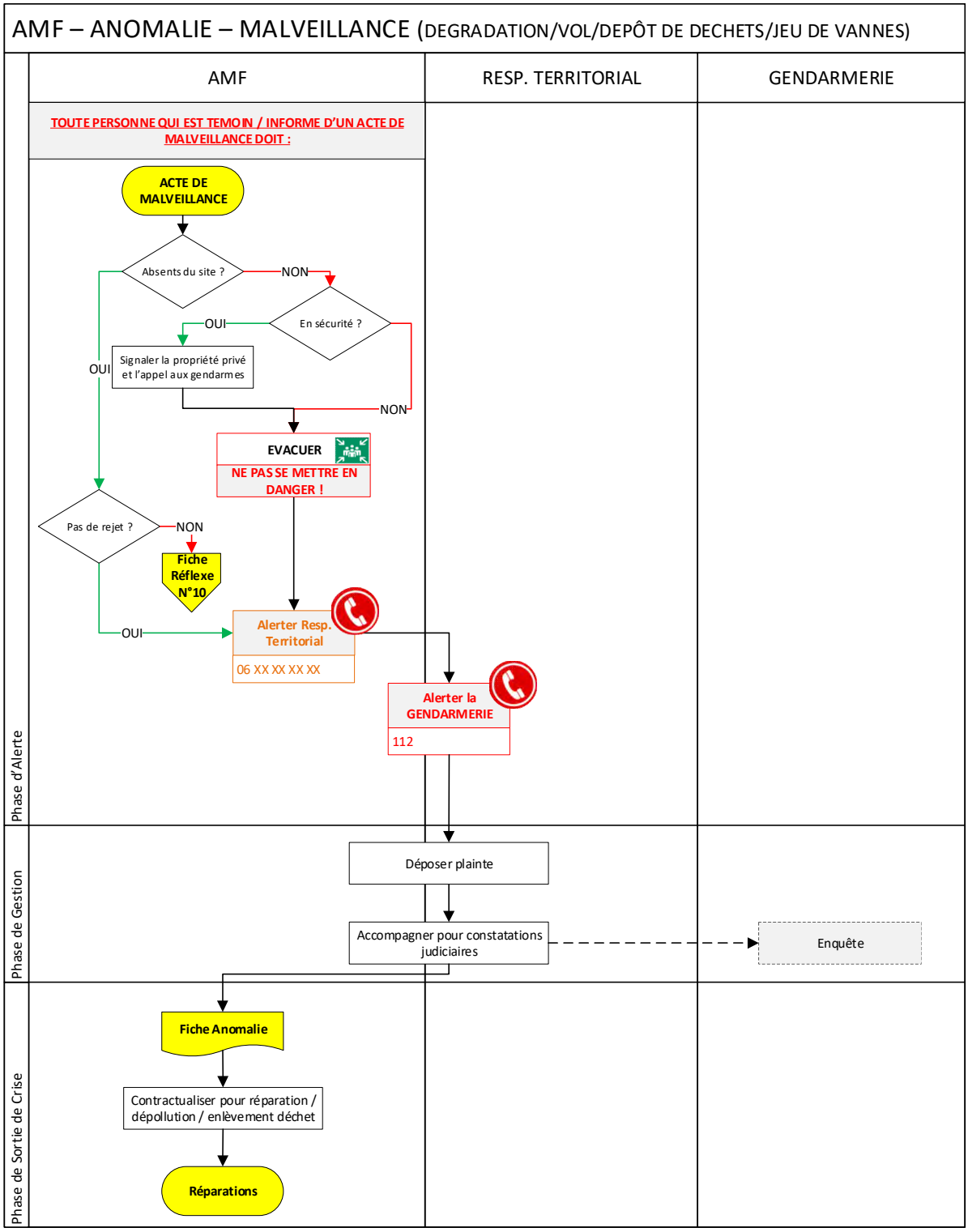


Figure 8 - Emergency sheet for malicious acts.

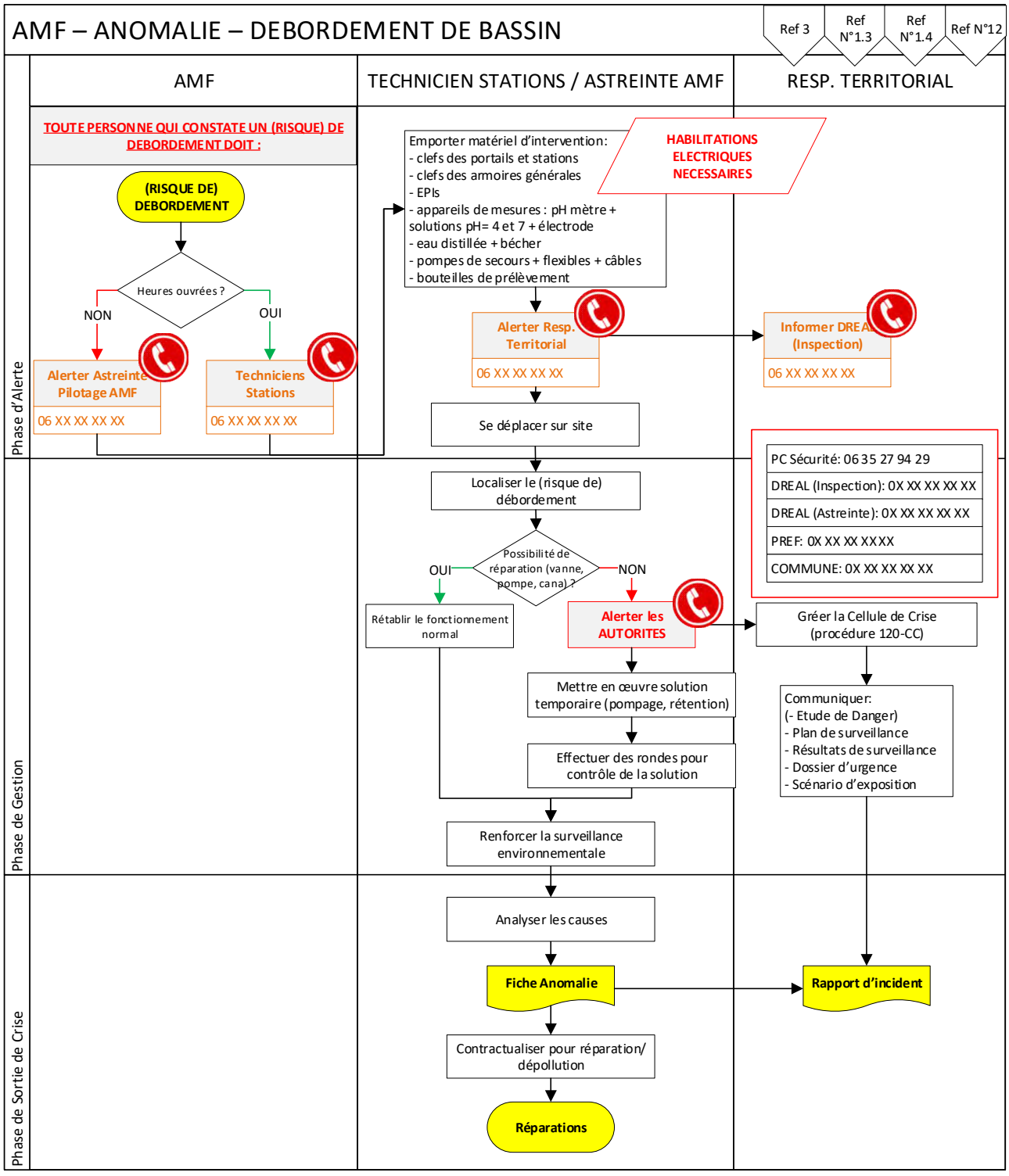


Figure 9 - Emergency sheet for pond overflow.

6. Financial capacity (Point B.10)

Orano Mining provides the estimated costs of environmental monitoring and, as necessary, the remediation works over several years. These provisions are regularly reassessed and audited yearly by auditors. Their opinions are published with the results report and the annual activity report of the Orano group.

In addition, the French Environment Code requires the operator to take out financial guarantee insurance to cover 30 years of operation and any remediation in case of anticipated closure of a facility classified on the French environmental protection list. These financial guarantees must be renewed every 5 years and proof of them must be provided to the administration.
The Prefectorial Order no. 237-DDPP-18 dated June 19, 2018, requires this type of guarantee from Orano Mining. Guarantee established in 2018 and renewed in March 2023.

Appendix:
Self-assessment of the mining tailings facility – Bois Nois Limouzat