AUTORITÉ DE SÛRETÉ NUCLÉAIRE

ASN GUIDE

BNI

Management of soils contaminated by the activities of a Basic Nuclear Installation in France

GUIDE N°24

Version of 08/30/2016

Preamble

The ASN collection of guides is intended for professionals concerned by the nuclear safety and radiation protection regulations (licensees, users or transporters of ionising radiation sources, health professionals). These guides can also be issued to the various stakeholders, such as the local information committees (CLIs).

Each guide sets out recommendations with the aim of:

- explaining the regulations and the rights and obligations of the persons concerned by the regulations;

- explaining the regulatory objectives and, as applicable, describing the practices considered by ASN to be satisfactory.

- giving practical tips and information concerning nuclear safety and radiation protection:

Contents

1 INTRODUCTION 4

1.1 Reference texts: 4
1.1.1 Legislative and regulatory framework 4
1.1.2 Principles and guides associated with post-operational clean-out, remediation and decommissioning 4
1.2 Definitions 5
1.3 Document status 5
1.4 Scope of application 6
1.4.1 Users concerned 6
1.4.2 Types of contamination 6
1.4.3 Case where the contamination extends outside the premises 6
1.4.4 Legal responsibilities of the licensee and of the land owner 8
1.4.5 Water contamination 8
1.5 Aims of the guide 8
1.6 Reminder of the management procedure and the methodological aids 9

2 SOIL REMEDIATION PROCEDURE 12

2.1 Diagnosis and conceptual diagram (step 1) 14
2.2 Implementation of the reference procedure: complete removal of the contamination (step 2) 16
2.3 Procedure to follow if it is impossible to apply the reference procedure (steps 3 and 4) 17
2.3.1 Breakdown of the management procedure 17
2.3.2 General principles for achieving compatibility with all uses 17
2.3.3 The established, envisaged and potential uses are not compatible with the state of the soil: implementation of a management procedure (step 4) 18
2.4 End of the soil remediation operations (step 5) 19
2.4.1 The state of the soil is compatible with any use 19
2.4.2 The state of the soil has been rendered compatible with any use 19
2.4.3 The state of the soil is/has been rendered compatible at least with the established use (BNI in operation) 19
2.4.4 The remediation work does not render the soil compatible with the considered use(s) (step 6) 20

3 METHODOLOGY OF SOIL REMEDIATION BY EXCAVATION 21

3.1 1st line of defence 22
3.1.1 Definition of "areas to excavate" 22
3.1.2 The remediation objective 22
3.2 2nd line of defence 23
3.3 3rd line of defence 23
3.4 Management of the excavated soils 24
3.4.1 Status of the excavated soils and methods of management 24
3.4.2 Storage of excavated soils within the perimeter of the BNI 24

4 ADMINISTRATIVE PROCEDURES 25

4.1 Steps before starting remediation work 25
4.1.1 Concerning the diagnosis 25
4.1.2 Concerning work preparation 25
4.2 During the remediation work 26
4.3 After the remediation work 26
4.4 Implementation of particular management measures after the remediation work 27
4.5 Informing the public and involvement of the stakeholders 27

5 QUALITY ASSURANCE REQUIREMENTS 28

1 INTRODUCTION

1.1 Reference texts:

1.1.1 Legislative and regulatory framework

[1] Environment Code, more specifically title II of book I and titles IV and IX of book V
[2] Order of 7th February 2012 amended, setting the general rules concerning basic nuclear installations.
[3] ASN Resolution 2008-DC-0106 of 11th July 2008 relative to the implementation of internal authorisation systems in basic nuclear installations;
[4] ASN Resolution 2013-DC-0360 of 16th July 2013 relative to control of detrimental effects and the impact of basic nuclear installations on health and the environment
[5] ASN Resolution 2015-DC-0508 of 21st April 2015 relative to the study of waste management and the inventory of waste produced in the BNIs.

1.1.2 Principles and guides associated with post-operational clean-out, remediation and decommissioning

[6] Basic principles of the ASN doctrine of 4th October 2012 on the management of sites contaminated by radioactive substances.
[7] Methodological guide for the management of sites potentially contaminated by radioactive substances - December 2011
[8] ASN policy concerning the decommissioning and delicensing of basic nuclear installations in France – April 2009
[9] ASN Guide No. 6: Final shutdown, decommissioning and delicensing of BNIs in France – version of 30/08/2016
[10] ASN Guide No. 9: Determining the perimeter of a BNI - version of 31/10/2013
[11] ASN Guide No. 14: Post-operational clean-out of structures in BNIs in France – version of 30/08/2016
[12] ASN Guide No. 23: Drafting and modification of the waste zoning plan for basic nuclear installations - version of 30/08/2016
[13] Guide to the off-site use of excavated soils in road engineering and development projects – BRGM/RP-60013-FR - INERIS – BRGM – MEDTL – February 2012
[14] Ministerial note of 8th February 2007, its appendices and associated methodological guides - Polluted sites and soils - Conditions of management and redevelopment of contaminated sites
[15] Methodological guide for the preparation of the basic report provided for by the Industrial Emissions Directive (IED) – DGPR, version 2.2, October 2014

1.2 Definitions

The definitions of the following terms used in this guide are taken from order [2]: "*establishment*" and *"potential nuclear waste production zones (ZppDN)"*.

The definitions of the following terms used in this guide are taken from guide [9]: *"decommissioning", "« post-operational clean-out and remediation" and "delicensing"*.

The definitions of "*reference waste zoning map*", "*definitive declassification of waste zoning*" and "*conventional waste zone (ZDC)*" are taken from resolution [5]. The definitions of "*vigilance ZDC*" and "*reinforced memory ZDC*" are taken from guide [11].

The definitions of "*verification criterion*", "*clean-out/remediation objective*" and "*all purposes*" are taken from guide [11]. By extension and so as to verify and measure the clean-out/remediation objective operationally, it can be expressed in another unit if necessary, such as an activity concentration or mass concentration.

The definition of "*BNI perimeter*" is that of the environmental code [1], supplemented by that taken from guide [10].

The definition of "*contamination"* is that of guide [7].

The definition of "*concentrated contamination"* is that of note [14]. For information, this is the "*volume of the subsurface environment to treat, delimited in space, within which the concentrations of one substance or more are significantly higher than the concentrations of these same substances in the immediate vicinity of this volume"*.

Reference state
Initial state of the environment reflecting the state of the environmental media before the activities causing the contamination actually began. In effect, according to guide [7] "*the level of contamination of the environmental media must be assessed in comparison with a reference state. This reference state can be based on an initial state of the environment reflecting the state of the environmental media before the activities causing the contamination one is seeking to identify actually began.* It corresponds to the initial state mentioned in article R. 122-5 of the environmental code [1] and to the basic report for an installation subject to the IED directive [15]. Failing this, the licensee implements the procedure mentioned in II of article 3.3.7 of resolution [4].

Reference environment
Environment considered as not being affected by the activities of the studied site but situated in the same geographical zone and whose characteristics are similar to those of the contaminated site.

Off premises
All the land that is not under the responsibility of the licensee of the BNI that caused the contamination.

Site
Geographical area that can accommodate one or more premises.

Licensee
The term licensee will be used to designate either the licensee or the owner of the land on which the installation is situated in the event of the licensee defaulting.

1.3 Document status

ASN Guide No. 24 is the culmination of more than four years of work on the management of soils contaminated by a basic nuclear installation. It has been produced by a working group of ASN staff representing the regional divisions and the departments and has been discussed with the licensees, IRSN

(French Institute for Radiation Protection and Nuclear Safety) and ASND (Defence Nuclear Safety Authority) at various stages of its preparation.
This guide is in its definitive version which takes into account the comments made during the public consultation conducted in the 1st half of 2016. This version of the guide may nevertheless undergo changes according to the feedback from its application.

1.4 Scope of application

1.4.1 Users concerned

This guide is intended for BNI operators when soil contamination leading to the undertaking of a remediation or soil management procedure has been detected. It is based on a methodological guide relative to the "*management of sites potentially contaminated by radioactive substances*" [7] which takes into account the regulations relative to BNIs, the particularities of the BNIs, the ministerial notice of 8th February 2007 [14] and the DGPR methodological guide [15] for chemically contaminated soils.

In the remainder of the guide, the recommendations relative to BNIs in the monitoring phase, that is to say waste disposal BNIs, shall apply in the same way as for BNIs in operation, with the exception of the deferred decontamination approach.

1.4.2 Types of contamination

This guide addresses the remediation of soils contaminated by radiological or chemical substances. The applicable procedure, which is defined in §2, is the same in both cases. §3 presents the remediation procedure by excavation and concerns primarily soils contaminated by radioactive substances. With regard to purely chemical contamination, various aids and methods are recommended by the Ministry of the Environment [14] and must be applied taking into account the regulations relative to BNIs.

With regard to chemical and radioactive contamination, the procedure defined in §2 must be applied and the management plan must address the two types of contamination as a whole.

1.4.3 Case where the contamination extends outside the premises

The licensee is responsible for the management of contamination caused by the BNI it operates, even beyond the perimeter of the BNI. Such cases concern the land contaminated by any activity exercised within the perimeter of the BNI, such as the operation of facilities and engineering structures present within the perimeter.

The figures below illustrate different contamination situations outside the installation perimeter that can arise. In both cases the licensee of the BNI causing the contamination is responsible for managing the contamination.

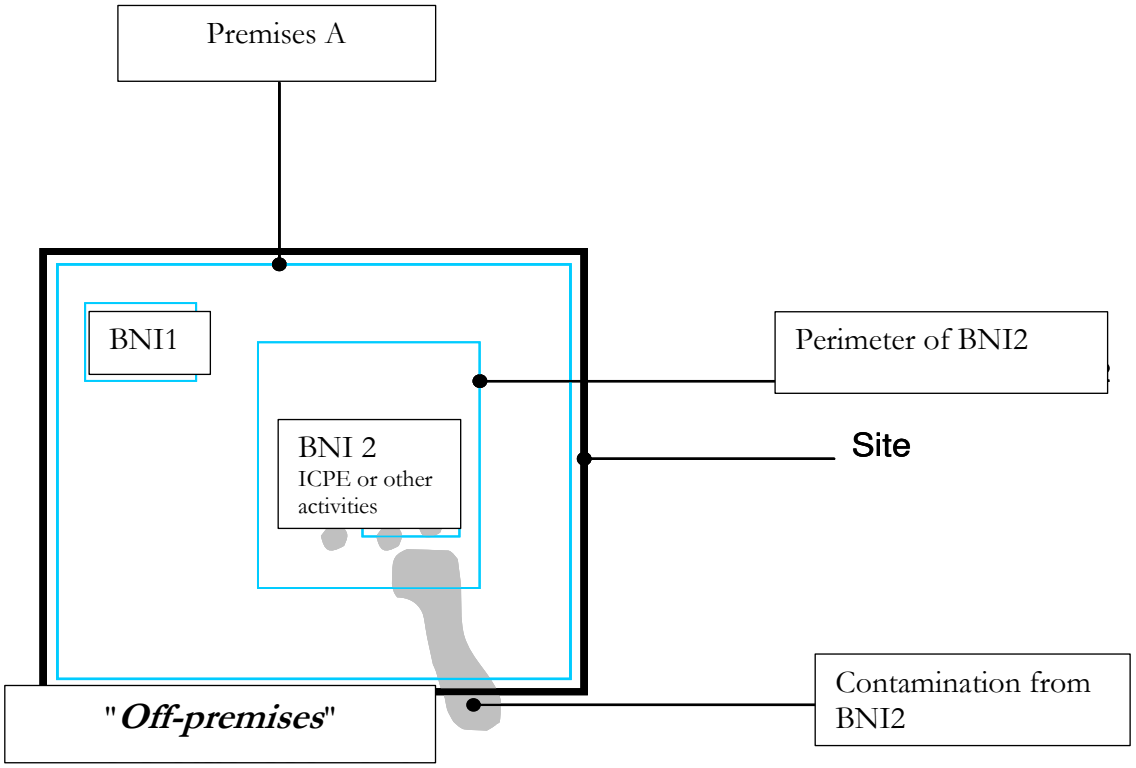


Figure 1: A single licensee: case of contamination extending outside the premises.
This contamination may have been caused by installations or engineering structures situated within the perimeter of BNI2 and spread physically outside the premises.

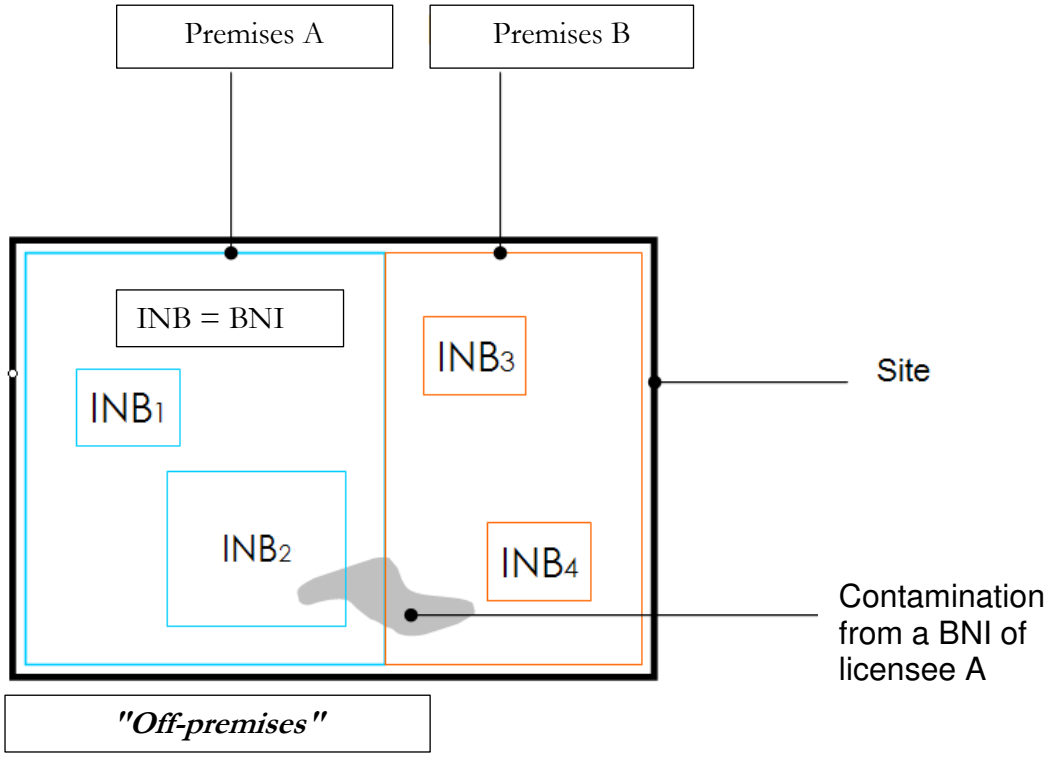


Figure 2: Several licensees on the same site (Premises of licensee A and Premises of licensee B): case of contamination spreading outside the premises and affecting other premises.

ASN is the competent authority for regulating and inspecting the activities exercised within the perimeter of a BNI.

In cases where the contamination of land off the premises is directly linked to the BNI's activities, ASN can, in accordance with the provisions of the environmental code [1], prescribe that the responsible entity characterises the soils with a view, if necessary, to imposing the implementation of measures resulting from the abovementioned management procedure. ASN coordinates its actions with the other State services to supervise and monitor the decontamination operations.

However, in the case of accidental spillage and contamination of very limited extent, the licensee can undertake simple and rapid measures with the aim of achieving complete remediation and restoring the reference state without it being necessary to implement the management procedure proper.

Lastly, this guide does not apply to soil contamination associated with an emergency situation such as is defined in article 1.3 of order [2].

1.4.4 Legal responsibilities of the licensee and of the land owner

Article L. 593-6 of the Environment Code [1] stipulates that a BNI licensee is responsible for controlling the risks and adverse effects that its installation can present for public health and safety and for protection of nature and the environment[1].

However, in the event of the licensee defaulting, the owner of the land - whether he was already the owner or became the owner after the said defaulting - can be subject to the same obligations if he was informed of the obligations that can be incumbent upon him[2].

1.4.5 Water contamination

Cases of water contamination are not specifically addressed in this version of the guide. Nevertheless, groundwater, runoff water and surface water constitute potential contamination transfer routes and depending on the uses of the water off the premises (alimentary, domestic, agriculture, etc.), they represent numerous sources of exposure for the population and the environment and consequently can be the predominant source of exposure. The "water" environmental medium must therefore be an integral part of the management process.

1.5 Aims of the guide

The management of sites potentially contaminated by radioactive substances is covered by a methodological guide published jointly by the Ministry responsible for the environment, ASN and IRSN in 2011 [7][3] in which it is stated that "*this guide is applied without prejudice to the specific provisions applicable […] to BNIs […] defined by the general regulations, the ASN guides or the prescriptions set by ASN on a case-by-case basis.*"

Subsequently, in October 2012 [6], ASN established its doctrine for the management of sites contaminated by radioactive substances which is based on four broad principles applicable to all situations and defines the procedure to apply: *"Pursuant to the Public Health Code, the exposure of individuals to ionising radiation during operations to manage sites contaminated by radioactive substances must be kept as low as reasonably achievable given current technology and economic and social factors. Thus, from an operational standpoint, in ASN's opinion, the reference procedure to adopt when technically feasible is to completely remediate sites contaminated with radioactivity, even if the human exposure induced by the radioactive contamination seems limited."*

[1] Interests protected by article L. 593-1 of the Environment Code [1].
[2] Articles L. 593-6, L. 593-7, L. 593-17 and L. 596-5 of the Environment Code [1].
[3] The issuing of this guide was accompanied by a letter co-signed by the Minister and ASN dated 16th November 2011. This letter indicates that *"removal of the maximum of the contamination in order to tend towards complete remediation is the prime objective, to avoid having to carry out additional remediation measures later on"*.

Moreover, ASN had already recommended in its decommissioning policy [8] the application of post-operational clean-out practices that aim to attain a final state in which all the hazardous and radioactive substances have been removed. This recommendation also figures in §9.1 of guide [9].

With regard to the management of contamination that is purely chemical, the applicable reference procedure is that recommended in the Ministry of the Environment's national policy for the management of contaminated sites and soils which states [14] that *"first and foremost, the possibilities of eliminating the sources of contamination and their impacts must be duly sought. If the sources of contamination are not controlled, it is not economically or technically appropriate to seek to control the impacts. The risk management policy in practice in no way opposes seeking possibilities of eliminating sources of contamination taking into account the available techniques and their economic costs. Thus, when contamination concentrations are identified (floating matter on groundwater, soil impregnated with products, pure products, etc.), the first priority is to extract the contamination concentrations, which are generally contained within limited areas, and not to undertake studies to justify not removing them."*

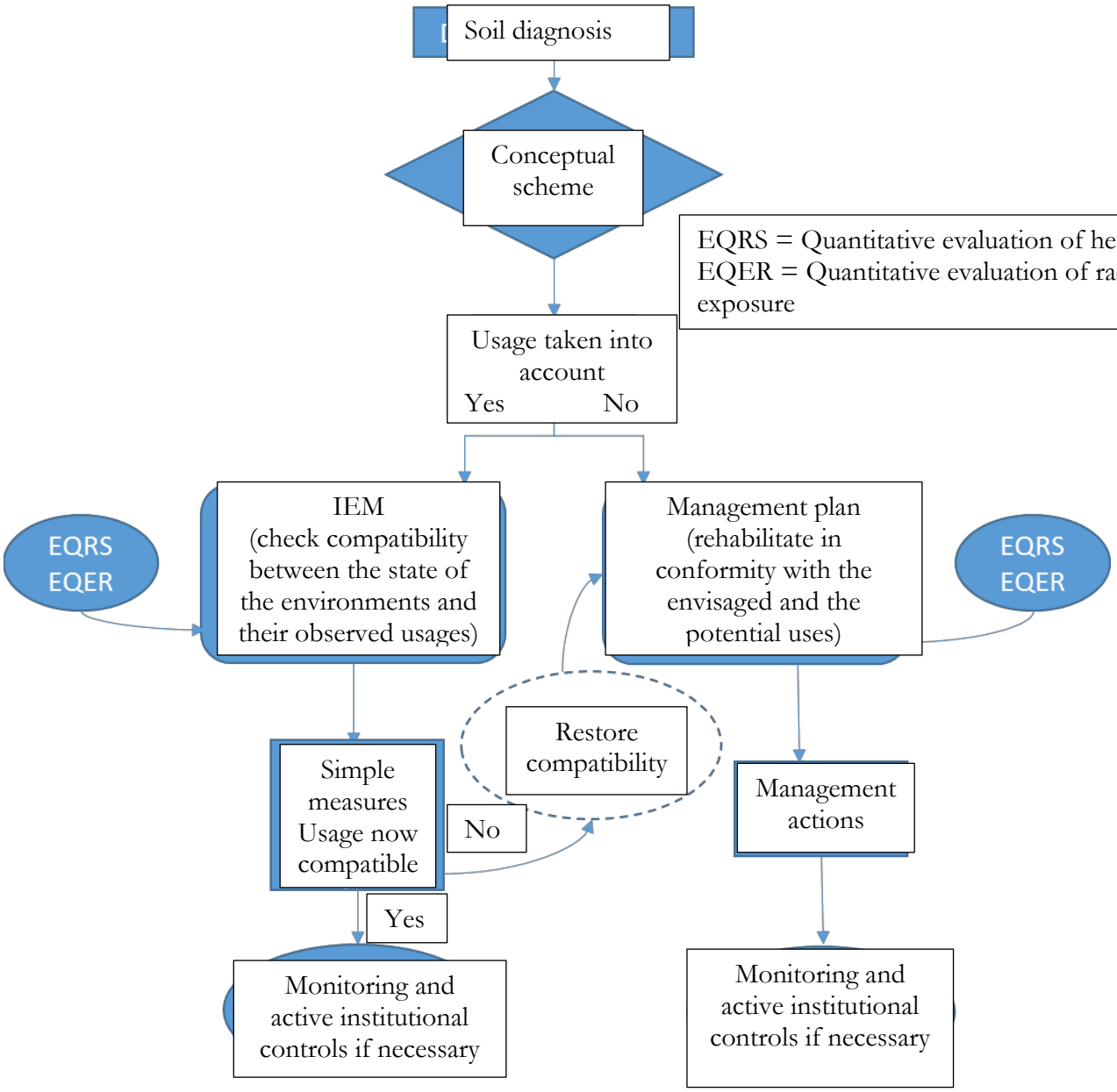
Lastly, the regulatory framework governing basic nuclear installations was substantially modified with the entry into application of order [2] and the publication of resolutions [4] and [5].

The aim of this guide is to explain the relationships between these documents for the management of radioactive or chemical contamination associated with the activity of a BNI and to detail the expectations of ASN. This document was made available for consultation by the licensees and stakeholders from 8th February to 8th March 2016 before it was approved.

1.6 Reminder of the management procedure and the methodological aids

This paragraph provides a brief recap of the main methodological aids applied in the general procedure for managing contaminated soils of guide [7] and of ministerial notice [14] to be implemented. The diagram below shows the relationships between these aids.

The breakdown of these aids, taking into account the regulations relative to BNIs and the particularities of BNIs, is detailed below for contamination resulting from BNI activities. **It is nevertheless advisable to supplement this by referring to the notions detailed in guide [7].**



- <u>The diagnosis</u>

The aim of the diagnosis is to characterise the sources, the transfer pathways and the receiving environments in order to develop **conceptual diagrams**. It must therefore from the outset be as exhaustive as possible so that the management of the site as a whole can subsequently be examined.

For information, the diagnosis guide referenced in notice [14] emphasises that the diagnosis must in particular allow:

- the construction of the **conceptual diagram**;
- the risks linked to the state of contamination of the site to be analysed;
- the quantification and characterisation of the volumes of soil to treat in order to prepare and organise the management routes and the remediation worksite (soil sorting, inspections, costs),
- the residual exposure levels to be verified,

This will be mainly be a progressive and iterative process that will underpin the entire management procedure.

The principle of the conceptual diagram is to produce an assessment of the environment or site in question and to detail the relationships between:

- the sources of contamination;
- the various transfer media and their characteristics;
- the stakes to protect: the neighbouring populations, the uses of the environmental media and of the environment,
- the exposure media and the natural resources to protect.

- Environmental condition interpretation (IEM)

This aid is used, possibly after applying simple contamination removal measures, to demonstrate the compatibility of the radiological or chemical condition of the ground with the considered usage. [It makes use of all the knowledge and characterisation measures acquired for the site and the areas affected by it].

- The management plan

This constitutes the procedure to implement when the diagnosis or the IEM reveals an incompatibility between the observed level of contamination and the uses of the affected areas considered in the procedure.

Whether in the context of the IEM or the management plan, and in order to ascertain the compatibility between the radiological and chemical state of the land and its observed, envisaged or potential uses, the user may conduct a quantitative evaluation of radiological exposure (EQER) and/or a quantitative evaluation of health risks (EQRS).

Indeed, if contamination is left *in situ* and leads to exposure, a quantitative evaluation of the risks must be carried out to verify the compatibility between the level of residual contamination and the envisaged uses. In the case of radioactive contamination, a quantitative evaluation of radiological exposure (EQER) is performed. With radionuclides presenting a chemical and radiological risk, the EQER is supplemented or replaced by a quantitative evaluation of health risks (EQRS) defined in the national policy for the management of contaminated sites and soils, issued by the circular of 8th February 2007 [14]. In the case of purely chemical contamination, only the EQRS is carried out.

This quantitative evaluation, whether it concerns radiological exposure or the health risk associated with chemical substances, validates the sufficiency of the planned or completed remediation; it must not under any circumstances be used to determine the scale of the remediation operations.

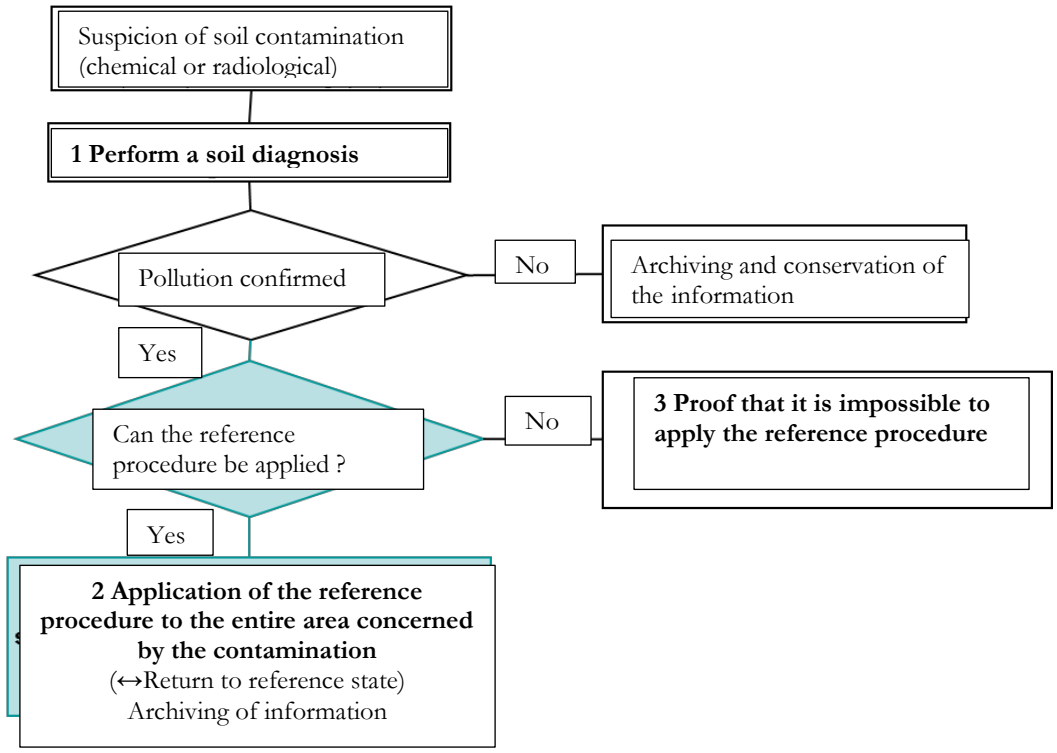
2 SOIL REMEDIATION PROCEDURE

The contaminated soils management procedure involves several methodological aids described in guide [7] of which the general principles are mentioned in § 6 and reiterated below:

- the diagnosis,
- the conceptual diagram,
- the environmental condition interpretation (IEM)
- the quantitative evaluation of radiological exposure (EQER),
- the quantitative evaluation of health risks (EQRS),
- the management plan.

The breakdown of these aids is detailed below for the case of contamination resulting from BNI activities. **It is nevertheless advisable to supplement this by referring to the notions detailed in guide [7].**

The management procedure recommended by ASN is broken down as shown in the following logic diagram where each numbered step is detailed in the sections that follow. Before a licensee engages the key stages of the soil management procedure it must inform ASN and, when necessary, receive its validation, consent or approval (see §4).



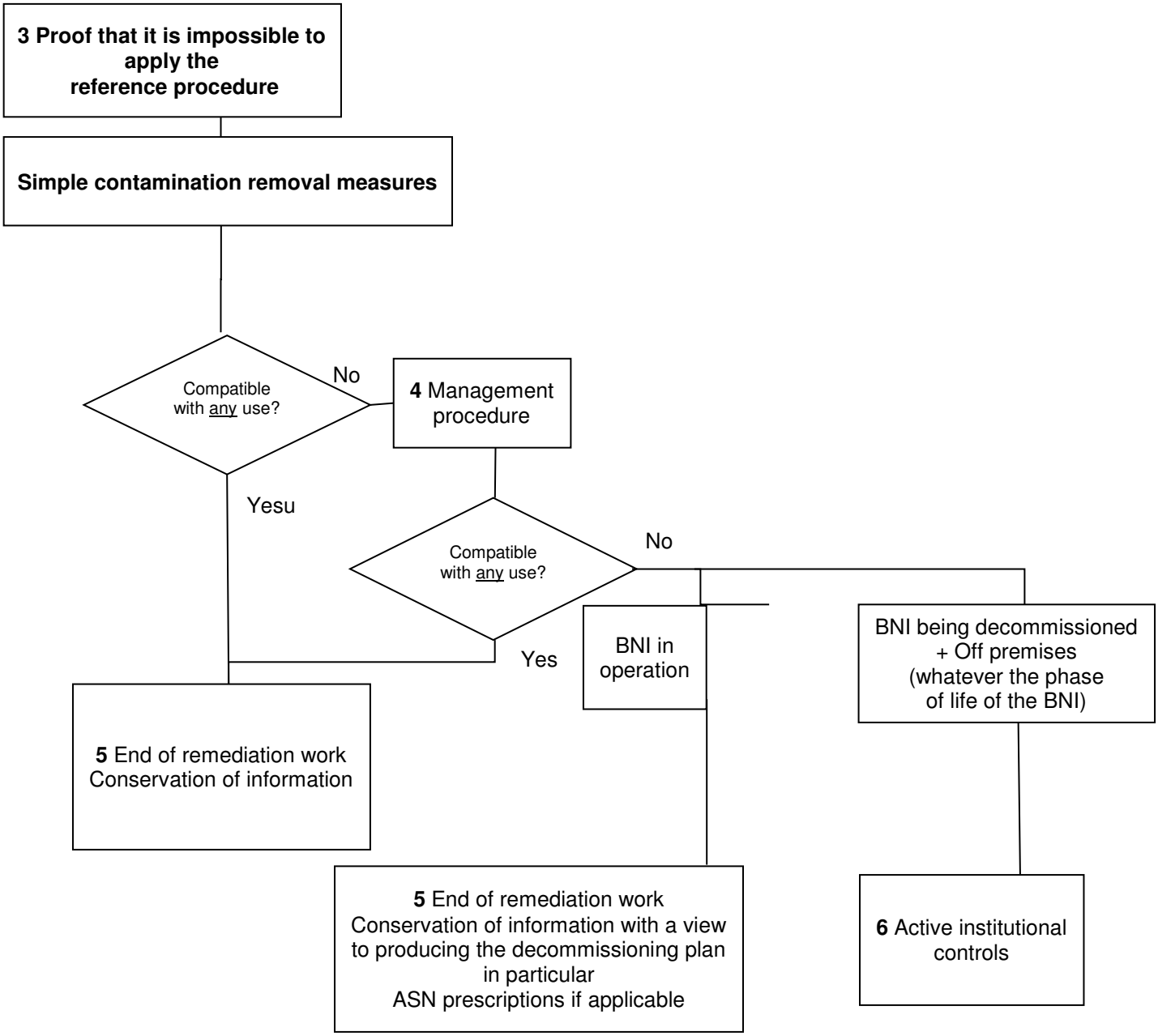


Figure 3: Logic diagram illustrating the steps in the soil management procedure in a BNI

2.1 Diagnosis and conceptual diagram (step 1)

As soon as contamination is suspected, the licensee carries out a diagnosis. The diagnosis aims at establishing, confirming or ruling out the existence of contamination and, if applicable, characterising the nature and extent (surface area and depth) of the contamination in detail. The objective of the diagnosis is to produce an assessment of the situation that will be used to produce a conceptual diagram which will underpin the entire management procedure.

The areas examined and the substances looked for in the investigation must not be too restricted, as this could result in shortcomings in the situation analysis, leading to inappropriate decisions. The investigation must seek all the substances and degradation or reaction products from these substances which can be measured given the best techniques available.

The diagnosis is based on a desk study and field investigations.

Desk study

This is based on a historical study and a vulnerability study, supplemented by a site visit. These studies serve to prepare the field diagnosis work with a view to obtaining the fullest possible characterisation of the contamination sources the investigations seek to identify.

- "Historical" study

This study if essential to acquire a clear understanding of the past and current activities of the installation. The useful information is that which can provide indications on the nature and scale of the contamination. To conduct this study optimally, the licensee can use, for example:

- the information relative to the activities practised and the processes used in the installation. This covers more specifically the manufacturing processes, the unit operating schemes, the "material" balances, the history of waste production and management, the list of pollutants present in the waste and the effluents produced by the activities exercised on the site. The licensee will be able to use the available plans of the installation,
- interviews with employees and outside contractors, whether current or former, having worked in the installation for several years,
- the reports of notified significant events, incidents or deviations recorded or mentioned in the reports provided for in article 4.4.2 of order [2] which might have led to the uncontrolled release of pollutants into the environment or the weakening of a containment barrier which might have led to chronic contamination,
- a visit of the installations to supplement the information gathered during the desk study and prepare the field investigations,
- operating experience feedback from other similar installations.

- Vulnerability study

This study consists in defining, in relation with the physical-chemical characteristics of the pollutants, the factors that could favour or slow down their transfer to the various environmental media. It also aims at identifying the presence of sensitive receiving environments in the vicinity of the installation (for example: groundwater used for the drinking water supply or for agricultural purposes, presence of dwellings or other sensitive uses, etc.). The licensee may, if necessary, use its impact study to identify the transfer pathways to consider.
If remediation is not immediate, this study is necessary in order to estimate the potential migration of pollutants. The licensee may, if necessary, use this study to propose measures to implement between discovery of the contamination and carrying out the remediation work (example: lowering of the groundwater, etc.), provided this does not delay the remediation.

Field investigations

These investigations are carried out after the desk study and aim at confirming or ruling out the existence of contamination in the previously identified areas.

The licensee defines a sampling plan (areas and substances) and an analyses programme in order to verify the hypotheses resulting from the desk study, applying the best techniques available.

- Visit of the site (initial investigations)

The desk study serves to establish an inventory of the potential types of contamination and guide the choice of measuring devices to use for the field investigations accordingly. When looking for substances, radioactive or not, the licensee shall take care to select measuring devices according to the types of radiation looked for, the energy range to measure and the required precision of measurement. The equipment used is subject to maintenance, periodic verification and calibration, and is operated by persons qualified in the measurement of such substances.

- Additional investigations

Additional investigations (with core drilling, for example) are generally required in order to characterise the areas precisely or to acquire knowledge of the development of certain parameters over time. They may be necessary for characterisation at depth or to widen the contamination search. A sampling and analysis strategy is then established in order to obtain sufficiently reliable information about the contamination.

At the end of these investigations, for radioactive contamination, a typical spectrum must be established. A typical spectrum lists the radionuclides that are or could be present, and associates each radionuclide with a presence ratio with respect to one or more easily measured tracer radionuclide(s) (for example: ^{60}Co, ^{137}Cs; etc.). The typical spectrum must be conservative and established such that it does not underestimate either the share of the radionuclides that are not measured directly or the activity of the radionuclides that have the highest toxicity, while at the same time ensuring that the exposure estimations made on the basis of this spectrum remain realistic.

The advantage of typical spectra is that they allow the radiological inventory of the source of contamination to be estimated from the measurement of one or a few tracer elements which can be quantified using appropriate technical means and detection limits. The typical spectrum must allow the conservative and representative nature of the source of contamination to be guaranteed.

On completion of this first step, a conceptual diagram is produced and will be used by the licensee to examine the possibility of implementing the reference procedure consisting in the complete removal of the contamination, whether it is radiological or chemical.

- Conceptual diagram

The conceptual diagram, produced on the basis of the information gathered from the diagnosis, aims at presenting the qualitative and quantitative data relative to:

- the types of contamination,
- the transfer pathways and the various environmental media affected,
- the uses of the environmental media and protection of the resources and natural spaces (persons and environmental media).

Examining all these factors as a whole leads to an understanding and precise characterisation of the impacts and risks associated with the studied situation and is presented as a diagram.

The following table provides some examples of elements necessary for the production of a conceptual diagram.

Aim of the step	Source of information
What? Identification of types of contamination Know the pollutants and their properties, including their mobility	Operating experience feedback (OEF), historical and desk studies, available measurement results, waste tracking, *in situ* monitoring of the environmental media
Where? Identification of the exposure media Only consider the media that are relevant for exposures	Impact study, vulnerability study, OEF, historical and desk studies, available measurement results (soil, surface waters, groundwater, air)
How? Identification of the transfer pathways Mapping of the transfers with arrows materialising the potential movement or accumulation of the contaminants in the environmental media	Vulnerability study, knowledge of the substances and their properties, environmental monitoring system (piezometers, taking samples from the environment)
Why? Identification of the receiving media and the uses of the various exposure environmental media	Impact study, vulnerability study, knowledge of the substances and their properties, environmental monitoring system

When producing the conceptual diagram, the licensee shall consider all the established uses and the envisaged or potential uses, and give reasons for excluding those it has rejected. If the modelling is supplemented by measurements, the licensee shall specify their respective limits, particularly in terms of representativeness and uncertainties.

2.2 Implementation of the reference procedure: complete removal of the contamination (step 2)

The reference procedure recommended by ASN in its doctrine [6] is "*when it is technically possible, completely clean out radiologically contaminated sites, even if the human exposure induced by the radioactive contamination seems limited.* The same procedure shall be applied in the case of chemical contamination.

The removal of radiological or chemical contamination is considered to be complete when the final state obtained at the end of the treatment corresponds to the reference state.

The licensee may use the information contained in its initial impact study (updated in application of article 3.3.3.6 of resolution [4] if necessary) to provide a reference state. For existing installations which do not have this information, the final state will be compared with a control environment, that is to say the local geochemical background in terms of radionuclide spectrum and substances present on a terrain with geological characteristics analogous to those of the studied area.

ASN considers that the implementation of this procedure must be envisaged in all cases and that any other strategy (see § 2.3) must be justified with respect to the reference procedure (technical constraints calling into question the mechanical strength of a building, large volume of excavated soils, predicted high dosimetry for the personnel during the work) when producing an environmental condition interpretation (IEM) or a management plan.

2.3 Procedure to follow if it is impossible to apply the reference procedure (steps 3 and 4)

2.3.1 Breakdown of the management procedure

If it is impossible to apply the reference procedure, the licensee shall apply the procedure detailed in §2. For information, the main methodological aids of the general contaminated soils management procedure of guide [7] to be implemented after completing the diagnosis are listed in §1, along with their purpose.

Initially, the licensee must envisage undertaking simple soil removal measures in order to reduce the contamination. On completion of these measures, the licensee assesses the compatibility of the condition of the ground by carrying out an environmental condition interpretation (IEM). The licensee shall study, in addition to the established use, several scenarios including that envisaged in the short term for the reuse of the land as well as scenarios for sensitive uses which could be implemented on the land in question.

In this respect, the licensee could find it useful to refer to the typical scenarios of guide [7] drawn up for established uses. The guide proposes 11 typical scenarios corresponding to predetermined modes of exposure which can be adapted to the particularities of the land on which the BNIs are located:

- incursion onto derelict land,
- work site,
- building for professional use,
- private building,
- car park,
- market gardening,
- business activity,
- residence,
- school,
- sports centre,
- leisure centre.

Other scenarios must nevertheless be added to the above.

If on completion of this step of simple contamination removal measures the site has not been rendered compatible with all uses, the licensee must produce a management plan. In this context, the licensee shall give clear reasons for excluding the scenarios it does not adopt in its management plan.

ASN draws attention to the fact that if the IEM should reveal an incompatibility between the state of the ground and the **established use**, immediate measures are to be envisaged (see § 2.3.3.1).

The conditions of implementation of the management by excavation option are detailed in § 3.

2.3.2 General principles for achieving compatibility with all uses

In situations where, due to the characteristics of the contamination and of the facility, it would be difficult to implement the reference procedure, the licensee must go as far as is reasonably possible with the remediation operations. The licensee undertakes a management procedure in which the primary objective is to render the condition of the soils compatible with any use (established, envisaged and potential use). This procedure is hereinafter designated "tightened remediation".

In situations where soil contamination that is incompatible with certain uses subsists, the licensee shall demonstrate that the remediation procedure has been taken as far as is reasonably

possible under acceptable technical and economic conditions (reminder: any procedure that consists in calculating the remediation objective from an impact value is to be prohibited).

This procedure is detailed in the following sections. Solutions that consist in maintaining contamination beneath constructions, particular for installations undergoing decommissioning, and in managing the impacts by constructive measures are in principle to be prohibited.

With installations in service, should it finally be impossible to render the state of the soil compatible with any use, and given that the presence of an activity on the site can create technical constraints (which must be substantiated) preventing execution of the work that would be necessary for tightened remediation, the licensee shall:

- Propose management measures with the aim of:
  - controlling the sources or, failing this, the impacts (actions on the uses and transfer pathways) in order to guarantee that the impact on workers, the public and the environment **for the established use** is as low as possible and detail this in a residual risks analysis comprising an EQER and/or an EQRS;
  - guarantee the possibility, during decommissioning of the installation, of applying the reference procedure or, if applicable, the tightened remediation strategy;
- Conserve the information relating to the diagnoses, especially the memory of the types of contamination, and the actions taken in view of decommissioning the installation;

In accordance more specifically with article 8.3.2 of the order [2], the licensee shall also provide proof that it has implemented the best remediation methods and techniques available under economically acceptable conditions.

2.3.3 The established, envisaged and potential uses are not compatible with the state of the soil: implementation of a management procedure (step 4)

2.3.3.1 Immediate actions to take if the soil is incompatibles with the established use

For contaminated areas situated **on the premises**, whatever the life phase of the BNI, if the conclusions of the IEM indicate that the associated impacts could call into question the established use, the licensee shall take the necessary measures without delay to ensure the **safety** of the personnel, the public and the environment.

These measures may be materialised by markings, restricting or prohibiting the access of personnel to these areas, and if necessary, putting in place an impermeable cover to reduce exposure.

With regard to contamination situated **off the premises**, if the established use presents a risk of exposure[4] of the neighbouring populations, the licensee shall inform the competent authorities without delay and propose measures to ensure the safety of the impacted populations.

In all cases a management plan shall then be drawn up with a view to carrying out the remediation work necessary to restore compatibility of the state of the soil with the established use or any use, depending on the situation in question.

2.3.3.2 The management plan

As indicated earlier and in the methodological guide [7], the management plan constitutes the procedure to undertake when the level of contamination is not compatible with the uses observed in the IEM, or

[4] This results more specifically in the exceeding of the maximum exposure limit for the public set at 1 mSv/year by the Public Health Code

with the envisaged and potential uses in the case of redevelopment of the site. It proposes management options which aim to restore compatibility between the state of the environmental media and the uses.

It is drawn up on the basis of a **cost-benefit analysis** and, depending on the situation, in consultation with all the actors concerned.

To achieve this it is necessary to estimate the environmental, societal and financial implications for each of the envisaged management options on the basis of a technical-economic study. This study is carried out under the responsibility of the licensee and must present:

- the production and removal of the waste,
- the long-term durability/robustness of the studied solution,
- a quantitative evaluation of radiological exposure (EQER) and, if necessary, a quantitative evaluation of the health risks (EQRS), during and on completion of the soil remediation work
- the adverse effects created during the work (environmental impact, noise pollution, etc.),
- the feasibility of the studied solution,
- the induced costs.

This study must enable a cost-benefit balance to be drawn up for the various remediation options envisaged, favouring the management options which aim at controlling the sources. On the basis of this cost-benefit balance, a **management proposal report** is drawn up indicating all the arguments, particularly technical and economic, that led to the choice of the selected option and, if applicable, to the abandoning of solutions controlling the sources in favour of solutions controlling the impacts. It must also indicate the remediation objectives and the way in which achieving them shall be verified.

As indicated in § 2.2, the cost-benefit balance must justify the chosen option with respect to the reference procedure.

2.4 End of the soil remediation operations (step 5)

2.4.1 The state of the soil is compatible with any use

The licensee demonstrates compatibility through an IEM.

2.4.2 The state of the soil has been rendered compatible with any use

The methods of validating achievement of the remediation objectives are detailed in § 4.3.

When the licensee has conducted a remediation procedure and the work has achieved the objectives set out in the management plan providing for the soils to be made compatible with any use, the soil remediation and management procedure can then be considered completed.
The licensee uses a residual risks analysis to demonstrate achievement of this compatibility.

The licensee keeps all the documents relating to the remediation operations. The same principles apply if the licensee has been able to remove all the contamination by applying the reference procedure.

2.4.3 The state of the soil is/has been rendered compatible at least with the established use (BNI in operation)

In the case of a BNI in operation, if contamination subsists, the licensee will subsequently - in the decommissioning phase - have to conduct more thorough (tightened) remediation of the soils. The licensee demonstrates that this tightened remediation can only be carried out during installation decommissioning. The licensee takes the projected date of final remediation into consideration in the demonstration.

In the interim, the licensee implements the following management measures:

- it optimises the exposure of persons who could be exposed by taking simple exposure-reduction measures consisting in covering the area where pollution is detected with a view to preventing contaminated particles going back into suspension or lowering the level of exposure to radiation by putting in place a radiological protection;
- it takes the necessary measures to ensure and demonstrate that there is no migration of the contamination and, if necessary, takes action to prevent this phenomenon;
- it ensures that the information on the areas where contamination subsists is conserved, notably by updating the waste zoning in the case of radioactive contamination. It sets up and implements appropriate monitoring of these areas. If necessary, the monitoring measures can supplement the environmental monitoring plan of the installation. The duration of implementation of these measures shall be subject to justification.

In the same way as above, the licensee shall demonstrate through a residual risk analysis that the management measures implemented enable the objectives detailed above to be achieved.

If remediation work has been carried out, all the related documents are conserved until the remediation operations are resumed on entry into the decommissioning phase.
The methods of validating achievement of the remediation objectives are detailed in § 4.3.

During operation of the installation, any new construction that could render access to the contaminated soils difficult or compromise their subsequent treatment must in principle be ruled out.

2.4.4 The remediation work does not render the soil compatible with the considered use(s) (step 6)

If the contamination is left in place and is not compatible with any use, management measures are instituted (confinement, monitoring, restrictions on use). These measures are detailed in § 4.4.

Pending implementation of these measures, the licensee shall take the necessary measures to prevent any migration of the contamination and to conserve the information and any documents relating to the impacted areas.

3 Methodology of soil remediation by excavation

This chapter details the method of soil remediation by excavation in the case of radioactive contamination. In the case of non-radioactive contamination, ASN recommends the licensee to transpose the concepts of ZppDN/ZDC (potential nuclear waste production zone/conventional waste zone) and then draw up a soil removal plan taking into account the various national recommendations [14], applying the method described below which is adapted to the particularities of these types of contamination. In accordance with the provisions of III of article 3.3.7 of resolution [4], the licensee submits the planned management methods to ASN for approval.

In accordance with article L. 541-4-1 of the Environment Code [1], the non-excavated soils are not considered to be waste. Nevertheless, if the licensee engages in a management by excavation procedure, and in accordance with the provisions of order [2] and resolution [5], the area affected by radioactive contamination and to be excavated is reclassified as a ZppDN, subject to the adaptations mentioned at the end of this secction, if it was not already reclassified, including if the area is outside the site. If the contamination is situated at least partially outside the licensee's premises and within other premises which are not a BNI (*see figure n° 2*), the licensee of the BNI causing the contamination liaises with the licensee of these other premises. The licensee informs ASN and the authority responsible for oversight of that establishment.

The remediation work for radiological contamination is undertaken with the aim of definitively declassifying the area with respect to waste zoning. In accordance with chapter 3.6 of resolution [5], the licensee establishes an appropriate remediation methodology which is submitted to ASN for approval (see §4). Moreover, in accordance with the provisions of III of article 3.3.7 of resolution [4], these management measures are submitted to ASN for approval (see §4).

The following section provides recommendations concerning the treatment of contamination by excavation. They have been established consistently with the principles developed in [11] with application of the principles of independent and successive lines of defence of the waste zoning. Thus, any remediation operation by excavation, no matter how complex, must be based on the development of zoning that takes into account the presence of radioactive contamination in the soils, constituting an *"area to excavate"*. Comparison with the reference state enables the areas to excavate to be determined.

In the case of very extensive contamination, soil remediation by excavation can prove difficult due to the quantities of earth that can be involved (in surface area or in depth). The favoured approach remains remediation that is a thorough as possible while at the same time reducing to the minimum the volumes of earth to excavate.

Application of the "waste zoning" concept to soils

Application of waste zoning to soils contaminated by radioactive substances with a view to their excavation is imposed by order [2] and resolution [5]. Nevertheless, given the particularity of soils with respect to buildings[5], the licensee must apply appropriate measures. The licensee presents the conditions it adopts for this situation in the general operating rules (article 2.4.1 of the appendix to resolution [5]) and in the remediation methodology.

[5] Example: difficulties in performing certain radiological checks required by article 3.5.1 of the appendix to resolution [5] before carrying out the remediation, or the impossibility to deploy physical barriers.

3.1 1st line of defence

3.1.1 Definition of "areas to excavate"

By analogy with guide [11], the first line of defence is similar to performing the diagnosis as detailed in § 2.1, based on a desk study and field investigations.

The soil diagnosis must allow the state of the soil within the study perimeter to be established and the contamination, if any, to be characterised in 3 dimensions (3D), with a view to determining conservatively the depth of excavation corresponding to the ZppDN.

The 3D definition of the volume of soils to excavate must display a flat-rate precautionary margin to integrate the uncertainties due to the representation and the estimation of the phenomena of migration and diffusion in the soils. Any reduction or even elimination of this margin will require justification.

Furthermore, particular attention must be paid to ensuring that the definition of "zones to excavate" is adapted to the heterogeneity of the pollutants present over the studied perimeter. Thus the delimiting of a contaminated area must be based on the same characteristics (utilisation of the same typical spectrum, same type of work to implement) at any point in the area. The excavation surface areas and depths are established:

- on the basis of the comparison with the reference state when a complete remediation procedure is applied,
- on the basis of a cost-benefit balance figuring in the management plan (see § 2.3.3) when a tightened remediation procedure is applied.

The areas to excavate must be clearly indicated by means placed as close as possible to the work sites.
The methods of managing the earth excavated from these areas are defined in §3.4.

3.1.2 The remediation objective

With regard to radiological contamination, on the basis of the known typical spectrum, the licensee proposes a remediation objective which can be expressed in total activity per unit volume, weight or mass expressed in dry matter. With regard to chemical contamination, the licensee proposes a remediation objective for each substance, expressed, for example, in mass concentration in dry matter.
The set objective must correspond to tightened remediation aiming to render the area compatible with any use. **This objective must be broken down into operational criteria so that it can be easily measured and verified on completion of the remediation operations.**

The diagram below shows the two types of remediation objectives that can be proposed and the correspondence with application of waste zoning in the case of simple contamination which decreases with depth.

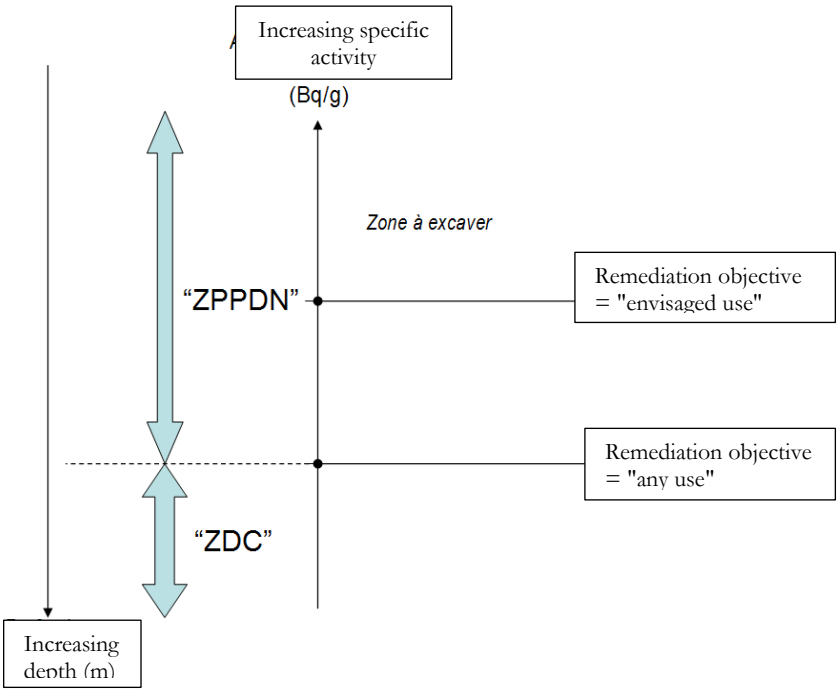


Figure 4: Correspondence between the waste zoning applied to the soil and the remediation objectives

3.2 2nd line of defence

The verification programme is carried out on the soils left in place with a view to ascertaining compliance with the previously defined remediation objective.

The radiological and chemical inspection programme must comprise:
- the method of defining the points to check,
- the type of verifications to perform,
- the period in which these verifications must be performed,
- the measurement methods and techniques (surface activity measurement, specific activity measurement indicating the depth of integration and, if applicable, of sampling). When the measurements cover large integration surface areas, the uniformity of the residual contamination must be verified in order check there are no atypical points,
- the detection limits of the measuring devices, the uncertainties associated with the measurements, and the verification criteria defined by the licensee before carrying out the operations, enabling it to consider that the remediation objectives have been achieved.

To verify achievement of the remediation objectives, choosing radionuclides and physical-chemical parameters that are adapted to the measuring methods should enable readily-usable verification criteria to be obtained to validate the final inspections. The choice of these criteria shall be justified by supporting arguments with respect to the radioactive or chemical pollutants concerned.

3.3 3rd line of defence

In the case of radiological contamination, the 3rd line of defence consists in the radiological monitoring of conventional waste at the site exit using measuring means appropriate for the radionuclides likely to be present in accordance with article 3.4 of the appendix of resolution [5].

3.4 Management of the excavated soils

3.4.1 Status of the excavated soils and methods of management

Two cases must be considered depending on the nature of the contamination.

The first concerns soils contaminated by **chemical substances**. These soils constitute "waste" in the meaning of the Environment Code from the moment the holder discards them or has the intention or obligation to discard them. However, article L. 541-4-3 of the environment code provides a procedure for waste having undergone recovery measures to lose its waste status under certain conditions. The soils from remediated areas must be managed in accordance with the provisions of article L. 541-4-1 et seq. of the Environment Code. In the case of recovery of excavated soils contaminated by chemical substances only, guide [13] sets a methodological framework that the licensee can use as a basis for the management of these soils.

The second case concerns soils contaminated by **radioactive substances. These soils coming from a ZppDN must be managed as radioactive waste in accordance with the provisions of I of article 3.1.3 of the appendix to resolution [5][6].** This waste must be directed to dedicated management routes and figure in the installation's annual waste management report provided for by article 6.6 of the order [2]. Soils contaminated by radioactive and chemical substances must be considered as radioactive waste and managed accordingly in the dedicated management routes.

3.4.2 Storage of excavated soils within the perimeter of the BNI

The soils from the "*areas to excavate*", which will not be able to be sent directly to the appropriate routes, can be stored in dedicated facilities or areas of the BNI. The creation of a storage facility or area within the BNI is carried out in accordance with the provisions of the environmental code [1] and in compliance with the provisions of article 4.3.1 of order [2].

The licensee shall implement the necessary technical measures to prevent or sufficiently mitigate the risks or adverse effects the installation presents for the protected interests mentioned in article L. 593-1 of the Environment Code [1] and in particular to prevent migration of the contamination and its leaching in wet weather (storage on an impervious area, protection with waterproof tarpaulins, etc.). These provisions aim more specifically at guaranteeing a level of exposure of workers and the public that is as low as reasonably achievable and preventing any migration of the contamination into the environment. In this respect the licensee shall define the periodic checks to guarantee the integrity of its storage area.

In addition, a radioactive waste storage facility shall comply with the provisions of chapter 4 of title 8 of order [2].

Exceptionally and provided it is justified, the creation of storage areas for these soils in the form of embankments may be envisaged, constituting radioactive waste storage areas that meet the above-mentioned objectives. As such, and in accordance with the provisions of IV of article 8.4.2 of the order [2], these storage areas must be designed and operated such that the waste can be recovered at any time and at the latest during decommissioning.

Subject to the necessary justifications, the on-site disposal of soils from excavated areas contaminated by radioactive substances can be envisaged.

[6] II of the same article stipulates that if the licensee demonstrates that this waste *"could not in any way and at any time be contaminated and activated"* and that ASN approves this demonstration, this waste can be managed as non-radioactive waste. §3.4 of guide [11] presents these methods.

4 ADMINISTRATIVE PROCEDURES

This section addresses the administrative procedures to implement when the licensee engages in a contaminated soils management procedure.

Engaging the key steps of the soil remediation procedure must be discussed with ASN.

It must firstly be pointed out that the moment accidental contamination of soils by radioactive or chemical substances is detected, even if this contamination is not likely to induce a significant health impact, ASN shall be informed without delay, in accordance with article 4.4.1 of order [2]. Furthermore, informing ASN is required under the provisions of articles 4.4.2 and 4.4.4 of order [2] and article 3.3.2 of resolution [4].

4.1 Steps before starting remediation work

4.1.1 Concerning the diagnosis

The licensee informs ASN when it starts investigation work. It reports in particular on the contamination detected outside its premises.

If an IEM is carried out, ASN is informed of its conclusions and of any simple management measures implemented. The latter may, if applicable, be subject to ASN approval.

4.1.2 Concerning work preparation

In the case of radiological contamination and in accordance with the provisions of section 3.6 of resolution [5] and the provisions of article 3.3.7 of resolution [4], the licensee transmits the remediation methodology it envisages applying to ASN for approval. In the case of chemical contamination the provisions of section 3.6 of resolution [5] are not applicable; only the provisions of article 3.3.7 of resolution [4] are applicable. **Consequently, whatever the nature of the contamination, the engagement of remediation work is subject to ASN approval.**

ASN recommends that the licensee submits the file at least 12 months before the envisaged date of start of work.

This file comprises in particular:
- the diagnosis containing the desk study, the results of the investigations and the resulting conceptual diagram,
- the strategy adopted with, if applicable, the management proposal report containing more specifically the cost-benefit balance, the option envisaged for treating the contamination found, and the assigned remediation objectives in radiological and/or chemical terms,
- a projected work schedule.

In its consent on the remediation methodology or when it approves the work, ASN can stipulate specific conditions for providing information and minimum time frames before/after starting the remediation work or irreversible redevelopment operations. These minimum time frames take into account the conditions of safety of the excavation work site.

If the licensee wishes to implement a remediation methodology which is applicable to the contamination in question and has already been approved by ASN, it has simply to inform ASN of this.

4.2 During the remediation work

Within the scope of its remit concerning the oversight of BNIs[7], ASN may have to take action to verify the conformity of the operations with the chosen strategy.

When excavation work is carried out, the areas to excavate are clearly signalled on the surface and are marked out, as provided for by resolution [5] for radioactive contamination on account of the ZppDN classification. The licensee puts in place the health and safety measures.

The management provisions for the excavated soils, including their storage within the perimeter of the installation, are presented in § 3.4.

4.3 After the remediation work

On completion of the remediation work, the licensee provides a review of the operations presenting a summary of how the work proceeded, demonstrating that the objectives set out in the management proposal report have been achieved, with explanations for any deviations.

This review must also include information on the lessons learned from the difficulties encountered or the techniques developed during the operations, a dosimetric assessment and an assessment of the waste produced and the associated treatment routes.

If residual contamination subsists, the licensee transmits the following for the areas concerned:

- the technical reasons which make it impossible to achieve the remediation objective,
- the location of the point(s) in the areas concerned,
- an update of the EQER/EQRS in view of the data measured on the actual radiological and chemical state,
- the management methods it proposes implementing.

The licensee keeps the remediated areas duly secure, safe and accessible.

Within the scope of its remit concerning the oversight of BNIs[8], ASN may have to have measurements taken by a third-party organisation at the licensee's expense to ascertain that the remediation objectives have been achieved.

The definitive declassification of the area with respect to waste zoning is ruled further to achieving a remediation objective that allows the land to be reused for any use. The conditions of declassification are defined in resolution [5] and guide [11]. Otherwise, particular management conditions may be defined in the active institutional controls (§4.4).

All the documents relative to the remediation operations are archived.

[7] Article L. 596-1 of the Environment Code [1]
[8] Article L. 596-1 of the Environment Code [1]

4.4 Implementation of particular management measures after the remediation work

Depending on the achieved state, different management measures can be applied on the initiative of the licensee or ASN.

	BNI being decommissioned	BNI in operation
In cases where the work performed removes all the sources of contamination and restores the site to a state compatible with <u>any use</u>	The result of the remediation work supports the delicensing application file, in particular the elements required by the provisions of articles L. 214-6 and L. 513-1 of the environmental code [1]. In accordance with § 8.3 of guide [11], **no active institutional control is required when delicensing takes place.**	The review of the work sites shall be conserved for use in the installation decommissioning plan and to support the decommissioning file.
<u>If contamination is left in place</u> (exclusions from certain reuse scenarios, containment measures for the remaining contamination, etc.)	The result of the remediation work supports the delicensing application file, in particular the elements required by the provisions of articles L. 214-6 and L. 513-1 of the environmental code [1]. The licensee details the measures to implement and their duration (lasting or temporary). The provisions of article L. 593-5 of the Environment Code **allowing the introduction of active institutional controls on or around the land on which the BNIs are situated**. The procedure for introducing active institutional controls is specified in articles 50 to 52 of decree [2].	The information relative to the contaminated areas must be taken into account when **drawing up the installation decommissioning plan and when updating the waste zoning at the time of decommissioning** (see guide [11]). In addition, these documents can provide inputs for the diagnosis (see § 2.1) which will be renewed when the BNI is undergoing decommissioning. ASN may prescribe management measures for the licensee under article 18 of decree [2] pending implementation of final remediation.

4.5 Informing the public and involvement of the stakeholders

With regard to the management of contaminated soils in the BNI or on the premises, the licensee ensures that the local information committee (CLI) for the BNI is informed of this work.

With regard to contamination situated off the premises, the stakeholders and the persons concerned are involved as early as possible in the soil remediation procedure. The licensee may use the recommendations of methodological guide [7] for the identification of and communication with these entities/persons.

5 QUALITY ASSURANCE REQUIREMENTS

ASN considers that remediation operations are activities that impact the protected interests and should be defined by the licensee as activities important for protection (AIP) and form the subject of requirements defined in an appropriate quality assurance programme that is included in the integrated management system. If the licensee subdivides the remediation activity into elementary activities, ASN considers that these activities are also AIPs, unless detailed justifications to the contrary are given in the remediation methodology.

More specifically, if unexpected elements are discovered during the remediation operations, the licensee must review the validity of each step in the applied methodology, especially the hypotheses considered in the remediation methodology.

The system for handling deviations must be formalised within the licensee's integrated management system and the actions to correct deviations must be duly recorded in accordance with the requirements of chapter 6 of title II of order [2].

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No.12 Notification and codification of criteria related to significant safety, radiation protection or environmental events applicable to BNIs and radioactive material transport operations

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