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## **French Soil Quality Monitoring Network Manual RMQS2: second metropolitan campaign 2016–2027**

Claudy Jolivet, Jose-Luis Almeida Falcon, Philippe Berché, Line Boulonne, Marie Fontaine, Laëtitia Gouny, Sébastien Lehmann, Baptiste Maitre, Céline Ratié, Elodie Schellenberger, et al.

► **To cite this version:**

Claudy Jolivet, Jose-Luis Almeida Falcon, Philippe Berché, Line Boulonne, Marie Fontaine, et al.. French Soil Quality Monitoring Network Manual RMQS2: second metropolitan campaign 2016–2027. 2022, 2-7380-1451-8. 10.17180/KC64-NY88 . hal-03823026

**HAL Id: hal-03823026**

**<https://hal.inrae.fr/hal-03823026>**

Submitted on 9 Nov 2022

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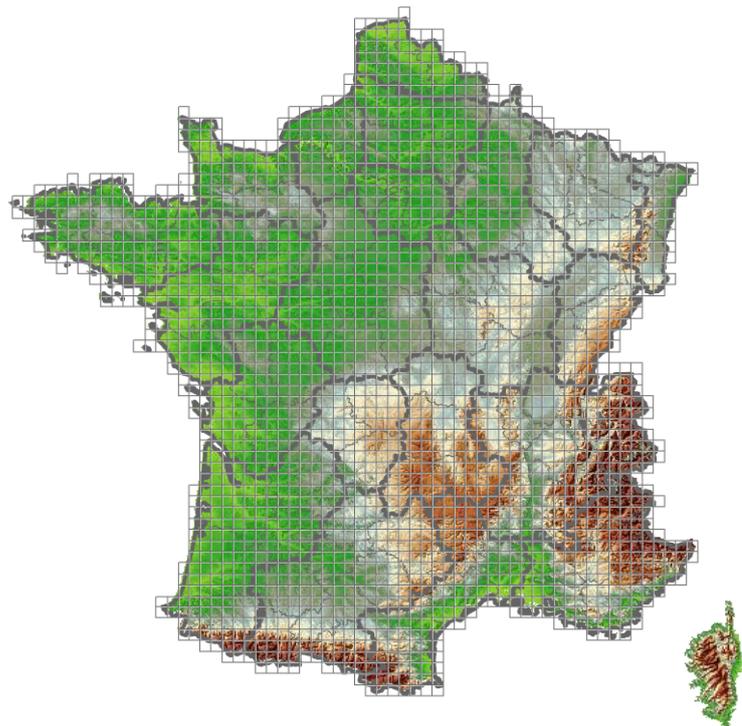


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## French Soil Quality Monitoring Network Manual

RMQS2:  
second metropolitan  
campaign  
2016–2027



# INRAE

US 1106 InfoSol



INRAE US 1106 InfoSol  
Val-de-Loire Research Centre

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**RMQS2:  
second metropolitan campaign  
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Sébastien Lehmann, Baptiste Maître, Céline Ratié,  
Élodie Schellenberger & Nicolas Soler-Dominguez

ISBN: 2-7380-1451-8  
EAN code: 9782738014511

This document is a translation of the French version 3 of the 23<sup>rd</sup> of January, 2018.

Edition: November 2022.

DOI: [10.17180/KC64-NY88](https://doi.org/10.17180/KC64-NY88)

This document was written by:

- Jose-Luis Almeida-Falcon
- Philippe Berché
- Line Boulonne
- Marie Fontaine
- Laëtitia Gouny
- Claudy Jolivet
- Sébastien Lehmann
- Baptiste Maître
- Céline Ratié
- Elodie Schellenberger
- Nicolas Soler-Dominguez

Directors of the publication: Claudy Jolivet and Déborah Chavrit

**Citing reference:**

Jolivet C., Almeida-Falcon J-L., Berché P., Boulonne L., Fontaine M., Gouny L., Lehmann S., Maître B., Ratié C., Schellenberger E. & Soler-Dominguez N., 2022, French Soil Quality Monitoring Network Manual. RMQS2: second metropolitan campaign, 2016–2027, Version 3, INRAE, Orléans, France, <https://doi.org/10.17180/KC64-NY88>.

**For further information, please contact:**

Unité InfoSol

INRAE Centre Val-de-Loire

2163, Avenue de la Pomme de Pin

CS 40001 Ardon

45075 ORLEANS Cedex 2

Telephone: +33 02 38 41 78 00

[infosol@inrae.fr](mailto:infosol@inrae.fr)

This manual can be downloaded from the GIS Sol website and at the link: <https://hal.inrae.fr/hal-03823026>

Throughout the Manual, you will encounter this icon



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# 1. Introduction

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**This manual describes the second campaign for setting up the sites of the soil quality monitoring network in mainland France. It provides principles and instructions for carrying out the various stages of the installation and monitoring of the network sites. As such, it constitutes the specifications that each partner undertakes to respect when signing an agreement with INRAE. Therefore, this manual is primarily intended for the regional partners involved in the installation of the network sites. It will also be useful to all those who wish to obtain information on the objectives, configuration and methods implemented on the sites of the French Soil Quality Monitoring Network.**

## 1.1. The French Soil Quality Monitoring Network: a long-term monitoring tool

Soils are constantly evolving under the effect of major natural factors as well as under the effect of human activities (uses, land development, agricultural practices, sludge spreading, atmospheric deposition, accidental pollution, etc.). These anthropogenic changes are, more often than not detrimental to the maintenance of soil quality. They are the result of long and cumulative processes, which are difficult to detect and may, in some cases, be irreversible on a human timescale. The maintenance of soil quality makes it crucial to detect the appearance and trends of these changes at an early stage. For the past 15 years, the French Soil Quality Monitoring Network (RMQS - Réseau de mesures de la qualité des sols) has been meeting these goals of long-term assessment and monitoring of soil quality in France.

## 1.2. Institutional framework

The RMQS is a programme of the Scientific Interest Group (GIS - Groupement d'intérêt scientifique) Sol. This grouping brings together representatives of the French ministries in charge of agriculture and the environment, the French Agency of the ecological transition (ADEME - l'Agence de la transition écologique), the French National Research Institute for Agriculture, Food and Environment (INRAE - l'Institut national de recherche pour l'agriculture, l'alimentation et l'environnement), the French National Institute for Sustainable Development (IRD - l'Institut de recherche pour le développement) and the French National Institute of Geographic and Forest Information (IGN - l'Institut national de l'information géographique et forestière).

## 1.3. 2,240 sites sampled every 10 to 15 years

The RMQS network is based on the monitoring of 2,240 sites spread evenly over the French territory (2,170 sites in mainland France and 70 sites in the French overseas territories), according to a square grid of 16 km sides (**Figure 1**). Of these 2,240 sites, about 550 are joint with the Systematic Forest Damage Monitoring Network (RSSDF - Réseau systématique de suivi des dommages forestiers, cf. Nicolas et al., 2014)<sup>1</sup>, coordinated by the Forest Health Department (DSF) of the Ministry of Agriculture. These 550 sites will be referred to as RMQS-BioSoil in the remainder of the manual. Soil samples, measurements and observations are taken every 10 to 15 years at the centre of each grid cell. The first sampling campaign in mainland France took place from 2000 to 2009, while the second will take place from 2016 to 2027. The RMQS also covers the

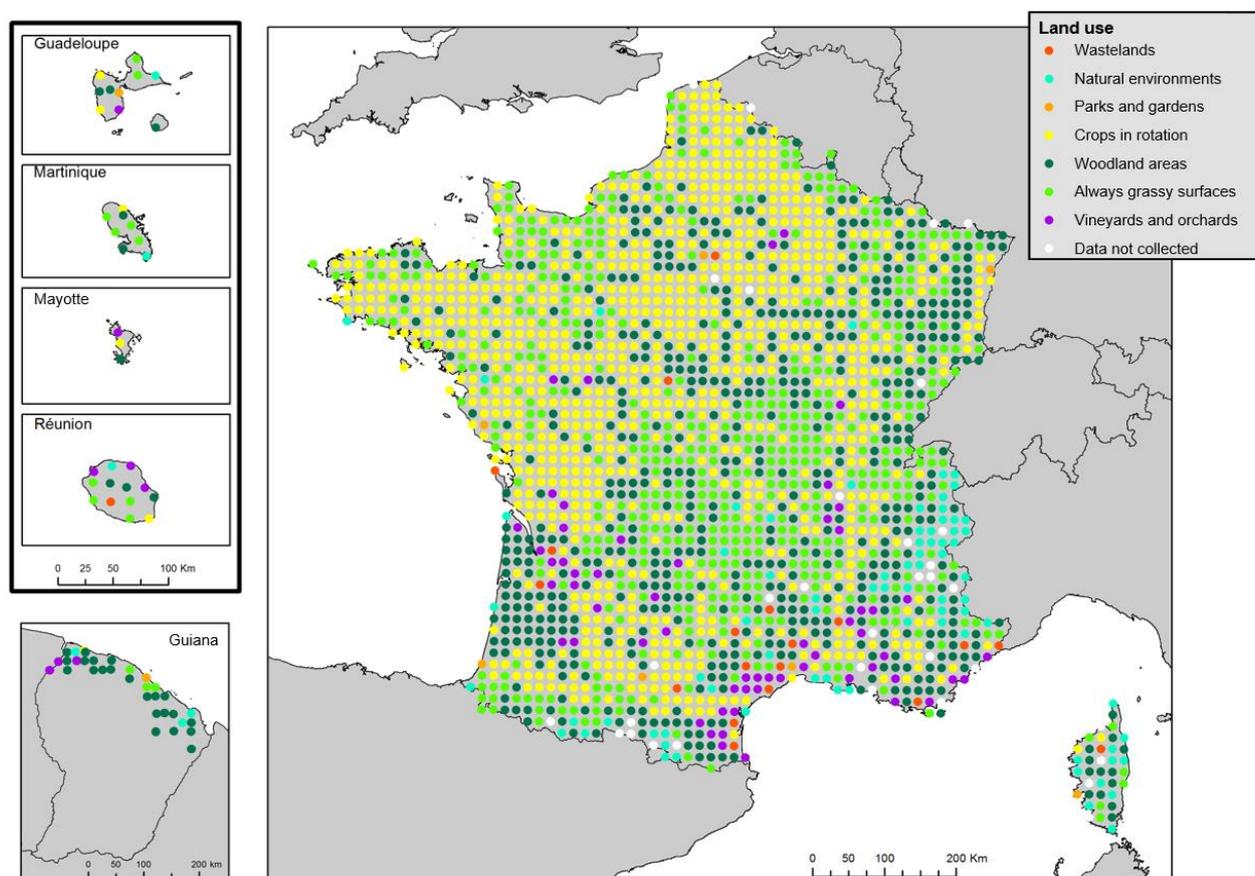
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<sup>1</sup> Manuel NICOLAS et al.; L'apport des dispositifs de suivi vis-à-vis des enjeux de fonctionnement et de gestion des écosystèmes en relation avec les sols; Revue Forestière Française, 2014, Vol.66, N°4, "Ateliers REGEFOR 2013: la gestion de la fertilité des sols forestiers est-elle à un tournant?", pp. 491–500.

overseas departments: after its deployment in 2006–2007 in the Antilles, in 2013 in Reunion and in Mayotte, the implementation of the RMQS continued in French Guiana in 2014 and 2015.

#### 1.4. First RMQS campaign (2000–2009): evaluation of soil contamination

Soil quality assessment and monitoring is based on the analysis of physical, chemical and biological soil properties, combined with the search for sources of diffuse contamination and the knowledge of each site's history of occupation and management practices. The first RMQS campaign (2000–2009) focused on soil contamination and allowed mapping the levels of nine metallic trace elements (MTEs): cadmium, cobalt, chromium, copper, molybdenum, nickel, lead, thallium and zinc. Thanks to the samples stored by the European Conservatory for Soil Samples (CEES - Conservatoire européen des échantillons de sols), the analysis of the samples is currently ongoing through the measurement of other mineral (As, Hg) and organic (polycyclic aromatic hydrocarbons - PAHs, polychlorinated biphenyls - PCBs, pesticides, dioxins and furans) contaminants.



**Figure 1** – The RMQS network in mainland France and overseas.

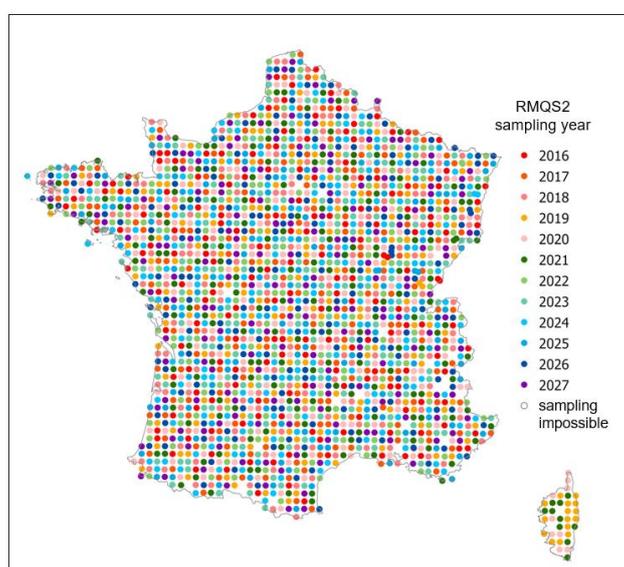
#### 1.5. Second RMQS campaign (2016–2027): Soils, climate change and biodiversity

The data obtained in the first RMQS campaign allowed the accurate reassessment of soil carbon stocks and the mapping of soil microbial richness and diversity. These parameters will be repeated during this new campaign to measure the evolution of soils between the two campaigns. New parameters will also be added to better assess the sensitivity of soils in the context of climate change (useful reserves, particulate organic matter, deep carbon stocks). As well as this, indicators of greenhouse gas emissions from soils and of biodiversity will also be proposed.

### 1.6. An annualised sampling strategy

The second RMQS campaign will be carried out on a regular annual sampling basis over the continental metropolitan territory (2,170 sites). The campaign will last 12 years, from 2016 to 2027. Approximately 8% of the sites (173 to 196) will be sampled each year, according to an *a priori* schedule. For the sampling process, the RMQS cells were grouped into clusters of 12 cells. In each cluster, one cell is drawn at random each year. The draw is carried out 12 times without replacement so as to constitute 12 annual samples. The distribution of the annual samples is shown in **Figure 2**.

Because of its insular nature, Corsica will be sampled over a short campaign, similar to the overseas departments and it will be the subject of a specific partnership agreement.



**Figure 2** – Annual samples of the RMQS2 campaign. The map is an updated version from April 2022.

### 1.7. Organisation of the RMQS2 campaign

Between 2016 and 2027, a new sampling campaign will take place at the 2,170 RMQS sites in mainland France. The GIS Sol has entrusted the INRAE Val de Loire's InfoSol Unit with the responsibility for the national coordination of the RMQS2 programme (definition of sampling strategies, monitoring of site set-up, data and sample management and exploitation of results).

The InfoSol Unit is also in charge of coordinating the network of regional partners that ensure the collection of data and samples on the French mainland territory. InfoSol relies on a network of regional partners to ensure the implementation of the RMQS on the French territory. This network is made up of teams belonging to regional structures, with expertise in soil science and the necessary infrastructures to take charge of setting up the network sites in the field (Chambers of Agriculture, higher education institutions, consulting firms, associations, etc.). These partners will operate within a defined regional perimeter.

The Forest Health Department (DSF - Département de la santé des forêts) of the Ministry of Agriculture will support the InfoSol Unit and regional partners in setting up RMQS-BioSoil sites through its network of correspondent-observers.

### 1.7.1. Role of the regional partner during the RMQS2 campaign

On the regional perimeter concerned:

- the regional partner provides the necessary human and technical resources to set up the RMQS sites;
- the regional partner is responsible for contacting the owners/managers/foresters and farmers of the plot of land where the RMQS sites are or will be located in order to obtain their agreement to conduct the RMQS2 campaign and set the date of intervention, in accordance with the established annual calendar. If the current owners/managers/foresters and farmers do not match the data provided by InfoSol, the regional partner will have to search for the new owner/manager/foresters and farmers of the plot and provide InfoSol with the new contact details. For the RMQS-BioSoil sites, the DFS correspondent-observers are responsible for collecting authorisations from the forest owners or managers and submitting them to the RMQS2 partners.
- if the owner/manager/foresters and farmers of the plot refuses to carry out the second campaign on the plot where the RMQS site was set up during the RMQS1 campaign, or if it is impossible to conduct the soil sampling (e.g., urbanised plot), the regional partner must inform InfoSol, which will decide on the alternative to be adopted (search for a new plot or put the site on hold).
- the regional partner is responsible for setting up the RMQS sites and for collecting data and samples at these sites, according to the protocols defined in this manual and according to an annual sampling schedule established by InfoSol, which must by all means be respected.
- the regional partner is responsible for validating the description of the soil pit profiles from the first campaign, or for re-describing the profile if it does not validate the first description. The entry of the description data of these soil pit profiles into DoneSol is entrusted to the regional partner.
- the regional partner is responsible for regularly sending the collected samples and data to InfoSol.
- the regional partner is responsible for regularly communicating the observations and analysis results to the owners/managers/foresters and farmers of the plots of land where the RMQS sites have been set up during the campaign, as and when they are made available to the regional partner by InfoSol.

### 1.7.2. Role of InfoSol during the RMQS2 campaign

On the regional perimeter concerned:

- InfoSol ensures the overall coordination of the RMQS2 project as well as the annual sampling campaigns.
- InfoSol provides the regional partner with an annual sampling schedule that defines the number, list and type of sites to be sampled each year.
- InfoSol is responsible for informing the sites' owners/managers/foresters and farmers about the RMQS2 programme and its modalities before the beginning of the sampling year.
- InfoSol provides the regional partner with the necessary protocols to carry out the RMQS2 campaign, which are contained in the RMQS2 Manual, and organises the necessary demonstrations and field training for the regional partner to collect data and samples at the RMQS sites.
- InfoSol provides the regional partner with the necessary elements in its possession for the location and relocation of the RMQS sites, a summary of the observations conducted during the first RMQS campaign and specific instructions for each RMQS site.
- InfoSol provides the regional partner with specific equipment within the framework of a separate agreement (GPS equipment and a hardened tablet for entering observations in the field when the

mobile data entry tool is available) and supplies equipment for taking volumetric samples, the bags and containers for taking the samples as well as the boxes for sending the samples.

- InfoSol has put in place a system to monitor the quality of the implementation of the RMQS2 Manual, with regular advisory field visits to about 10% of the sites.
- InfoSol will be able to assist the regional partner's field teams on the most difficult sites (mountain sites requiring the use of pack animals, estimated at 3-4 per year for all mountain ranges);
- InfoSol is responsible for entering the data into DoneSol (except for the data on the description of soil pit profiles, which is entered by the regional partner's soil scientist) and for checking it.
- InfoSol manages and analyses the samples.
- InfoSol provides the regional partner with access to DoneSol so that they can use their data when it is inserted in the database.
- InfoSol will regularly inform the site owners/managers/foresters and farmers of the RMQS programme progress and at the end of the RMQS2 campaign, InfoSol will organise a national presentation of the results to the site owners/managers/foresters and farmers.

### 1.8. Sampling and observations planned during the RMQS2 campaign

The RMQS2 programme consists of a basic list to be applied at each site and of additional observations or samples to be applied at selected sites.

The basic list includes:

- 1) relocating the sampling device according to different modalities and conducting new surveys.
- 2) auger sampling of the sampling surface for composite samples at different depths and up to 1 m if the soil depth allows it.
- 3) observing the soil profile and validating the description made during the first campaign.
- 4) taking volumetric samples from the soil profile to determine the bulk density of the corresponding composite samples.
- 5) taking photographs of the site and profile and observing the site environment.
- 6) collecting data concerning the management of the plot since the first campaign.
- 7) describing the soil profile and the sampling of soil horizons where this was not done during the first campaign or where the RMQS2 soil profile differs from that observed during the first campaign.

The supplement is:

- 8) specific sampling for the determination of physical measures (available water content and rock fragments content) on approximately 25% of the sites.

The operational tables 'a' and 'b' in document INFOSOL\_RMQS2\_M\_24-1\_operational\_tables (in annex) list the operations planned on each RMQS site according to their occupation for the second campaign. The indicative average times for conducting these operations have been estimated so as to assess the labour force required according to the lists and under the constraint of all the operations being carried out in one day.

### 1.9. The intervention report: a major link between regional partners and InfoSol

The intervention report is a synthetic document that gathers the main observations collected by the regional partner during the implementation of a RMQS site. This document contains several sections that must be carefully filled in by the partner in the field:

- General site information.
- Information on the location and GPS survey of the sampling device.
- Characteristics of the sampling device.
- List of samples taken.
- Volumetric sample collection scheme.

There are two versions of this document: one for RMQS sites, with an additional section on tillage; and one for RMQS-BioSoil sites, with a particularly detailed "GPS location and survey" section.

All the information collected on the intervention report is capitalised and used by the staff of the European Conservatory for Soil Samples and by the project team in charge of monitoring the RMQS2 campaign. This information gives us an overview of the site, the conditions under which it was set up and the samples taken.

### 1.10. OGAM nomade: an application for consulting and entering data in the field

InfoSol has been collaborating with IGN for several years to develop a mobile data consultation and entry utility for the field. From a practical point of view, this application will simplify the field work by allowing i) the on-site consultation of RMQS1 data necessary for returning to the site and ii) the direct entry in the field of observations during the RMQS2 campaign. It will also allow a better flow of data transfer between InfoSol and the regional partners involved in the field while reducing manual data entry. This tool is being developed and should be deployed during the second campaign. Some of the information transfer procedures described in this manual will be modified once the tool enters the production phase, but most of the operating procedures will remain the same.

### 1.11. Organisation and use of this manual

This manual is organised into chapters that answer a specific question and correspond to a specific procedure. Supporting documents and blank forms are available in the appendix or by following a download link.

The strict application of these operating procedures is the guarantee that each RMQS site will be set up in an identical manner across the territory. This homogeneity in the application of robust protocols is the strength of RMQS, which makes it a reference network for monitoring French soil quality.

Through this manual, the editorial team has tried to provide the most comprehensive view possible of the situations that may arise in the field. **Nevertheless, unforeseen situations will inevitably arise, which this manual cannot address due to the diversity of soils and their uses. In such cases, the reader is invited to contact InfoSol, which will try to find the most appropriate response to the situation.**

## 2. How to contact the owners/managers/foresters and farmers of RMQS plots?

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**This procedure describes how to contact the owners/managers/foresters and farmers of the RMQS plots, how to prepare the intervention and the authorisations to be obtained before intervening.**

### 2.1 Prior information to owners/managers/foresters and farmers of the RMQS2 campaign

InfoSol will send a letter at the end of year  $n$  to the owners/managers/foresters and farmers of the RMQS sites concerned by an intervention during year  $n+1$ . This letter will inform them that they will be contacted by the regional partner responsible for setting up the RMQS site. It will be accompanied by an extract of the IGN 1/25 000 map locating the plot of land concerned by the RMQS site and a document presenting the RMQS programme, informing them of the detailed content of the programme, the methods of intervention, the analyses and observations carried out, and the data to be returned. This document (see INFOSOL\_RMQS2\_M\_24-8\_Four\_pages\_RMQS2 in the appendix) will also be made available to the partners.

The intervention on the RMQS-BioSoil sites is carried out in coordination with the Forest Health Department of the Ministry of Agriculture, which is responsible for the plots of the RSSDF (see chapter 7). Each year, the Forest Health Department will inform the interregional centres and the correspondent-observers in charge of monitoring the plots about the RMQS2 campaign planned for year  $n$ . Information to owners or managers will be provided by the correspondent-observers.

### 2.2 General data on RMQS sites

InfoSol provides the partner with a table showing the following about each site: its RMQS identification number, the BioSoil number for sites also belonging to the RSSDF, its geographical coordinates in WGS 84, the year of sampling planned for the site, the menu of samples to be taken, the name of the soil and the occupation during the first campaign. The coordinates of the sites are also provided in the form of a GPS receiver update file.

### 2.3 Details of the owners/managers/foresters and farmers of RMQS plots

#### 2.3.1 RMQS sites

InfoSol provides the partner with a table showing the following about each site: the contact details of the owner(s)/manager(s)/forester(s) and farmer(s) according to the data known by InfoSol (at the end of the first campaign).

The partner is responsible for contacting each site's owner/manager/forester or farmer. In the event of a change of owner/manager/forester or farmer of a site, the partner is responsible for finding their successors. If possible, in the event of several changes, it would be desirable to have the names and contact details of all the successors up to the current owner/manager/forester or farmer.

In the event of a change, the details of the current owner/manager/forester or farmer of the parcel can be found through their predecessors, by consulting the cadastral registers, the registers of the development

groups (GAD- Groupement de développement Agricole; GVAF - Groupement de vulgarisation agricole féminin, etc.), or by any other means.

In case no owner/manager/forester or farmer is indicated in the table for a given site, we invite the partner to contact the town council of the site's municipality to find the owner/manager/forester or farmer.

### 2.3.2 RMQS-BioSoil sites

**The correspondent-observers are responsible for contacting forest owners or managers.** Once this information has been provided, the correspondent-observers' list of contacts per region will be passed on to the partners by InfoSol.

**The partners should contact the correspondent-observers to jointly define the modalities of access to the sites.** The correspondent-observers know the location of the sites and may have additional or more recent information, particularly for plots where landmark trees may have been exploited. Correspondent-observers may be available, if their schedule allows them, to accompany partners in the field and help them find the site. They may also have elements enabling a more precise reposition of the central stake of the device.

Note: It may happen that an RSSDF plot is put on hold by the DFS, especially if there is a change of land use and the correspondent notifies it. Still, the plot remains part of the RMQS, and the RMQS-BioSoil system can be reinstated if the plot is accessible, and the owner authorises it.

## 2.4 Contact with the owners/managers/foresters and farmers of RMQS plots

### 2.4.1 Authorisation of the owner/manager/foresters and farmers of the intervention RMQS2

The RMQS sites are located on private plots of land or in the public domain (communal, regional, state-owned for certain forest plots). **It is therefore essential to obtain a written authorisation from the owners/managers/foresters and farmers before any intervention on the plot. The partner is responsible for contacting the owner/manager/foresters and farmers of each site to obtain their written authorisation for the intervention and to set the date of intervention with them.**

This authorisation consists of the signature by the owner/manager/foresters and farmers of an authorisation form for sampling and data collection (see INFOSOL\_RMQS2\_M\_24-3\_authorisation\_form in annex). It is recommended that the owner of the parcel concerned by the RMQS site sign the form. If that is not possible, the manager or the foresters and farmers can sign the document. This form authorises the partner to install an RMQS site, take samples and collect data. It also authorises the subsequent use of the data and samples collected on the plot.

The partner will also ensure that the owners/managers/foresters and farmers undertake to answer the questionnaire on cultivation practices and the history of the plot.

If the owner/manager/forester or farmer refuses the intervention, the site will be suspended or abandoned. A new plot of land will have to be sought in the vicinity and a new RMQS site created (see chapter 3).

For RMQS-BioSoil sites, the DSF correspondent-observers are responsible for getting the authorisation forms signed by the owners or managers.

### 2.4.2 Preparation of the intervention

Direct contact (by telephone or via a visit to the site) with the owner/manager/forester or farmer should allow the acquisition of a certain amount of information so as to assess the modalities and intervention period on the site. Remember to consult recent orthophotos of the site to compare with the photos of the site environment from the first campaign and detect any changes.

- Has the occupation changed compared to the first campaign?
- Have there been any major events affecting the sampling location that would require the site to be moved? Examples: installation of hedges on the site, construction, excavation, collapse, parcel redistribution across the site.
- What agricultural or forestry work and passages are planned on the plot, thus imposing on the intervention period? Do not intervene during phytosanitary treatments or immediately after soil tillage.
- What crops are present? Vegetation cycles dictating the intervention period.
- Is the plot grazed? In some situations, the farmer does not want the field team to enter the plot when animals are present.
- Is the plot accessible by car? Some sites require a four-wheel drive vehicle, shorter or longer walk, with or without animal assistance and/or a reinforcement of the field team (in the case of some mountain and forest sites or sites near roads that are not easily passable at certain times).
- What are the conditions for digging the pit (manual or mechanical)?
- Are there any access restrictions to the plot (e.g., military firing range)?

**In case of difficulties, contact InfoSol to agree on the steps to be taken before intervening.**

After contacting the owners/managers/foresters and farmers of the RMQS sites and the correspondent-observers of the RMQS-BioSoil sites, the partner is asked to draw up an **intervention calendar** for all the sites in year  $n$ , which will be transmitted to InfoSol. This calendar will allow us to program with all the partners our interventions for the year and to foresee the flow of data and soil samples.

For RMQS sites, it is also advisable to prepare the survey information with the owner/manager/forester or farmer when making contact. This preparation consists of informing the owner/manager/forester or farmer of the content of the survey and asking him/her to prepare the necessary documents and records for the survey. RMQS-BioSoil sites are not concerned by the surveys.

### 2.5 Deliverables

- Intervention calendar
- Updated details of the owners/managers/foresters and farmers (in case of change)
- Sample collection and data collection authorisation forms

## 3. Relocation, put on hold, or abandonment of a site and search for a replacement plot

This procedure describes 1) the situations in which a site can be moved, put on hold or abandoned and 2) how to search for a new plot in case of an abandoned site and the steps to follow to qualify the site.

### 3.1. Moved, put on hold or abandoned site

An RMQS site sampled in the first campaign may no longer be accessible in this second campaign for various reasons. Depending on the situation, the site will be moved, put on hold or abandoned. The following table indicates the course of action to be taken depending on the situation.

Situation	Action to be taken
Parcel division across the site, resulting in different occupancy or management practices within the site	Site to be moved
Strong sampling constraint, temporarily preventing intervention (too dense vegetation, recent tillage in forest)	Site to be put on hold
Owner/manager/forester or farmer not identifiable despite extensive search	Site to be maintained, put on hold or abandoned (decision made according to context)
Refusal of the owner/manager/forester or farmer to allow the intervention	Site to be put on hold or abandoned (decision made according to context)
Artificial or excavated soil following the construction of road or urban infrastructures, for example	Site to be abandoned
Flooded soil following a change in the local water regime (e.g., seaside flooding)	Site to be abandoned

**Note: Whatever the situation, notify InfoSol before any intervention, so that the action to be taken can be validated.**

### 3.2. Moving a site

If the plot is divided across the site, thus generating different occupancy (e.g., afforestation of half the plot) or different management practices within the site (e.g., the site straddles two different crops or a wooded area and a cut area), the site can be moved. The relocation will be done within a short but sufficient distance so as to ensure that the site is in a homogeneous area in terms of occupation or management. The relocated site may retain some commonalities with the location of the first campaign. Give preference to the part of the plot where the occupation and the management practices are close to those observed during the first campaign.

### 3.3. Selection of an alternative site for year $n$ in case of a site put on hold

If a site should be put on hold, a replacement site can be selected until the plot is accessible again. The **random selection** of an alternative site will be made by InfoSol from the cluster of 12 contiguous sites previously used to define the annual sample. The selected site will be swapped with the site put on hold. If this situation occurs, InfoSol should be notified early enough so that the selection, swapping and setting up

of the site can occur before the end of year  $n$ . If the site put on hold is not yet accessible by the end of the second campaign, it will be put on hold until the next campaign.

### 3.4. Searching for a new plot in case of an abandoned site

When a site is abandoned, **InfoSol should be notified as soon as possible**. The site intervention report will be filled in with the reasons for the abandonment. The partner will be responsible for finding a new plot according to the same conditions as those of the first campaign: **as close as possible to the theoretical point, within a radius of no more than 1 km (Figure 3)** and with the same geomorphological, topographical, pedological and occupation conditions as the plot at the **theoretical point**.

These criteria are mandatory, in order not to bias a priori the national statistical representativeness of the network by selecting, for example, cultivated plots alone. Of course, these criteria cannot be applied if the theoretical location of the site falls into an area where there is no soil (e.g., a body of water/lake or an extensive urban area). In this case, the choice of a plot within the tolerance radius is left to the partner to decide. **Several selection criteria** will be used, such as the representativeness of the plot in the sector, or its pedological or environmental interest. If no plot is available within the tolerance radius, the site will be definitively abandoned.

The search for the details regarding the owner/manager/forester or farmer of the selected plot can be carried out by consulting the cadastral registers at the town hall or at the tax office, the registers of development groups (GDA, GVAF, etc.), or by any other means.

### 3.5. Qualification of a new site

The plot of land proposed for the installation of an RMQS site will only be definitively selected after a qualification process has been completed. This process includes:

- a **visit to the plot** of land to carry out **several reconnaissance auger borings**.
- the conduction of the **survey on the history, occupation, and management** of the selected parcel.
- **the validation of the parcel selection and assignment of a new site number by InfoSol**.

The reconnaissance auger borings are accompanied by a brief pedological description, using the DoneSol3 "Auger boring" sheet, which contains a description of the occupation, the parent material, the depths of the pedological horizons, the texture, the effervescence, the hydromorphic indices, and the load of rock fragments. This reconnaissance must allow the definition of a "homogeneous and undisturbed" soil zone. For this purpose, at least two auger borings are made on either side of the area where the site is to be installed. These auger borings also allow an assessment of the difficulties that may be encountered during the installation of the site. A quick GPS survey of the selected area will be used to return to the site for the installation.

#### **The new site must respect the following constraints:**

- Be in the presence of natural soil (cultivated or not). Exclude recently anthropised areas: recent embankments, industrial sites, landfills, former quarries, etc.).
- Have a homogeneous surface of at least 1000 m<sup>2</sup>.
- **Have the owner/manager/forester or farmer** permission to install the site. This authorisation consists of the signature by the owner/manager/forester or farmer of the sampling and data collection authorisation form (see INFOSOL\_RMQS2\_M\_24-3\_authorisation\_form in annex).

Some particular areas should be avoided:

- agricultural pounds,
- woodland edges,
- areas that straddle plots that have been consolidated or are under different crops,
- the edges of roads or stony paths, old roads that have been reconfigured (observable in particular by the presence of a slight eminence or of allochthonous pebbles),
- the banks of streams and ditches (cleaning),
- coal-mining rounds or former fireplaces,
- ancient human settlements (signature from the surface by shards of flint, shards, bricks, various debris, charcoal and/or black colour on an abnormal thickness),
- the close proximity of farms,
- small localized bumps or depressions,
- illegal dumpsites, scrap metal dumpsites.

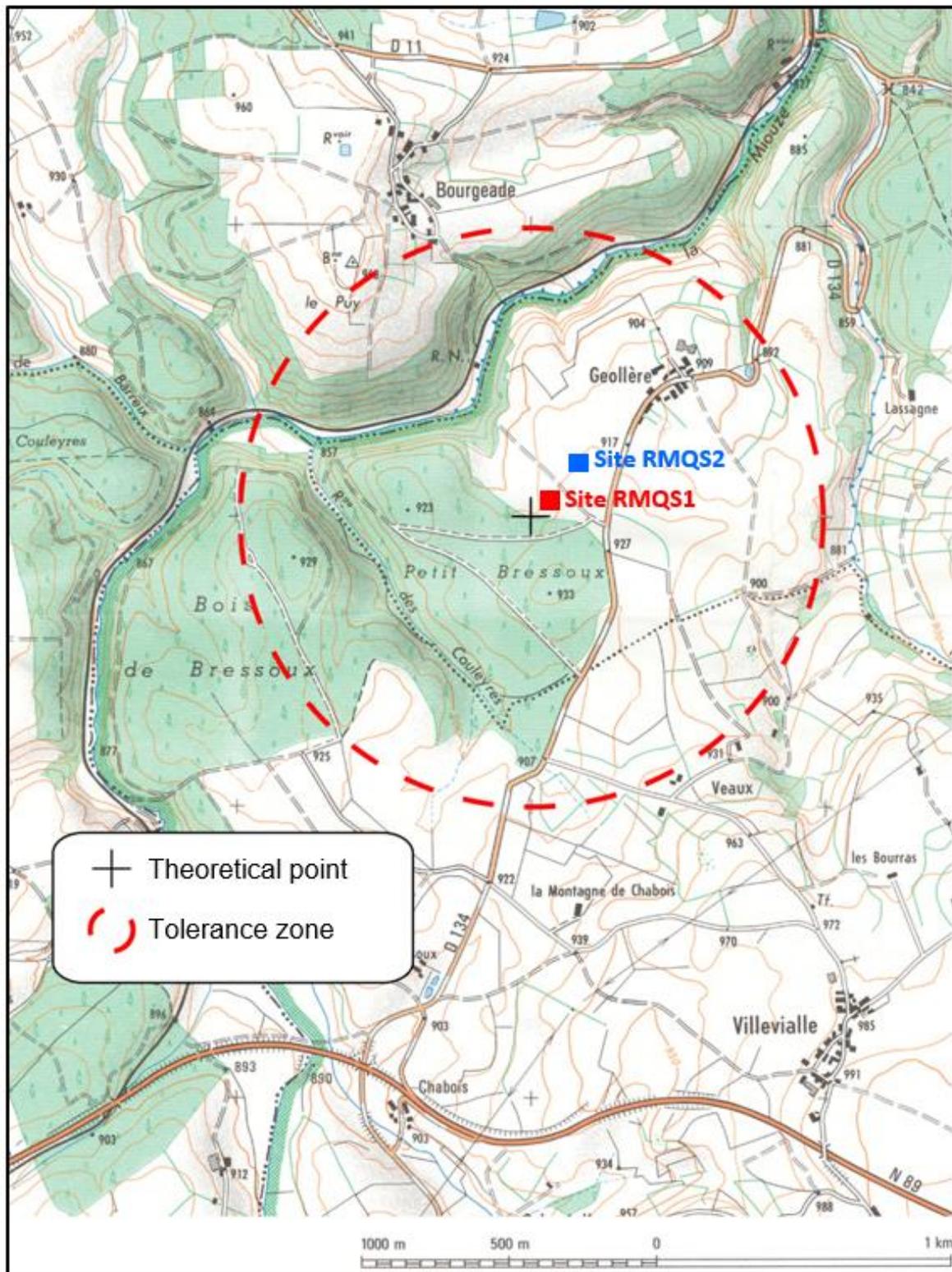
By observing the site and possibly with the assistance of the owner/manager/forester or farmer, the qualification of a site must make it possible to delimit a sampling area of approximately **1000 m<sup>2</sup>** with homogeneous characteristics in the plot:

- same surface colour,
- same physical behaviour (water regime, erosion, crusting, etc.),
- same crop precedents,
- same past as to the fertilization received,
- same vegetative appearance,
- homogeneous soil coverage,
- regular topography.

Given these constraints, a **tolerance of 1 km** around the theoretical point is provided for the selection of a new site

### 3.6. Deliverables

- reasons for relocation/put on hold/abandonment of a site (if applicable),
- Characteristics of the new site (if applicable): location, occupation, soil type, owner/manager/forester or farmer details.



**Figure 3** – Theoretical point, tolerance zone and location of the abandoned RMQS1 site and the new RMQS2 site. Extract from the IGN map 24320 © IGN – Paris – 1994 authorisation n. 42-2006-031.

## 4. How to take soil samples under optimal conditions?



**This procedure describes how to take soil samples under optimal conditions while respecting climatic and cultural constraints.**

The quality of the observations and samples is essential to guarantee the reliability of the soil properties that will be measured. This allows the detection of changes in such properties.

The monitoring of soil properties at RMQS sites is based on the collection of several sets of soil samples by auger at different depths. It is essential to minimise the risk of mixing the layers collected to avoid any risk of cross-contamination between samples. Similarly, the quality of the physical measurements used to calculate elemental stocks in the soil is subject to the conditions under which volumetric samples are taken. Therefore, these samples must be taken in compliance with climatic (soil moisture content) and cultural (physical condition of the soil) constraints.

### 4.1. Climatic conditions

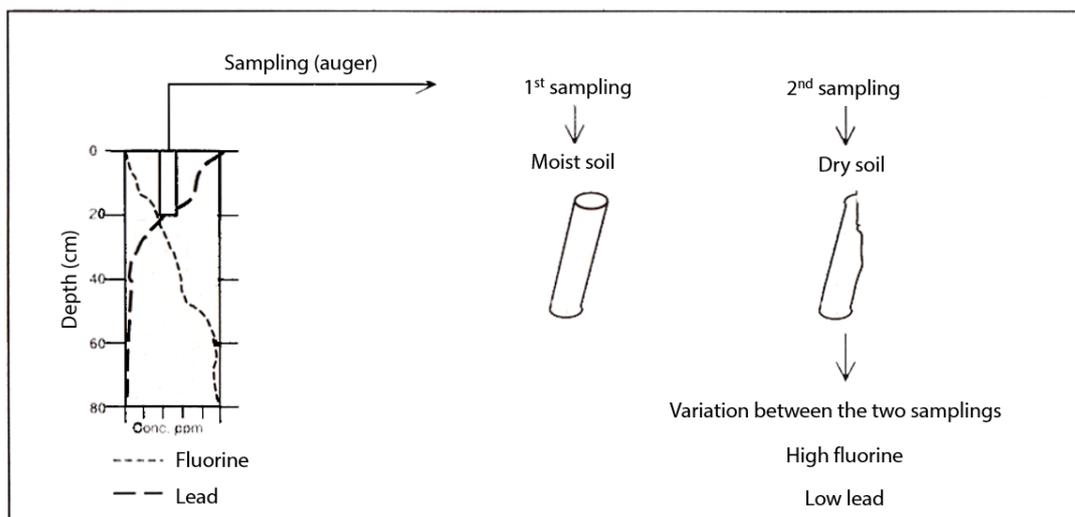
**The consideration of climatic conditions takes priority over any other criterion** in the choice of the intervention period, even if this interferes with organisational constraints. The acceptance of the clauses of the partnership agreement implies the compliance with the mandatory condition of intervening when soil moisture conditions are favourable for sampling and description. Soil samples taken under poor conditions cannot be used with reliability **and will therefore be rejected by InfoSol**. The partner will then be asked to take the samples again, at his own expense, under better conditions.

The ideal conditions for description and sampling are met when the soil moisture is close to field capacity (drained soil). **Interventions during periods of drought or excessive moisture should be avoided, not only because of the physical difficulty of taking quality samples, but also for reasons of observation accuracy.**

#### 4.1.1. Do not intervene when the soil is too dry

Dry conditions make auger sampling difficult, especially in stony or sandy soils. The upper part of a dry soil sample is often truncated, which can have consequences for the validity of the contents measured (see **Figure 4**). Similarly, the lower layer of the soil cannot be reached or is insufficiently sampled. Finally, the risk of cross-contamination of samples between two sampling layers increases greatly when the soil is too dry, as surface soil can easily fall into the pit.

Soil that is too dry makes it difficult or impossible to take the volumetric samples used to determine the bulk density of the soil. This is particularly true for sandy soils, where sampling is too fragile, and for clay soils, where compactness may bias the sampling. And of course, a soil that is too dry is more difficult to describe, as the structure, colours (and therefore the detection of stains) are poorly expressed.



**Figure 4** – Influence of soil condition on variations in elements content during sampling: "depending on the depth gradient of the various pollutants, the soil condition will have a systematically different impact on the content measured in the samples". Adapted from: Office fédéral de l'environnement, des forêts et du paysage (OFEFP), 2000 - Réseau National d'Observation des Sols, Variation des teneurs en polluants après 5 et 10 ans de suivi. Cahier de l'environnement n.320, 129 p., Bern, Switzerland.

#### 4.1.2. Do not intervene when the soil is too wet

In addition to the damage to vegetation and soil compaction that can be caused by trampling in excessively wet conditions, waterlogging considerably hinders the performance of quality work, especially that of augering. This is particularly true when the soil is clayey, since the samples are stickier and more difficult to extract from the auger.

In waterlogged soils, observations on the profile are more difficult (some structures are closed, for example) and it is more delicate to carry out volumetric sampling with precision, in particular in the deep layers of the soil, which may be drowned by the presence of a temporary water table.

#### 4.2. Cultural constraints

In cultivated soils, the ideal conditions for description and sampling are met when the soil is compacted. **Avoid taking samples from blown, recently ploughed, stubbled or under-soiled soil** to avoid any bias related to agricultural work, not only because of the difficulty of taking quality samples, but also for reasons of observation accuracy. **Allow the soil to settle naturally for a few weeks** before intervening. These precautions are paramount for the collection of surface composites and for the determination of soil bulk density in volumetric samples.

The sampling dates must therefore consider the calendar of cultivation operations, obtained from the farmers during the survey and revalidated during the contact with the farmer or manager before the operation.

#### 4.3. Deliverables

- Information on the sampling conditions noted on the intervention report (in particular the water status of the soil).

## 5. How to install the RMQS sampling device?

This procedure describes the RMQS sampling device (the RMQS-BioSoil device is described in procedure 7). It explains how to materialise the collection points on the sampling area using either a staking cable with coloured markers (for field crop and grassland sites), or measuring tapes, an optical square, a compass and a GPS laser distance meter. Finally, it specifies how to position the soil pit.

**Note: Remember to switch on the GPS as soon as you arrive in the field to give it time to initialise. Indeed, the installation of the device requires using the GPS in navigation mode (see instructions for use in chapter 6).**

### 5.1. The RMQS sampling device

The sampling device (**Figure 5**) consists of a **sampling area** and a **soil pit**.



The **sampling surface** area is a 20 m x 20 m square, divided into 100 elementary plots of 4 m<sup>2</sup> each (2 m x 2 m). This sampling plan is called stratified random. The principle is as follows: during the first measurement campaign, samples were taken from the 25 elementary plots with the number 1. **In the second campaign, the samples will be taken from the elementary plots with the number 2.** In the subsequent campaigns, the samples will be taken from the elementary plots with the numbers 3 and 4, respectively. **In each elementary plot, the sampling location shall be chosen randomly, not favouring any situation (hollow or bump).**

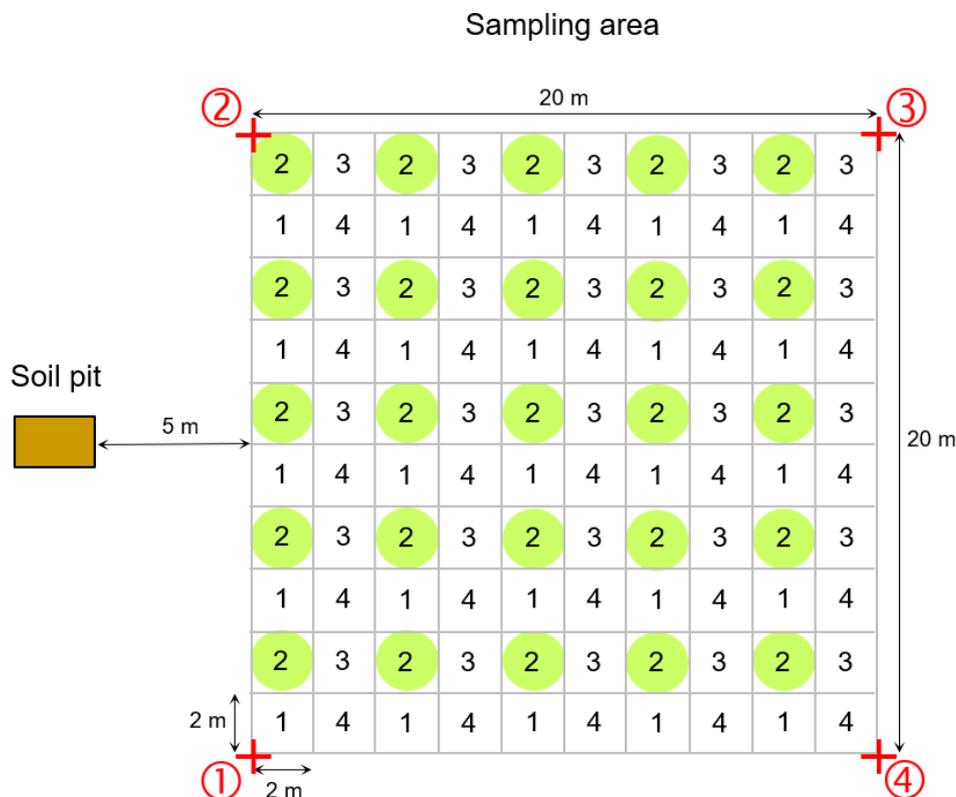


During campaign 1, the devices were generally set up in a **south-north orientation, with the pit placed to the south of the device.**

However, in case of major constraints - small plot size, steep slope, specific vegetation cover structure, vegetation with an aligned structure (forests, orchards, vineyards, etc.) - the orientation of the device could be adapted to the local geomorphology or to the structure of the plantation to facilitate its implementation.

In the event of a steep slope (> 10%) causing short-distance soil variability along the slope, the pit could be shifted so as to be placed in a way that is most representative of the sampling surface. In addition, for the relocation, the position of the points was recalculated without taking into account the slope percentage. Therefore, to avoid introducing a bias when setting up the sampling area, whenever the orientation of the

device allows it, it is advisable to start by setting up two points located on the same contour line as a reference point, and then set up the other two points using a measuring tape or the cable.



**Figure 5** – RMQS sampling scheme. The green circles represent the elementary plots numbered 2, which will be sampled during the second campaign. The points ①②③④ surveyed with GPS allow the site to be relocated.

## 5.2. The sampling area

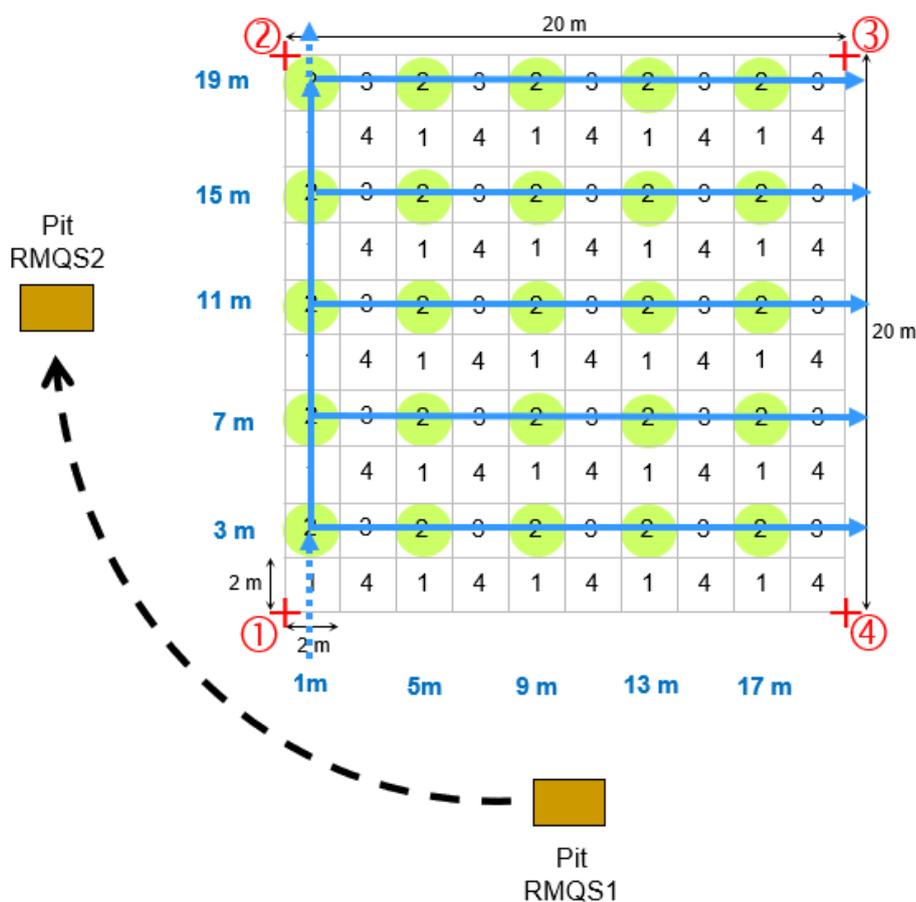
The setting up of the sampling area starts with the establishment of reference points with the GPS: corners of the sampling area in open areas or markers in forests. For forest RMQS sites, refer to the layout diagram provided, which specifies whether external markers exist and, if so, the position of the corners of the sampling area in relation to these markers. The coordinates of the reference points are provided to the partner (WGS84 coordinate file or data already recorded in the GPS).

The installation of the device is then carried out by staking, using the most appropriate method depending on the cover.

### 5.2.1. Installation of the sampling area in open areas

In open areas (farmland or grassland), the GPS allows the four corners of the sampling area to be precisely located (see Chapter 6). Then, using two measuring tapes, the markers of the grid delimiting the area and the 100 sampling units can be installed. The use of a staking cable is a quick and easy alternative which only

allows the materialisation of the 25 sampling points. This method is illustrated in **Figure 6** and is described in the following procedure.



**Figure 6** – Principle of staking the sampling points of the sampling area from the cable and setting up the RMQS2 pit.

**5.2.1.1. Material**

- six coloured stakes of sufficient height to mark the corners of the sample area and the location of the pit.
- four surveyor's stakes to maintain the tension on the cable.
- 10 white markers to mark the staking points of the baselines.
- 25 coloured markers to mark the sampling points.
- A 30 m measuring tape.
- A GPS.
- A special "RMQS2 campaign" staking cable.

Description of the staking cable: It is a 4 mm sheathed steel cable, 68.28 metres long with coloured markers (blue markers for the staking points on the baselines and red markers for the sampling points). This cable corresponds to two sides of the sample area plus the diagonal of the square. To allow alignment and to maintain some tension at each corner, loops were formed with flat cable ties.

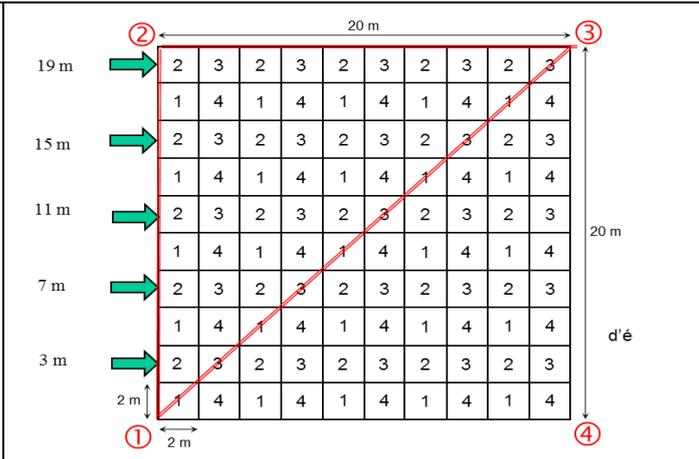


**5.2.1.2. Staking method with the cable**

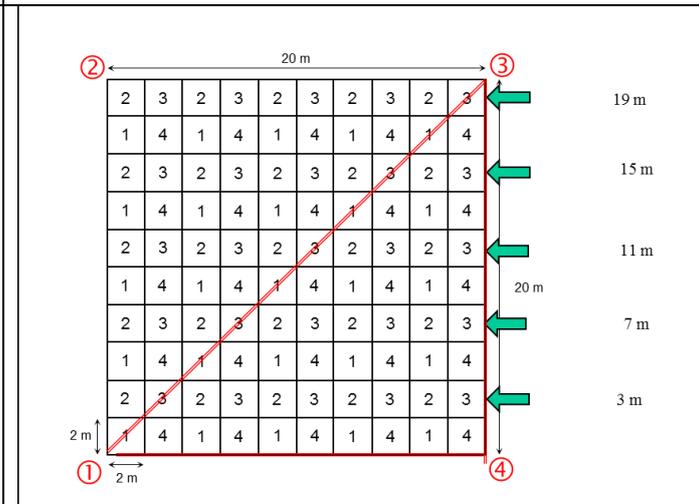
After setting up the four corners of the grid with the GPS, the staking cable is unwound. The sampling area marked by the dots ①②③④ should be re-established as in the first campaign, following the GPS indications. The orientation of the device does not necessarily follow the magnetic north. Follow the steps below:

<p>1. Set up the four corners ①②③④ of the grid with the GPS and mark them with four coloured stakes.</p> <p>Also, mark the position of pit RMQS1 with a fifth stake.</p>	
<p>2. Unwind the cable completely between points 1, 2 and 3 and then return to point 1.</p>	
<p>3. Stretch the cable between these three points using the loops and the surveyor's stakes.</p>	

4. Place the white markers on the blue markers of the cable corresponding to the centre of the elementary plots number 2.



5. Once this first baseline has been marked, switch the cable from point 2 to point 4 to mark the second part of the device by repeating instructions 3 and 4.



6. Once the markers have been placed on these two baselines, move the cable from staking point to staking point to mark the sampling points with coloured markers on the red markers of the cable.



7. With all the sampling points materialised, remove the white markers from the baselines.



8. Wrap the cable starting with the biggest length so that it is ready for future use.

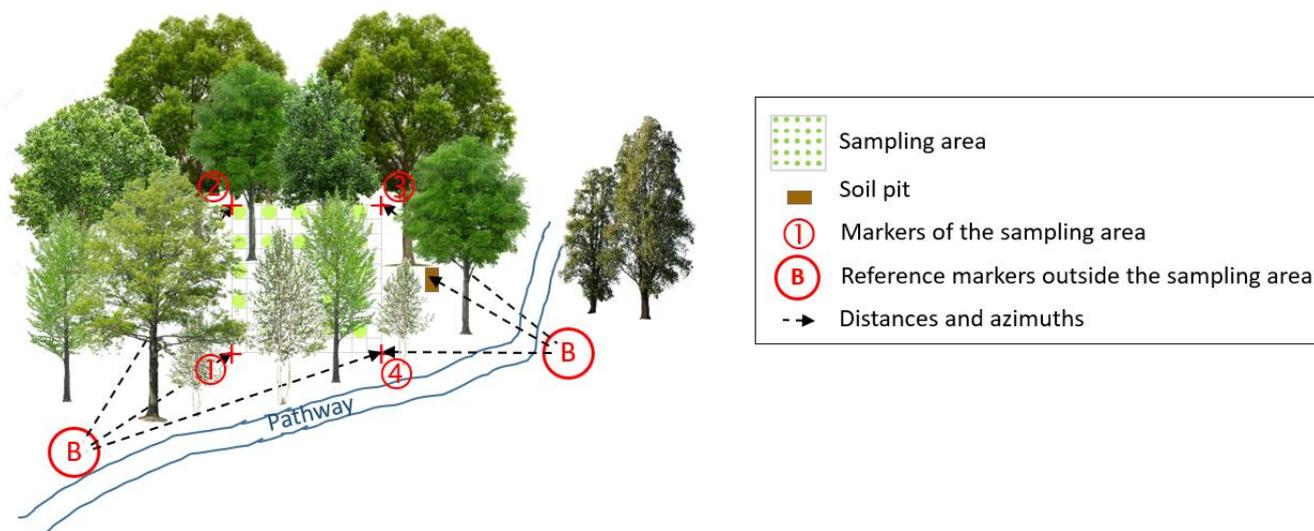
Then position the soil pit with the measuring tape five metres from the sampling area, **ensuring that it is representative of the sample area**. For the second campaign, the soil pit should preferably be positioned by turning a quarter of a turn clockwise around the sampling area starting from the position of the first campaign pit. **In case of constraints due to vegetation, geomorphology, or spatial variability of the soil, the pit will be positioned on another side of the sampling area.**

**In each plot, the location of the sample is chosen randomly within a radius of one meter around each stake, not favouring any situation (hollow, bump or proximity to the stake).**

### 5.2.2. Installation of the sampling surface in a closed environment

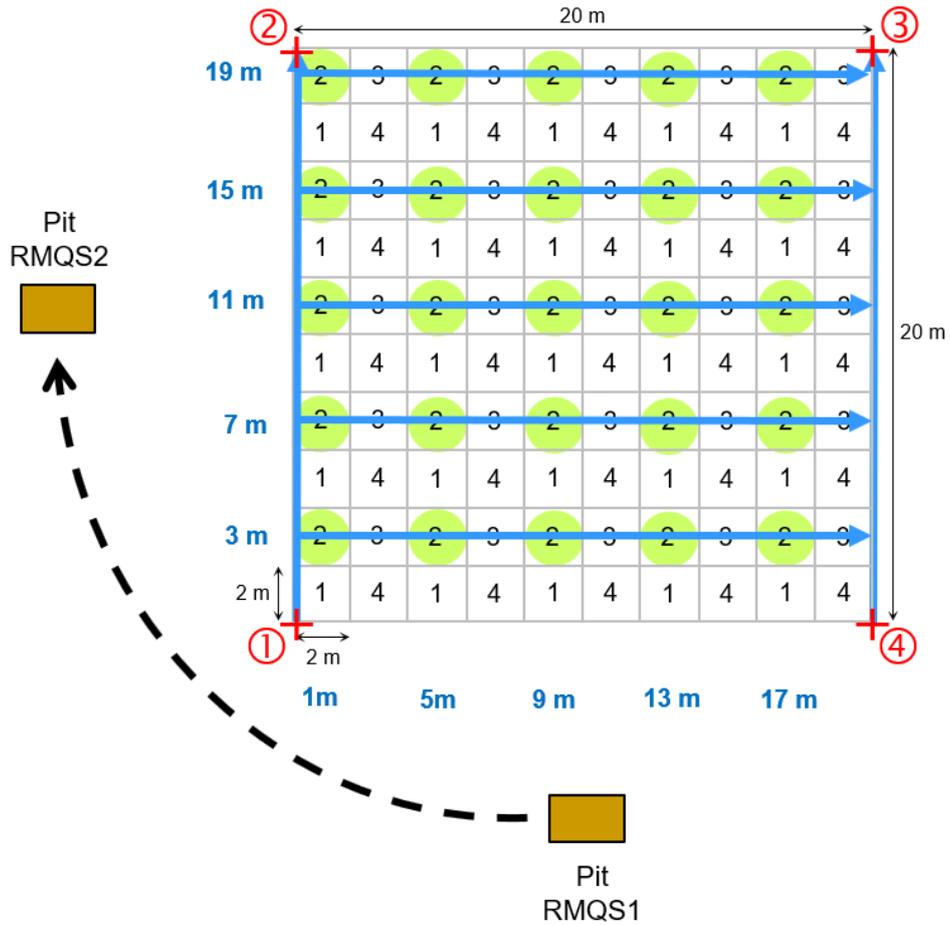
In forests (RMQS sites outside RMQS-BioSoil in particular) or when the vegetation is high, the implementation principle is similar to that of open areas. However, the use of cable is generally not possible in these situations. Measuring tapes are easier to handle, with the help of an optical square. The GPS compass and laser distance meter can also be used to good effect. The GPS allows the four corners ①②③④ of the sample area to be located, but accuracy may be reduced (see Chapter 6).

For these sites in a closed environment (**Figure 7**), the corners of the sampling surface are materialised by **surveyor's markers** that must be sought on the ground **using a metal detector**. In addition, markers outside the sampling area, which were positioned in an open environment allowing for a precise GPS survey, were mostly set up during the first campaign. The relative position of the four corners of the sampling area was measured (distance and azimuth) in relation to these external markers. These data are to be used for the relocation of the site.



**Figure 7** – Example of a RMQS site in a closed environment and the principle of demarcation (in order not to overload the diagram, only part of the arrows indicating distances and azimuths are shown).

The principle of setting up a site in a closed environment is illustrated in **Figure 8**. The staking method is described in the following procedure.



**Figure 8** – Principle of staking the sampling points of the closed environment sampling area and implementation of the RMQS2 pit.

**5.2.2.1. Material**

- six coloured stakes of sufficient height to mark the corners of the sample area and the location of the pit.
- 10 white markers to mark the staking points of the baselines.
- 25 coloured markers to mark the sampling points.
- Two measuring tapes with 30 m.
- A GPS, compass and laser distance meter (see chapter 6).
- An optical square.
- A metal detector.

**5.2.2.2. Staking method with measuring tapes, optical squares or compasses and laser distance meters**

When the four corners ①②③④ can be re-established with the GPS or when the surveyor's markers are found, it is easy to install the sampling points. Staking consists of setting up the baselines ① to ② and ④ to ③, by setting up marker stakes on these baselines, and then setting up the stakes marking the sampling points on the lines perpendicular to the baselines.

If only two out of four corners could be established using the GPS or from the outer markers, use the measuring tapes, the optical square or compass and the laser distance meter to re-establish the remaining corners before staking. You can stake by using a baseline and taking the perpendicular to this line to relocate the sample points.

### 5.3. Deliverables

- Information on the location of the device recorded in the intervention report with a diagram as precise as possible.

## 6. How to implement the RMQS device with a GPS receiver?

This document is both an instruction manual for the GEO7X GPS and a procedure for setting up an RMQS site outside RMQS-BioSoil.

**Precautions for using the device:**

- **Be very careful with the cable that connects the antenna to the receiver as the plugs are fragile.**
- **You have two batteries. Check the charge level of the batteries the day before and the morning of the operation. Remember to recharge the batteries in the evening after a site. Batteries can be used continuously for approximately 6 hours. Make sure you switch off the GPS when changing the battery.**
- **If you have any difficulties with the GPS when setting up a site, please contact the GPS Infosol correspondents on + 33 6 62 65 55 71 or by email at [correspondants-gps@inrae.fr](mailto:correspondants-gps@inrae.fr)**
- **In the event of a breakdown or malfunction of the device, please contact the D3E assistance service by telephone on 08 92 68 10 57 (0.34€/minute, only from France), on working days from Monday to Friday from 8.30am to 12pm and from 2pm to 5.30pm (5pm on Fridays) or by e-mail at [support@d3e.fr](mailto:support@d3e.fr). Remember to report that contact to InfoSol as soon as possible.**

### 6.1. Starting the device, calibrating and checking connections

Switch on the device by pressing the green button



Before each use, it is important to **calibrate the sensor's internal compass** as it will be useful for navigating to waypoints accurately.

*Caution: During calibration, avoid proximity to metal elements (posts, stakes, etc.) and make sure you do not carry a telephone or camera.*

*(The figures on the right are in French)*

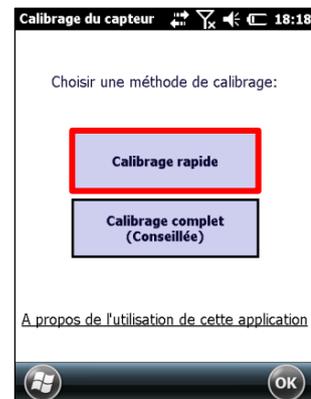
**To calibrate the device:**

Click on

Launch the compass

Click on the settings icon

Then click on "**calibrage rapide**" (fast calibration) and follow the instructions

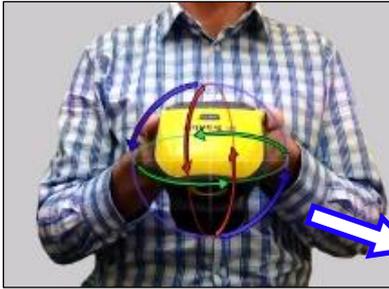


(The second figure on the right is in French)

Rotate the unit in all directions as indicated by the red, green, and blue arrows until the progress bar is filled. Wait for the calibration confirmation message.

Click on  Return to the home screen 

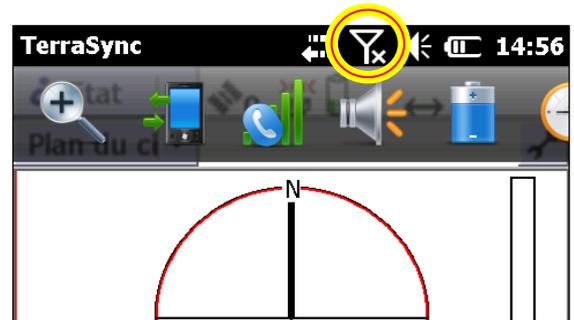
**Now connect the external antenna, then place the device on its rod and/or tripod.**



Check on the top banner that the cellular modem signal icon is active: 

Otherwise, click on the top bar, a window will open: see picture

Click on 



(The figures on the right are in French)

- > Settings
- > « Connectivité »: connections
- > « Gestionnaire sans fil »: wireless manager
- > « Téléphone »: activate the phone

Then close it



(The figure on the right is in French)

Launch **TerraSync** by clicking on the large icon in the centre of the screen

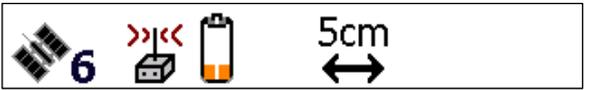
**On arrival at the site and once the antenna is connected, remember to wait a few minutes to allow the GPS to refine its position.**



To do this, check as follows:

- The icon  for the number of satellites

**Important: it is necessary to have at least four satellites to navigate and survey.**



The icons for the type of correction available:

- centimetric** accuracy
- metric** accuracy
- metric/multi-metric** accuracy

Click on to see the estimated accuracy:

Estimated accuracy in the field  
 Horizontal: 10cm  
 Vertical: 8cm  
 Estimated accuracy after postprocessing  
 Horizontal: 10cm  
 Vertical: 8cm

**Always check that the external source (Teria) is activated.**

Open the 'Setup' menu by clicking on the same tab as 'Map', 'Data', 'Navigation', 'Status', top left.

The "Ext Source" tab must be pressed down and in bold, as in the image on the right, otherwise, activate it by clicking on it with the stylus.

A call in progress message appears for a connection to Teria/GPRS.

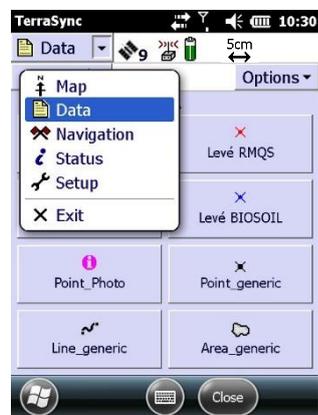


## 6.2. Navigation during relocation

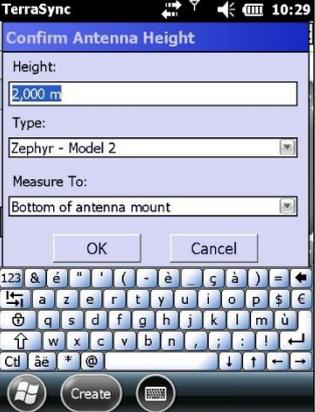
This approach requires creating the data file upon arrival at the site and proceeding point by point through the navigation and layout surveys.

### 6.2.1. Creating the GPS data file

On arrival at the site, once the device has been correctly initialised and calibrated, go to the drop-down menu: "Data"



The GPS creates a new file to be named

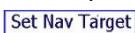
<p>Rename the file as follows:</p> <p>"n°site_municipality"</p> <p>"municipality" being the name of the municipality where the site is located</p> <p>Rules for writing the file name: for example, for site n°6 Armbouts-Cappel, the file name will be "200006_armbouts_cappel"*</p> <p>*The RMQS site number always starts with '2' in the second campaign and will be completed with zeros so as to have <u>six characters</u>.</p> <p>Then click on "Create"</p>	
<p>Confirm that the height of the antenna is 2.00 m</p> <p>Click on "OK"</p> <p><b>As soon as this file is created, the GPS continuously records its position until the file is closed.</b></p>	

**6.2.2. Navigation to the site's waypoints**

 <p>Before navigating to the corners of the sampling area and conducting site surveys, always check the connection to the <b>phone network</b> and <b>Teria</b> (external source) and ensure that the <b>external antenna</b> is properly connected.</p>	<p>From the drop-down menu, select </p> <p>Click on the tab below the menu and select "Waypoints"</p> 
---	---

First select the file containing the waypoints and click on 

Then select the point to navigate to

Long press with the stylus and click on 

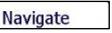
Two crossed flags appear on the selected point 

**Note: By clicking on "distance" you can sort the points closest to your current position**



*(The second figure on the right is in French)*

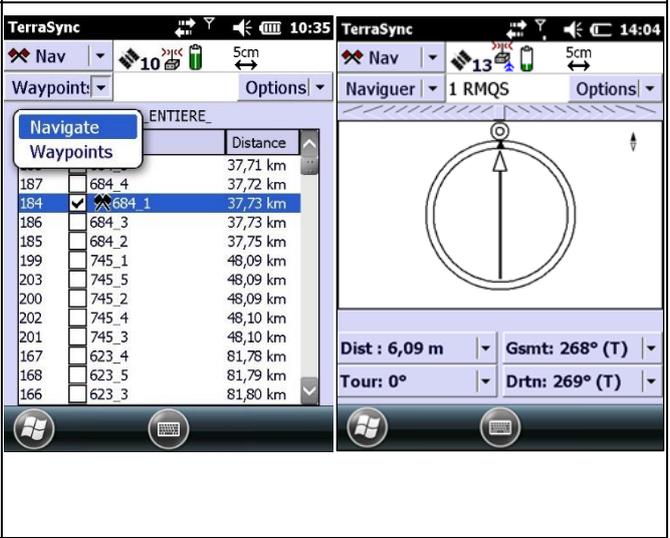
Return to the drop-down menu.

Select: 

A compass and a target appear.

When you move with the receiver, the arrow on the compass shows you the direction to go to the point.

The distance to the point is shown at the bottom of the screen (make sure the "Dist:" is selected to bottom).



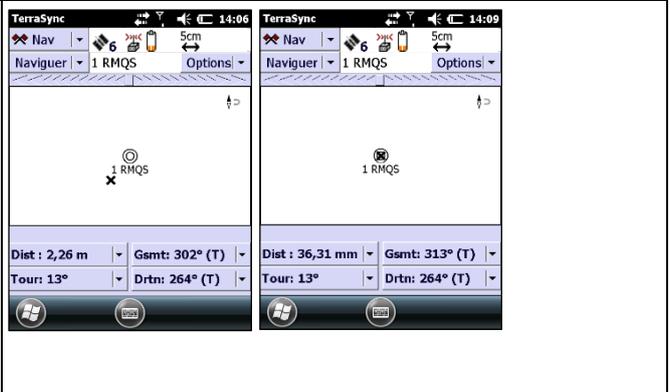
*(The figures on the right are in French)*

When you are 5 metres from the point, an alarm goes off.

Then a circle representing the point and a cross symbolizing your position appear.

The aim is to get as close as possible to the point.

To do this, perfectly align the cross with the circle.



Take care to make sure that the GPS rod is vertical to avoid any positioning bias. To do this, you can use the bubble spirit level on the rod.



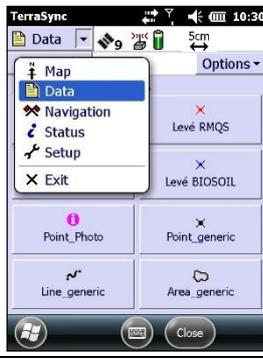
Once the target has been reached and the bubble spirit level has been checked, proceed to the location survey (see 6.3.1.) of the point and mark it with a marker. Repeat these steps for each of the other corners of the sampling area as well as for the pit from the previous campaign.

6.3. GPS surveys of site points 

The surveys are to be carried out on the **four corners of the sampling area and on the new pit**. For forestry sites outside the RMQS-BioSoil, the outer markers of the site must also be surveyed.

6.3.1. Implantation survey

An "Implant RMQS" survey is carried out at the same time as navigation to the corners of the sampling area. The procedure is quick, and the form simplified, with no 2nd or 3rd survey. It provides information on the GPS accuracy at the time of site installation. **This implantation survey is not useful for RMQS forest sites that do not have waypoints for navigation.**

<p>Go to the drop-down menu: "Data"</p> <p>The GPS keeps the previously created data file open before navigation to the waypoints.</p>	
<p><i>(The figures on the right are in French)</i></p> <p>Select "<b>Implant RMQS</b>"</p> <p>Fill in the following fields:</p> <p><b>"Type"</b>: it corresponds to the different corners of the sampling area, and the pit.</p> <p><b>"Opérateur"</b>: operator's name, mandatory field</p> <p><b>"Commentaire"</b>: to comment on the surveys and explain the situation</p>	
<p>A <b>15-second</b> survey per point is required. A tripod is not necessary as this is a quick survey. Be careful to keep the verticality constant by watching the bubble spirit level of the rod.</p> <p>If there is no real-time correction, the quality of the simulated position after post-processing is given in cm on the top right screen by clicking on the icon </p>	
<p> <i>If the estimated accuracy at the time of the survey is higher than 15 cm, check that the telephone network and the external source are activated on the GPS (see: 6.1. Starting the device, calibrating and checking connections).</i></p>	

<p>At the end of the measurement, click on the "Done" button to validate the survey of corner 1.</p> <p>The device returns to the data collection file window.</p>																											
<p>To navigate to the following corners and carry out their "Implant RMQS" surveys, repeat the operations:</p> <ul style="list-style-type: none"> <li>- 6.2.2. Navigation to the site's waypoints</li> <li>- 6.3.1. Implantation survey</li> </ul> <p>For corners 2, 3, 4 and the new pit.</p> <p>At the end of the "Implant RMQS" surveys, do not switch off the device, set it aside on its rod and stake the sampling device permanently before proceeding to the "RMQS survey".</p>	 <table border="1" data-bbox="1098 674 1374 920"> <thead> <tr> <th>Waypoint</th> <th>Distance</th> </tr> </thead> <tbody> <tr><td>187</td><td>684.4</td></tr> <tr><td>184</td><td>684.1</td></tr> <tr><td>186</td><td>684.3</td></tr> <tr><td>185</td><td>684.2</td></tr> <tr><td>199</td><td>745.1</td></tr> <tr><td>203</td><td>745.5</td></tr> <tr><td>200</td><td>745.2</td></tr> <tr><td>202</td><td>745.4</td></tr> <tr><td>201</td><td>745.3</td></tr> <tr><td>167</td><td>623.4</td></tr> <tr><td>168</td><td>623.5</td></tr> <tr><td>166</td><td>623.3</td></tr> </tbody> </table>	Waypoint	Distance	187	684.4	184	684.1	186	684.3	185	684.2	199	745.1	203	745.5	200	745.2	202	745.4	201	745.3	167	623.4	168	623.5	166	623.3
Waypoint	Distance																										
187	684.4																										
184	684.1																										
186	684.3																										
185	684.2																										
199	745.1																										
203	745.5																										
200	745.2																										
202	745.4																										
201	745.3																										
167	623.4																										
168	623.5																										
166	623.3																										

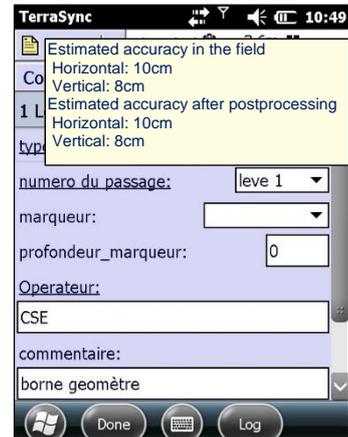
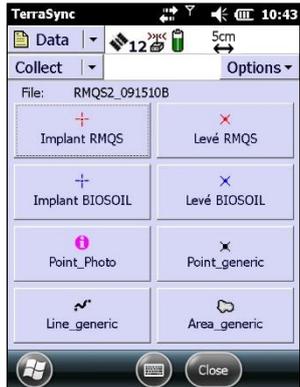
### 6.3.2. Final survey of the device

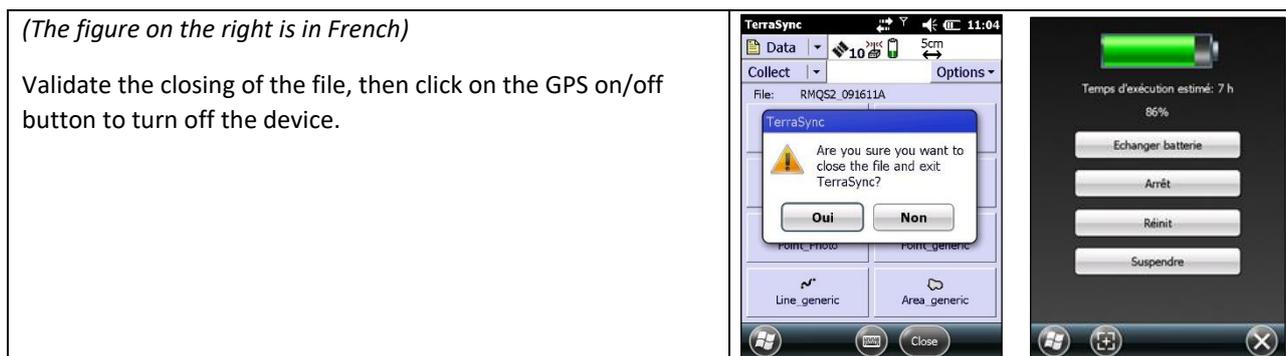
A final survey "RMQS survey" is carried out after the device has been fully installed and any corners of the sampling surface have been repositioned.

**A 2nd and 3rd survey are required** when the real-time correction (  : motionless symbol) is not available and/or when the estimated accuracy value of the GPS is greater than 30 cm.

This survey should be carried out when the sampling area is well established and staked. **It is imperative that the position of the corners of the sampling area and pit are not changed after this GPS survey.** The use of a tripod is strongly recommended when GPS reception is poor.

<p>Go to the drop-down menu: "Data"</p> <p>The GPS keeps the previously created data file open before navigation to the waypoints.</p>	
--	--

<p>Select “<b>levé RMQS</b>”</p> <p>Fill in the following fields:</p> <p>“<b>Type</b>”: it corresponds to the <b>four corners of the sampling area, the pit and reference markers 1 and 2</b> for the RMQS forest sites.</p> <p>“<b>Numéro du passage</b>”: 1 for the first pass on all the points to be surveyed and an increment for the following passes when the survey accuracy value is insufficient (&gt; 30 cm)</p> <p>“<b>Marqueur</b>”: presence or absence of a buried passive marker</p> <p>“<b>Profondeur du marqueur en cm</b>”: if present</p> <p>“<b>Opérateur</b>”: operator’s name, mandatory field</p> <p>“<b>Commentaire</b>”: to comment on the surveys and explain the situation</p>	 
<p>Be careful to stay level with the bubble of the rod or tripod during the survey.</p> <p>The quality of the simulated position after post-processing is given in cm on the top right screen by clicking on the icon </p> <p>The duration of the survey depends on the estimated accuracy: a minimum of 15 seconds per point, until an estimated post-processing accuracy of less than 30 cm is obtained when real-time correction is not available (flashing symbol  or motionless symbol ).</p> <p>At the end of the measurement, click on the “<b>Done</b>” button to validate it.</p>	
<ul style="list-style-type: none"> <li> If the estimated accuracy at the time of the survey is higher than 15 cm, check that the phone network and the external source are activated on the GPS (see: 8.1. Starting the device, calibrating and checking connections).</li> <li> Under tree cover, <b>allow the GPS to recalculate its position in a more open area before returning to the point to be surveyed.</b></li> <li> If the 30 cm accuracy value is not reached after 5 minutes, perform a GPS survey 2 hours later, and a third one if necessary.</li> </ul>	
<p>The device returns to the RMQS window and you can then go to corner 2 and proceed to its <b>final survey</b> as well.</p> <p>Repeat the operation for corners 3, 4 and the new pit. For forest sites outside the RMQS-BioSoil, the outer markers will also need to be surveyed.</p>	



### 6.3.3. Use of GPS for RMQS forest sites

For RMQS forest sites, GPS reception may be poor and it may not be able to accurately locate all corners of the sampling area. Points are often marked by **surveyor's markers** that must be searched for on the ground near the site or at the corners of the device. The documents provided enable the relocation of the site by referring to a layout diagram that specifies the existence of external markers and, if applicable, their position (distance/azimuth) in relation to the four corners of the sampling area.

The coordinates of the reference points are provided to the partners and recorded in the GPS. To set up the site when all the reference points are present in the device, simply follow the procedure "**6. How to implement the RMQS device with a GPS receiver?**" except for the part "**6.3.1. Setting up surveys**" which does not concern forest sites without waypoint to navigate to.

In cases where not all the waypoints are present in the GPS, refer to the information and measurements provided to find the surveyor's markers to establish the site. The laser rangefinder function of the GPS and a sight with a level are needed for this step, see: "**8.3. Setting up the central stake and markers B1 and B2 with the laser rangefinder.**".



Particular attention is paid to the long-term geolocation of the sampling device, as RMQS forest sites require:

- a 2nd or 3rd GPS survey, spaced in time;
- the installation of passive markers: at the four corners of the device, in the pit and at the external markers;
- a survey of additional points to materialize the reference markers or a path when the canopy is dense or led to close;
- taking distances and azimuths between the device and the surveyor's markers and between the pit and the device.

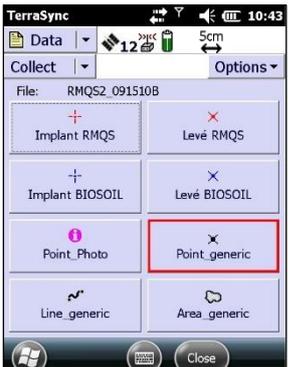
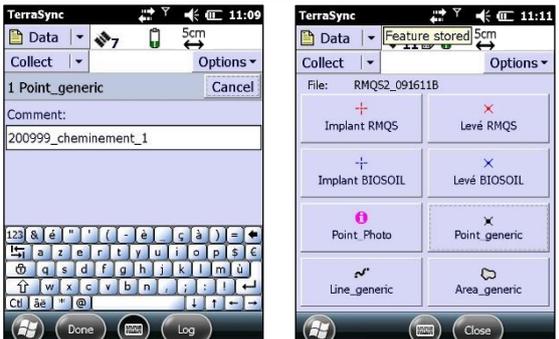
For details on how to geolocate these particular sites, see section "**9. How to install passive markers on an RMQS and RMQS-BioSoil site**".

6.4. Other GPS survey functions

First, the device must be properly initialised: see "6.1. Starting the device, calibrating and checking connections" and a GPS data file must be opened: see: "6.2.1. Creating the GPS data file."

6.4.1. Making a pathway

For sites in a closed environment and/or with difficult access, it can be interesting to outline a pathway: the principle consists of surveying georeferenced points at regular intervals to retrace the path taken to the sampling device. This additional information will be useful the next time you return to the site.

<p>Select the tab "Point_generic"</p>	
<p>Be sure to fill in the essential information about the surveyed point: <b>site number, point type and point number</b>.</p> <p>After clicking on "Done", the GPS switches to the home page of the file and a confirmation message appears</p> <p>Repeat this step regularly on the way to the site to make a pathway.</p>	

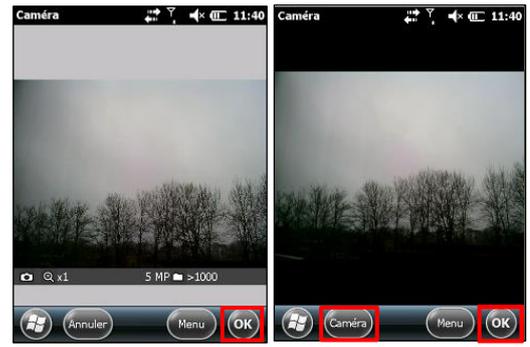
6.4.2. Taking a georeferenced photo

<p>Select the tab "Point_Photo"</p> <p>Click on the icon  to take a picture</p>	
--	--

(The figures on the right are in French)

To take the picture, click on "OK"

The captured photo appears: click on "OK" to validate it, or "Caméra" to take another photo if the previous one is not suitable.



(The first figure on the right is in French)

Once the photo is selected, the GPS returns to the previous page and the thumbnail of the image appears above the comment box.

The procedure must be completed by indicating the **site number**, the **type of photo** and the **number of the shot**.

Click on "Terminé" (Done) to validate the photo spot.



6.5. Checking and editing the GPS data file

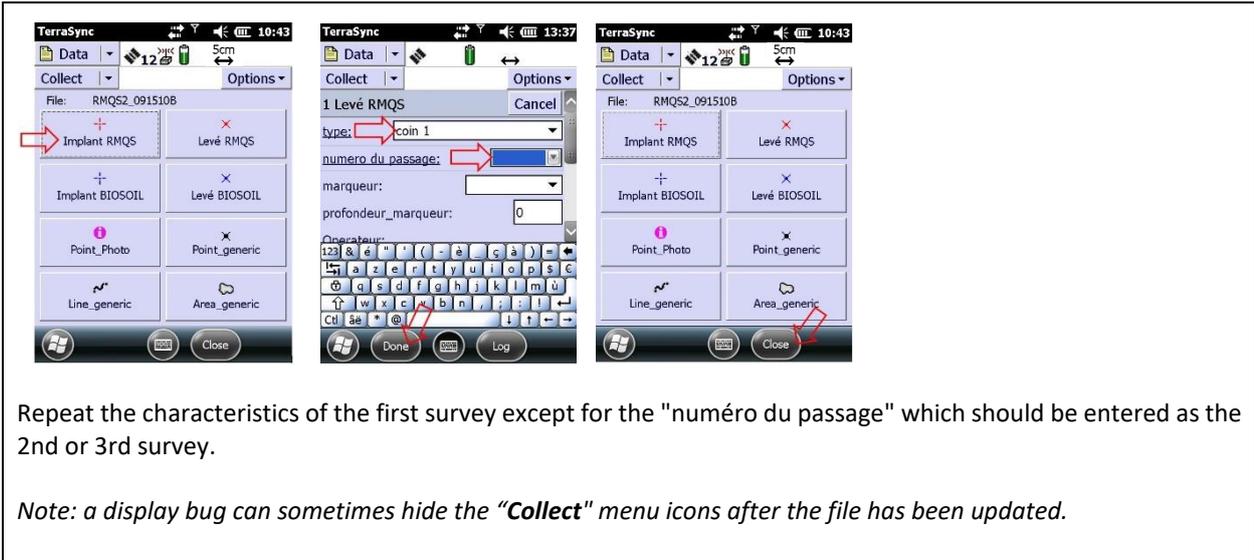
6.5.1. Completing a point already surveyed with a 2nd or 3rd pass

Procedure to perform additional surveys in the existing file.

**Opening the file corresponding to the site**

**Create a new point for the 2nd survey**

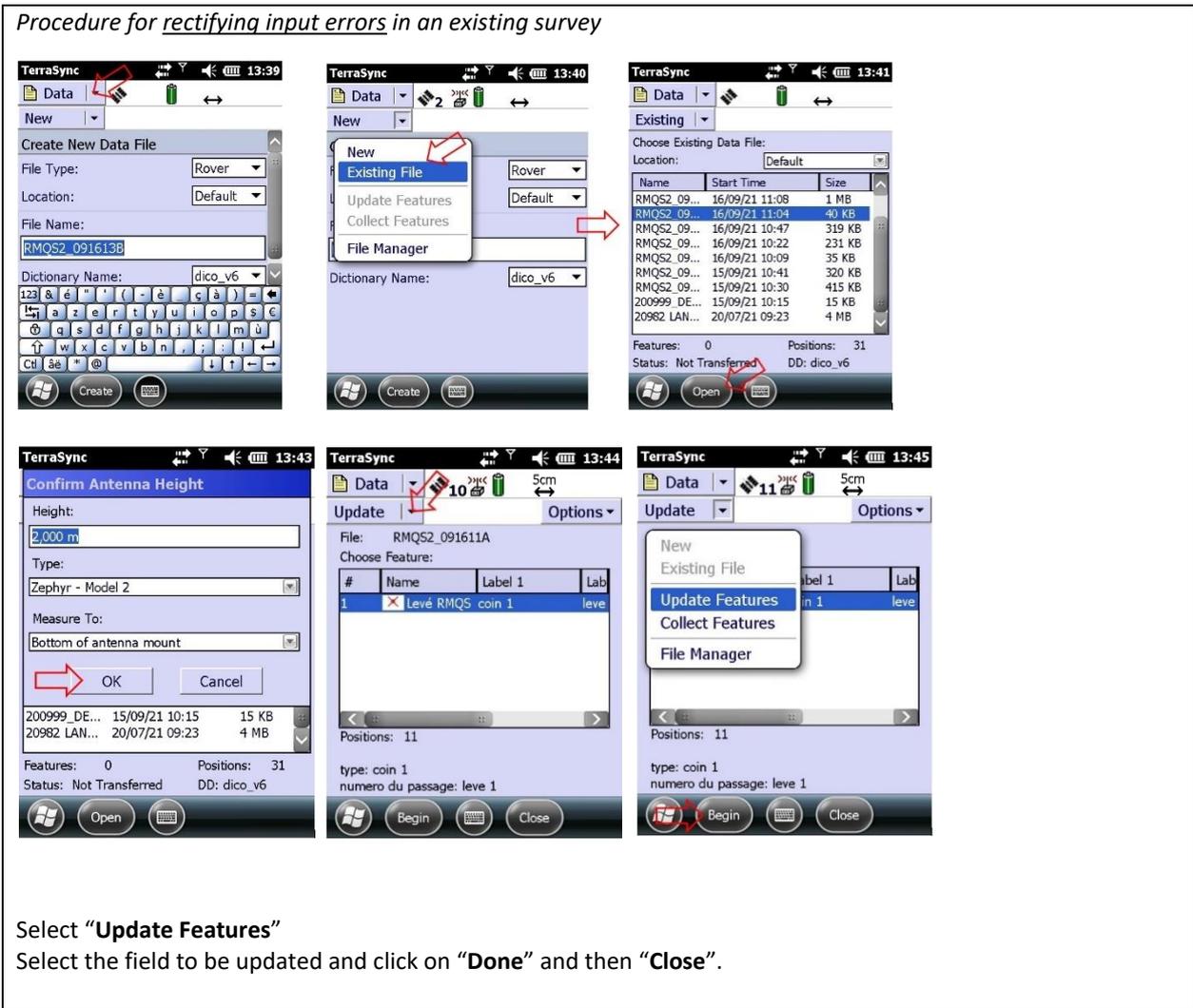
Select "Collect Features"



Repeat the characteristics of the first survey except for the "numero du passage" which should be entered as the 2nd or 3rd survey.

Note: a display bug can sometimes hide the "Collect" menu icons after the file has been updated.

6.5.2. Modifying the characteristics of a field a posteriori



**6.5.3. Delete or restore a point**

This action is possible from the menu: **Data > Existing File> Open.**

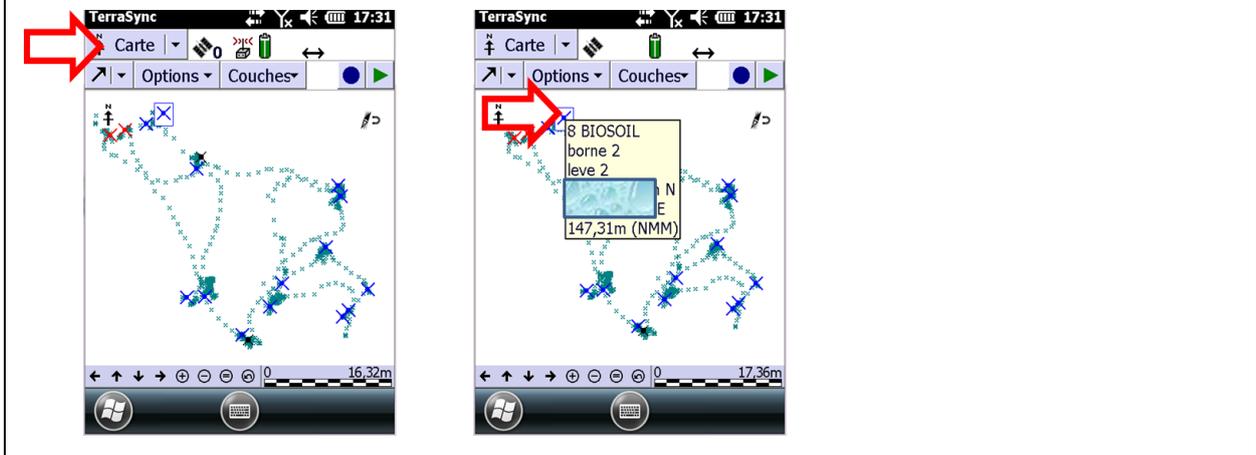


**6.5.4. Check all the surveyed points on the map**

*(The two figures below are in French)*

Select the menu "Carte"

Select one point with the stylus to see its characteristics



**6.6. Deliverables**

- GPS survey files
- Information on survey conditions recorded in the intervention report

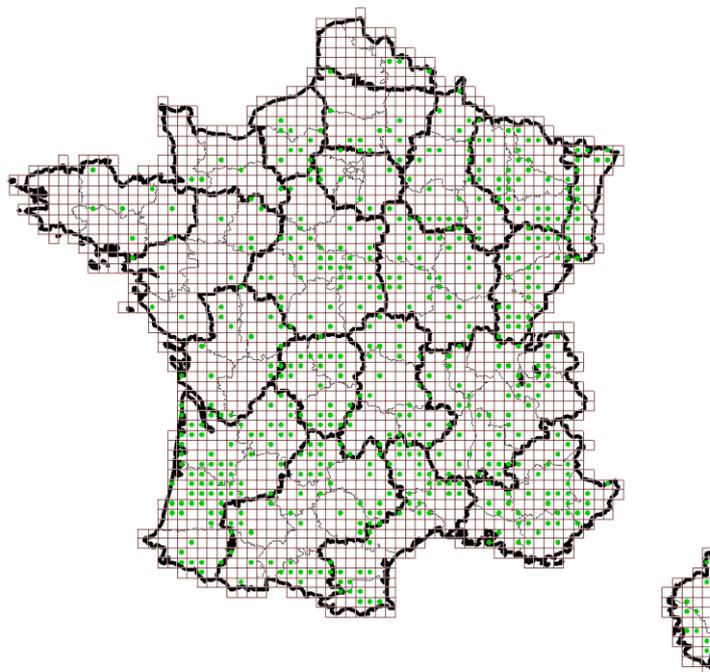
## 7. How to install the RMQS-BioSoil sampling device?

This procedure describes the sampling device for the RMQS-BioSoil sites, which has three possible configurations. It explains how to re-establish the device and mark the sampling points on the sampling area using measuring tape and/or optical squares, a compass, a metal detector and a GPS laser distance meter. Finally, it specifies how to position the soil pit.

**Note: Remember to switch on the GPS as soon as you arrive in the field to give it time to initialise. Indeed, the installation of the device requires the use of the GPS in navigation mode (see instructions for use in chapter 8). When using the compass, check the unit of the measured azimuths (degrees or grades).**

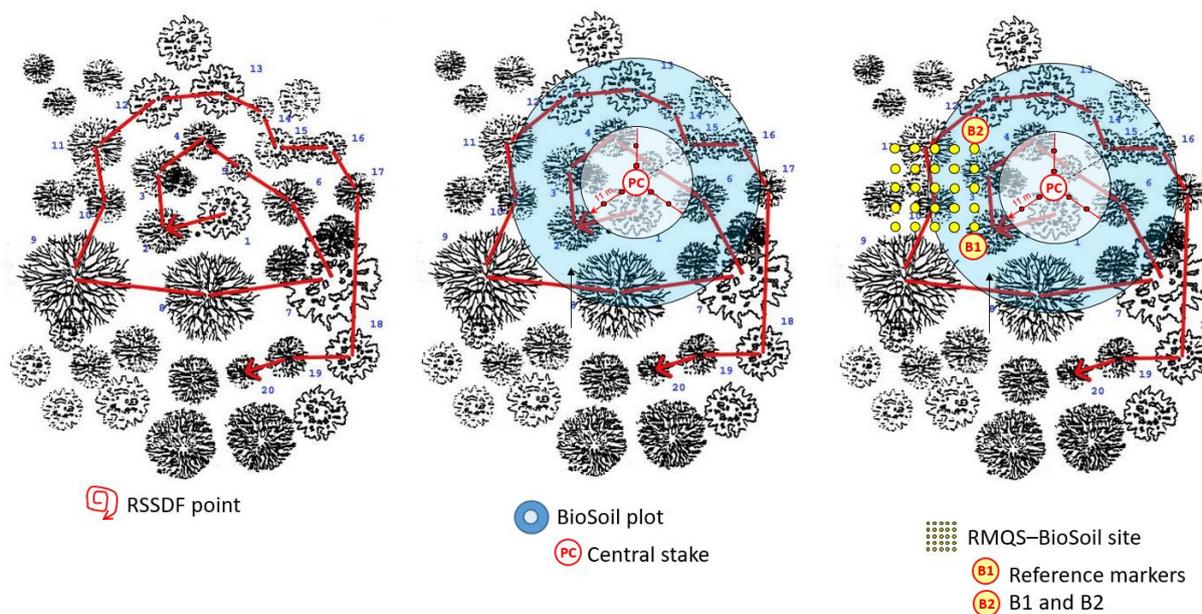
### 7.1. RSSDF points, BioSoil plots and RMQS-BioSoil sites

Among the 2,170 sites of the RMQS network in metropolitan France, about 550 sites are also part of the RSSDF (**Figure 9**). The RSSDF network was set up in France in 1989 by the DSF to monitor the long-term health status of forests. In addition to annual monitoring of forest stands, this network was used as a basis for a soil inventory in 1993-94 and for further soil sampling in 2006-2007 as part of the European BioSoil project and the first RMQS campaign. The points of the RSSDF network are marked by a spiral of trees, more or less regular, numbered from 1 to  $n$ . Two contiguous sampling devices were set up 10 years ago in the vicinity of this tree spiral: the BioSoil plot and the RMQS-BioSoil site.



**Figure 9** – RMQS (grid) and RSSDF (green dots) networks.

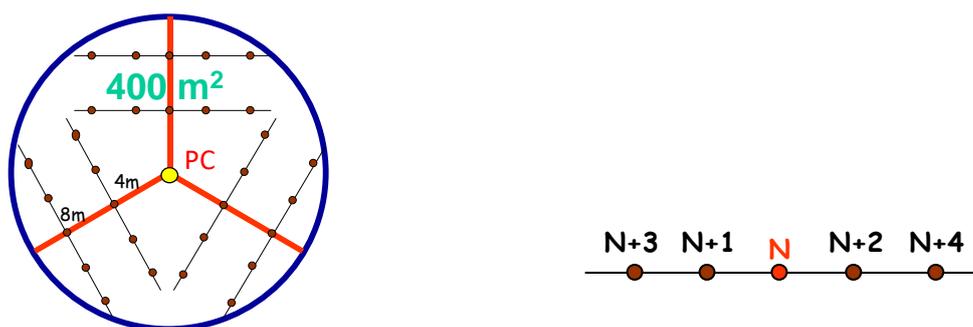
These three networks are based on the principle of long-term temporal monitoring of permanent plots, but with different strategies. **Figure 10** shows the theoretical layout of the three systems. The RSSDF point does not always correspond to a regular spiral, especially when the plot is narrow or when some of the numbered trees in the spiral have been cut during thinning.



**Figure 10** – RSSDF point, BioSoil plot and RMQS-BioSoil site, with their respective landmarks.

### 7.2. The BioSoil device

Like the RMQS device, the BioSoil sampling device (**Figure 11**) provides the possibility to collect several sets of soil samples. The sampling points are arranged on transects around the central point of the device. **This central point was installed in the centre of the numbered tree population of the RSSDF point. It was marked by a wooden marker stake painted in red and by an iron rod bent in the shape of an inverted "L", driven into the ground. This marker is hereafter called the "central stake" (PC). Where the numbered trees form a regular spiral, the central stake was placed 1 metre north of tree number 1 (Figure 10).**



**Figure 11** – BioSoil sampling device: six transects are arranged around the central point of the device (yellow dot). On each transect, five sampling campaigns are possible (N to N+4), PC = central stake.

### 7.3. The RMQS-BioSoil device

The RMQS-BioSoil device is an adaptation of the RMQS device to the particularities of forest soils. The RMQS sampling area is placed next to the BioSoil device (**Figure 12**), with an intermediate area of about 2 metres between the two devices, in which a mini soil pit has been dug to collect volumetric surface samples (0-30

cm). The proximity of the two devices means that the occupation and soil type are generally identical. **The location of the RMQS-BioSoil site is marked by the presence of two reference markers B1 and B2 whose position was measured (distances and azimuths) in relation to the central stake. An iron rod bent into the shape of an inverted "L" was also driven into the ground at the location of these two reference markers.**

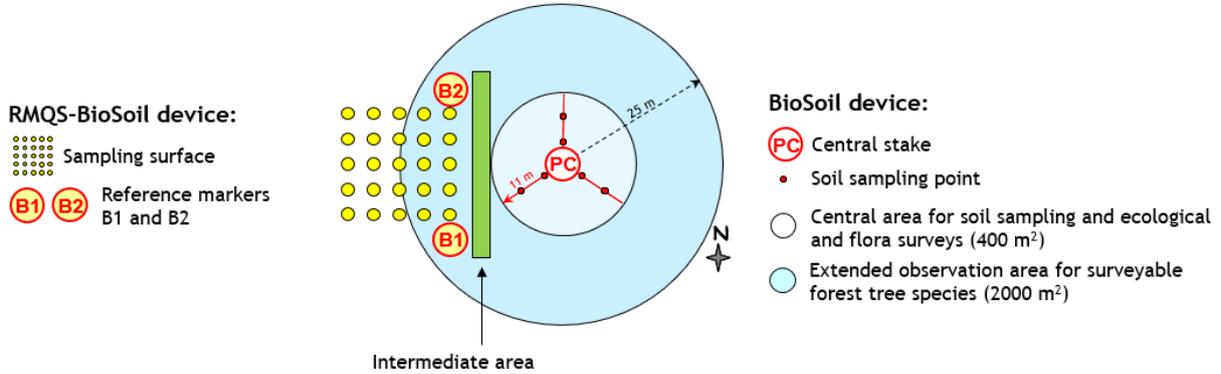


Figure 12 – BioSoil and RMQS-BioSoil devices.

Three configurations (5x5, 6x4 and 8x3) of the sampling area of the RMQS-BioSoil sites were proposed in 2006-2007 to facilitate the implementation of the device in case of major constraints related to plot size, plantation structure or steep slope (Figure 13).

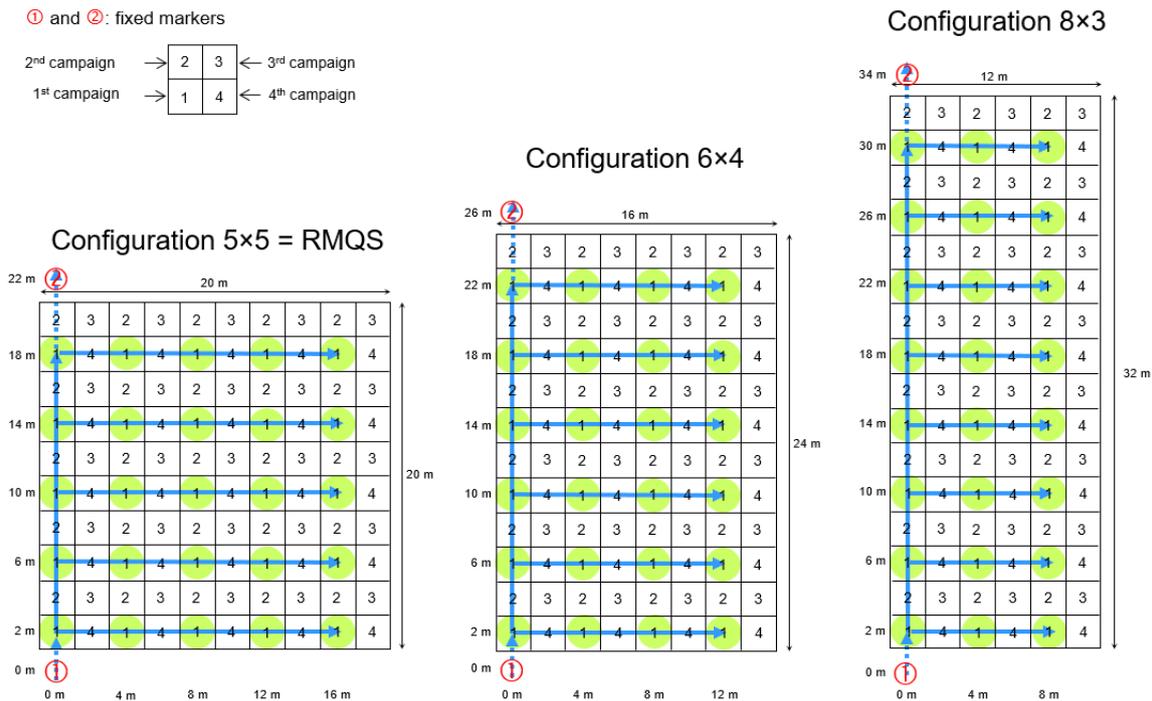


Figure 13 – Possible configurations of the RMQS-BioSoil device during the first campaign.

During campaign 1, the devices were generally oriented as shown in Figure 12. However, the orientation of the device could be adapted to field constraints. The combination of the three possible configurations of the device and its variable orientation gives a multitude of possible arrangements (Figure 14).

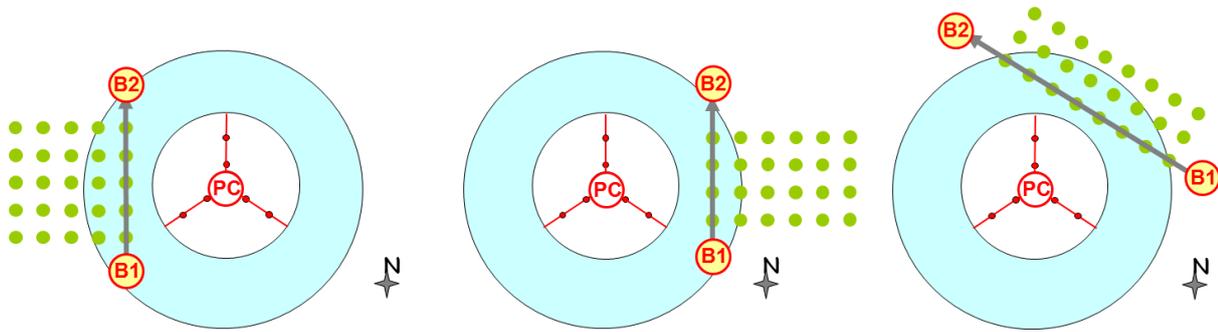


Figure 14 - Examples of orientation and configuration of the RMQS-BioSoil device.

The sampling device consists of a sampling area and a soil pit. On the sampling area, samples were taken from the 24 or 25 elementary plots with the number 1 in the first campaign. **In the second campaign, the samples will be taken from the elementary plots with the number 2 (Figure 15 and Figure 16).** In the subsequent campaigns, the samples shall be taken from the elementary plots with the numbers 3 and 4, respectively.

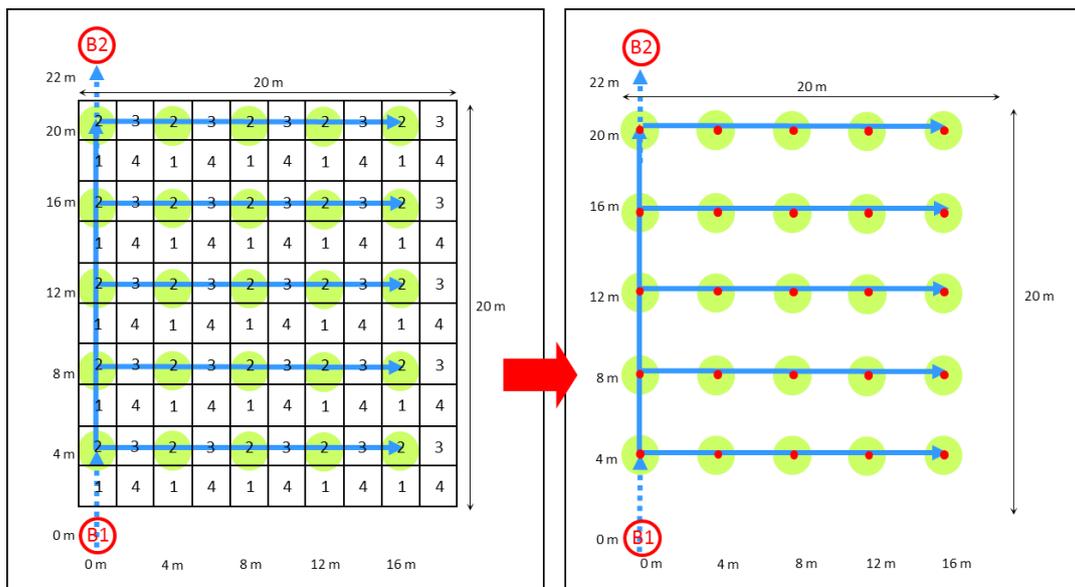


Figure 15 – RMQS-BioSoil 5x5 sampling device. The green circles represent the elementary plots number 2, which will be sampled during the second campaign. The markers B1 and B2 allow the relocation of the sampling area.

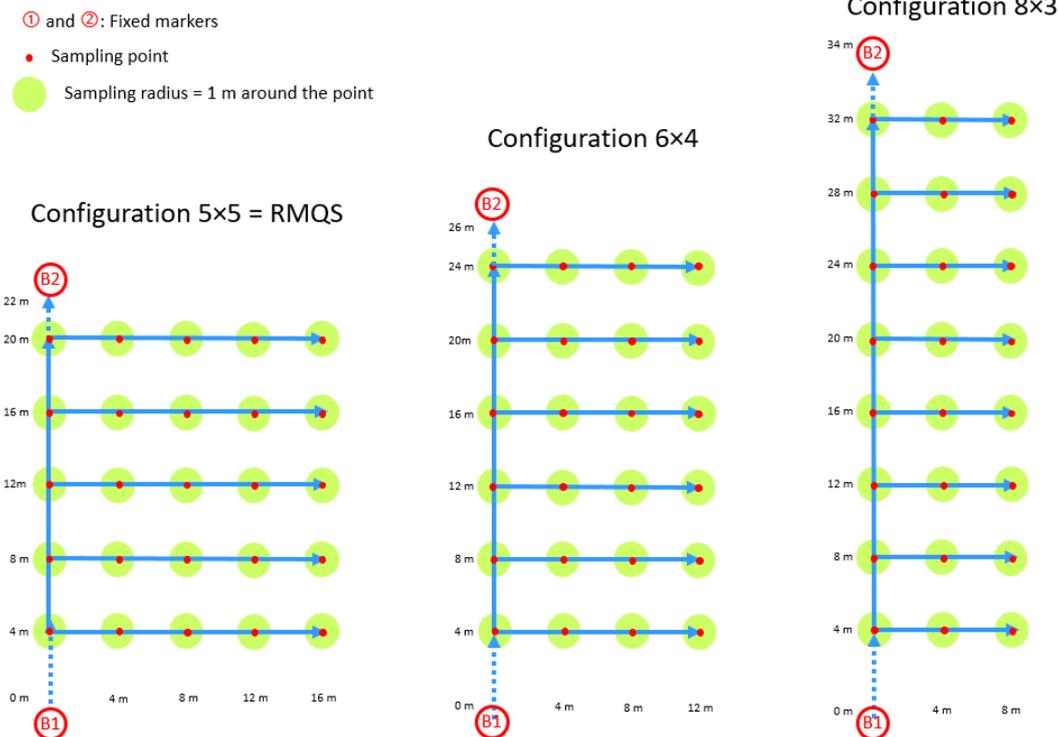


Figure 16 – Possible configurations of the RMQS-BioSoil sampling device for the RMQS2 campaign (same legend as Figure 15).

#### 7.4. Implementation of the RMQS-BioSoil site during the second campaign

The correspondent-observer of each site knows the location of the RSSDF point, so contacting him/her is essential before visiting a site. The GPS coordinates of the plot (WGS84 coordinates file provided or data already recorded in the GPS) can also be used to find the RSSDF point, but these coordinates are often imprecise.

InfoSol has compiled all the information available to find and re-establish the RMQS-BioSoil site in an implementation sheet. This information comes from several sources: DSF database, InfoSol and IFN archives. The consistency of the data is checked for each site and these data are accompanied by a quality indicator on the implementation sheet:



- *a priori* consistent data
- dubious data to be taken with caution
- *a priori* erroneous data

Where available, routing information is indicated on the sheet. This information can be very helpful in finding the numbered trees of the RSSDF point and then locating the BioSoil and RMQS-BioSoil devices.

**7.4.1. The sampling area**

The installation of the sampling area of the RMQS-BioSoil sites starts with the implementation of the BioSoil plot central stake and the two reference markers B1 and B2 that materialise the RMQS-BioSoil site. The position of the central stake of the BioSoil plot can be found from some numbered trees of the device called reference trees. The position of reference markers B1 and B2 can be found from the central stake. For each RMQS-BioSoil site, the partner has a layout sheet that schematises the available data and gives the distances (in metres) and azimuths (in degrees and grades):

- of the central stake from the nearest reference trees,
- of reference markers B1 and B2 from the central stake,
- between reference markers B1 and B2.



The present document is supplemented by a file containing this information.

During the 2006-2007 campaign, iron rods bent into the shape of an inverted "L" were driven into the ground when implementing the central stake and the B1 and B2 reference markers. **These iron rods should be searched for with a metal detector.** The indications of distances, deposits and reference trees help to delimit the search area for the central stake with the detector. Sometimes the iron rods are missing, sometimes a wooden stake is used to mark the central stake. A few degrees of deviation in the compass direction generates a deviation of several metres at a distance of about twenty metres. Therefore, a metal detector is essential to find the iron rods. **If no marker is found after an hour to an hour and a half of thorough search, it is considered that the markers are no longer present, and a new device will be installed.** If one or more markers are missing, follow the decision tree below to determine what to do:

Situation	How to proceed
1a - Numbered trees are missing, for example in the case of clear-cutting or stormy plots.	Set up a new site in the plot, following the qualification guidelines in Chapter 3. Install passive markers at the four corners of the sampling area (sticks) and in the pit (round marker). Install external reference markers (surveyor and/or sticks) if necessary. Measure the distances and azimuths of the four corners of the sampling area and the pit from the external reference markers. Survey all the markers with a GPS (four corners of the sampling area, soil pit, and external reference markers). Make a precise layout diagram in the intervention report.
1b - Numbered reference trees are missing.	Same instructions as above, with the new site located in the plot, close to the numbered trees.
1c - Numbered reference trees are present.	Proceed to the next point (2)
2a – The central stake is absent (no buried iron rod).	Relocate the central stake from the reference trees, then B1 and B2 from the relocated central stake. Install the device as described below.

2b - The central stake is present (buried iron rod found or wooden stake present).	Proceed to the next point (3)
3a – The reference markers B1 and/or B2 are missing (no iron rod buried).	Re-implant B1 and/or B2 and install the device as described below.
3b - The reference markers B1 and/or B2 are present (buried iron rods found).	Install the device as described below.

**Note: If the plot is difficult to penetrate because of particularly dense vegetation or the presence of blown down trees, contact InfoSol to find out what to do.**

**7.4.1.1. Material**

- Two surveyor's stakes to mark the reference markers B1 and B2.
- 25 coloured stakes to mark the sampling points.
- Two measuring tapes of 30 m.
- Compass (pay attention to the unit of measurement of azimuths, degrees or grades).
- GPS, compass and laser distance meter.
- Optical square.
- Sight with sighting plate for laser distance meter.
- Metal detector for locating iron rods.

*Indicative reference of the equipment used by InfoSol: Garrett 250 ACE performance:*

[http://www.garrett.com/hobbysite/hbby\\_ace\\_250\\_main\\_fr.aspx](http://www.garrett.com/hobbysite/hbby_ace_250_main_fr.aspx)

<http://detectopia.fr/detecteur-de-metaux/garrett-ace-250/>

**7.4.1.2. Staking method**

<p>1. Establish the central stake from the numbered marker trees using the laser distance meter and GPS compass (or compass and measuring tape). The use of a metal detector is essential to find the iron rod buried at the central stake.</p>	
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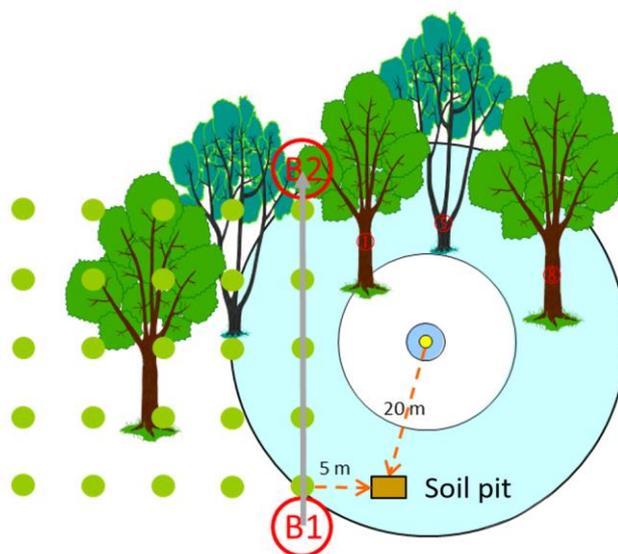
<p>2. Establish the B1 and B2 reference markers from the central stake using the laser distance meter and GPS compass (or compass and measuring tape). The use of a metal detector is essential to find the iron rod buried at the location of reference markers B1 and B2.</p> <p>3. Mark the position of the reference markers B1 and B2 with the surveyor's stakes.</p>	
<p>4. Unroll the measuring tape and then systematically place the coloured markers from reference marker B1 to reference marker B2, every 4 m up to 20 m for a 5x5 configuration, up to 24 m for a 6x4 configuration, and up to 32 m for an 8x3 configuration.</p>	
<p>5. After marking this first baseline, use the compass and the GPS laser distance meter (or an optical square and a measuring tape) to mark the perpendicular lines by installing a coloured marker every 4 m.</p>	

In each elementary plot, the sampling location is **randomly selected within a 1 m radius** around each stake, with no preference given to any location (hollow, bump or proximity to the marker).

**Note:** If there are major obstacles (rocks, large trees, blown down trees, etc.) on a line of the device that do not allow staking, sampling will not be carried out on this point.

### 7.4.2. The soil pit

The soil pit should be set 5 m back from the sampling area and more than 20 m from the central stake, so as not to disturb the sampling devices (**Figure 17**). Provided that these two conditions are met, **the soil profile should be representative of the RMQS-BioSoil device** and as representative as possible of the BioSoil device. To ensure the quality of the soil description, the pit should be positioned out of areas of disturbed soil (e.g., partitioning, land use, ruts, etc.).



**Figure 17** – Example of possible implantation of the soil pit.

**Note:** During the first sampling campaign of the RSSDF points in 1993-1994, pits were dug with described profiles in the vicinity of the device. During the second sampling campaign in 2006-2007 (BioSoil and RMQS-BioSoil programmes), mini-pits were dug to collect volumetric samples on the surface, generally in the intermediate zone between the two devices. Although some information on the location of these pits is sometimes available in the field documents (profile description sheets from 1993-1994 or surveys from the 2006-2007 campaign), the precise location of these pits is uncertain. The pedologist is therefore invited to be vigilant when setting up the new pit, by carefully examining the terrain, to avoid these disturbed areas.

### 7.5. Deliverables

- Information on the location of the device recorded in the intervention report with a diagram as precise as possible.

## 8. How to implement the RMQS-BioSoil device with a GPS receiver?

This document is both an instruction manual for the GEO7X GPS and a procedure for setting up an RMQS-BioSoil site.

### Precautions for using the GPS:

- **Be very careful with the cable that connects the antenna to the receiver as the plugs are fragile.**
- **You have two batteries. Check the charge level of the batteries the day before and the morning of the operation. Remember to recharge the batteries in the evening after a site. The autonomy is estimated at 6 hours per battery. Make sure you switch off the GPS when changing the battery.**
- **If you have any difficulties with the GPS when setting up a site, please contact the GPS Infosol correspondents on +33 6 62 65 55 71 or by email at [correspondants-gps@inrae.fr](mailto:correspondants-gps@inrae.fr)**
- **In the event of a breakdown or malfunction of the device, please contact the D3E assistance service by telephone on 08 92 68 10 57 (0.34€/minute, only from France), on working days from Monday to Friday from 8.30am to 12pm and from 2pm to 5.30pm (5pm on Fridays) or by e-mail at [support@d3e.fr](mailto:support@d3e.fr). Remember to report that contact to InfoSol as soon as possible.**

### 8.1. Starting the device, calibrating and checking connections

Switch on the device by pressing the green button



Before each use, it is important to **calibrate the sensor's internal compass** as it will be useful for navigating to waypoints accurately.

*Caution: During calibration, avoid proximity to metal elements (posts, stakes, etc.) and make sure you do not carry a telephone or camera.*

*(The figures on the right are in French)*

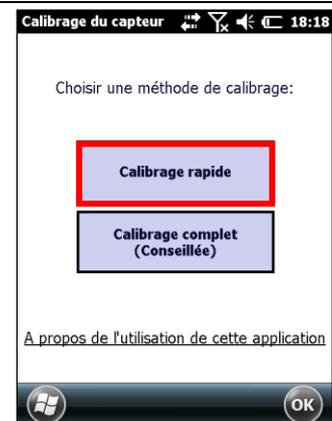
To calibrate the device:

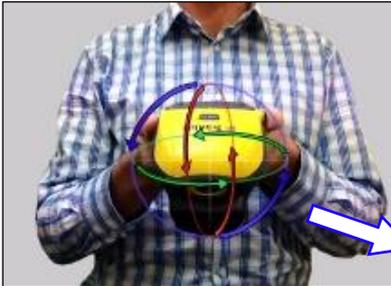
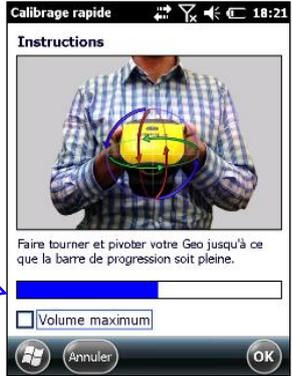
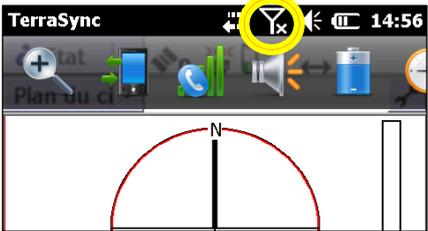
Click on

Launch the compass

Click on the settings icon

Then click on "**calibrage rapide**" (fast calibration) and follow the instructions



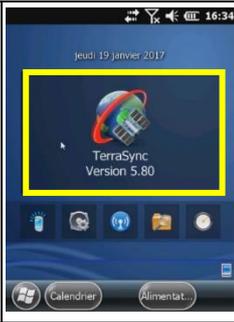
<p><i>(The second figure on the right is in French)</i></p> <p>Rotate the unit in all directions as indicated by the red, green, and blue arrows until the progress bar is filled. Wait for the calibration confirmation message.</p> <p>Click on </p> <p>Return to the home screen </p> <p><b>Now connect the external antenna, then place the device on its rod and/or tripod.</b></p>	 
<p>Check on the top banner that the cellular modem signal network icon is active: </p> <p>Otherwise, click on the top bar, a window will open: see picture</p> <p>Click on </p>	
<p><i>(The figures on the right are in French)</i></p> <p>&gt; <b>Settings</b></p> <p>&gt; « <b>Connectivité</b> »: <b>connections</b></p> <p>&gt; « <b>Gestionnaire sans fil</b> »: <b>wireless manager</b></p> <p>&gt; « <b>Téléphone</b> »: <b>activate the phone</b></p> <p>Then close it</p>	

**8.2. Navigation during relocation**

The relocation of an RMQS-BioSoil site requires a **metal detector** to search for the iron rods buried in the ground. The use of a **sight with a level and a sighting plate for the laser rangefinder** is strongly recommended when projecting the reference markers.

**8.2.1. Creating the GPS data file**

**The data file is created upon arrival near the site**, once the GPS is properly initialised and calibrated, before navigating to the centre of the BioSoil plot.

<p>(The figure on the right is in French)</p> <p>Launch <b>TerraSync</b> by clicking on the large icon in the centre of the screen.</p> <p><b>On arrival at the site and once the antenna is connected, remember to wait a few minutes to allow the GPS to refine its position.</b></p>	
<p>To do this, check as follows:</p> <p>- The icon  for the number of satellites</p> <p><b>Important: it is necessary to have at least four satellites to navigate and survey.</b></p>	
<p>The icons for the type of correction available:</p> <p> <u>motionless</u> for real-time correction: <b>centimetric</b> accuracy</p> <p> <u>motionless</u> for real-time SBASs correction: <b>metric</b> accuracy</p> <p> <u>flashing</u> for no real-time correction: <b>metric/multi-metric</b> accuracy</p> <p>Click on  to see the estimated accuracy:</p> <div data-bbox="740 965 1094 1099" style="border: 1px solid black; padding: 5px;"> <p>Estimated accuracy in the field              Horizontal: 10cm              Vertical: 8cm              Estimated accuracy after postprocessing              Horizontal: 10cm              Vertical: 8cm</p> </div>	
<p> <b>Always check that the external source (Teria) is activated.</b></p> <p>Open the 'Setup' menu by clicking on the same tab as 'Map', 'Data', 'Navigation', 'Status', top left.</p> <p>The "Ext source" tab must be pressed down and in bold, as in the image on the right, otherwise, activate it by clicking on it with the stylus.</p> <p>A call in progress message appears for a connection to Teria/GPRS.</p>	
<p>Go to the drop-down menu: "Data"</p> <p>The GPS creates a new file which must be named as follows:</p> <p><b>"n°site_municipality "</b>          "municipality" being the name of the municipality where the site is located</p> <p>Rules for writing the file name: for example, for site n°6 Armbouts-Cappel, the file name will be <b>"200006_armbouts_cappel"*</b></p> <p>*The RMQS site number always starts with '2' in the second campaign and will be completed with zeros so as to have <b>six characters</b></p> <p>Then click on "Create"</p>	

Confirm that the height of the rod is 2.00 m and click on "OK"

**As soon as this file is created, the GPS continuously records its position until the file is closed.**

8.2.2. Navigation to the site's waypoints

Before navigating to the plot centre, the GPS must be properly initialised and calibrated. Also, check the connection to the **phone network** and **Teria (external source)** and make sure that the **external antenna** is correctly connected.

If the GPS is having trouble getting a signal, move to a more open area so that it can refine its position for 5 to 15 minutes before returning to the BioSoil plot.

In the drop-down tab at the top left of the screen, select "Navigation"

First select the file containing the waypoints for the RMQS-BioSoil sites  
Click on

Then select the point corresponding to the plot number to navigate to

Long press with the stylus and click on

Two crossed flags appear on the selected point 200148\_5

**Note: By clicking on "distance" you can sort the points closest to your current position**

*(The second figure on the right is in French)*

Return to the drop-down menu.  
Select:

A compass and a target appear.  
When you move with the receiver, the arrow on the compass shows you the direction to go to the RMQS-BioSoil plot.

The distance to the point is shown at the bottom of the screen.

Once you have arrived at the location indicated by the GPS, go to the tab at the top left of the screen and select "Data".

It is advisable to **close TerraSync before opening the RangeFinder software**, as running both programs often causes the device to crash

Once on the collection file screen, click on "Exit" in the menu and validate the closing of the file and TerraSync



The coordinates provided for BioSoil sites are indicative only. They allow you to return to the area and contribute to the location of the marker trees

Once the numbered marker trees have been identified, the distances and azimuths provided should be used to find the central stake, which will then allow the B1 and B2 reference markers to be relocated.

**8.3. Setting up the central stake and reference markers B1 and B2 with the laser rangefinder**

*Warning: Before using the RangeFinder, the GPS must be calibrated. Do not remain in the vicinity of any metal object and do not carry a telephone or other devices with you during the calibration and use of the RangeFinder.*

(The figures on the right are in French)

Launch RangeFinder

Be sure to measure the offset, indicated at the top of the window.

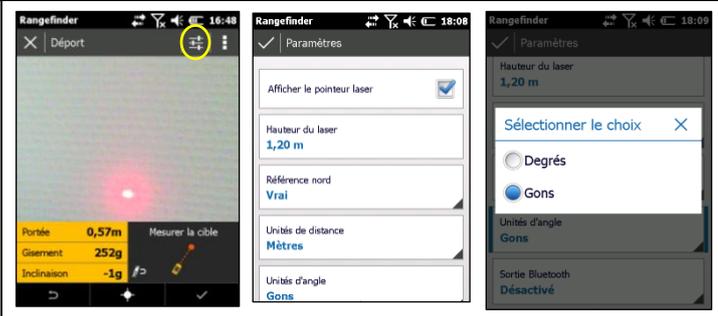
Otherwise, click on the three dots at the top right of the screen and click on "DEPORT".

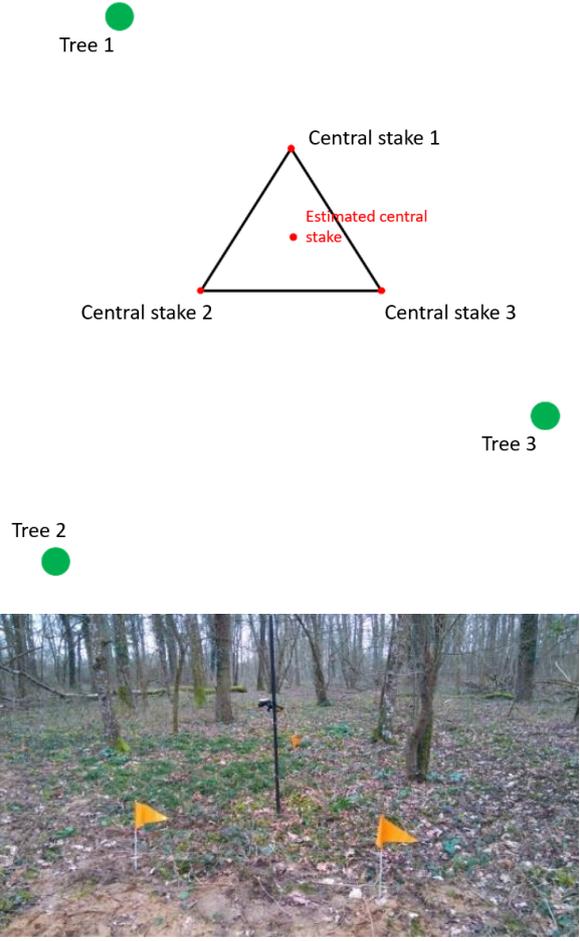


(The figures on the right are in French)

Check that the bearing is in **grades** (Gons) and the range in **metres** by clicking on the tab 

If this is not the case, click on "Unités d'angle" (Angle units).  
 Select "Gons" for grades.  
 Return to the RangeFinder screen.



<p>Position yourself at a numbered marker tree where you know the distance and azimuth from the central stake. Place the GPS as close as possible to the tree on the axis separating it from the central stake, paying attention to the level.</p> <p>Orient the unit until the laser is in the direction of the sight and guide the operator to the desired angle. Caution: the indicated distance may be disturbed by some element in the path of the laser. In this case, stretch a measuring tape between the GPS and the sight at the desired distance.</p> <p>Take into account the distance between the centre of the tree and the GPS position when measuring distances to the central stake. Place a marker at the location of the supposed central stake.</p> <p>Repeat the operation for each marker tree. You will obtain a triangle that shows the error in the position of the central stake. Look for the buried iron rod with the metal detector in and around the area marked by the triangle.</p> <p>If, after a thorough search, no iron rod is found (central stake, reference markers B1 and B2), it is recommended that you place yourself at the barycentre of the triangle - in this case the estimated central stake - and project the reference markers B1 and B2 using the measurements written on the sheet whenever possible.</p>	
<p>From the found central stake or the "estimated central stake", it is now possible to reposition the reference markers B1 and B2 by laser sight; proceed as for the "central stakes"; and set up the sampling area.</p>	
<p>See protocol <a href="#">INFOSOL_RMQS2_M_07_device_installation_RMQS-BioSoil</a></p>	

**8.4. GPS surveys after the positioning of the central stake, B1 and B2 reference markers and the pit**

Surveys are to be carried out on the **central stake, reference markers B1 and B2 and the new pit** after these have been found and marked.

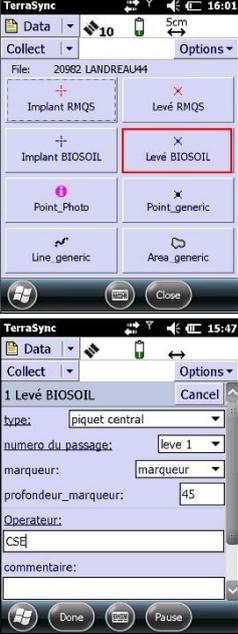
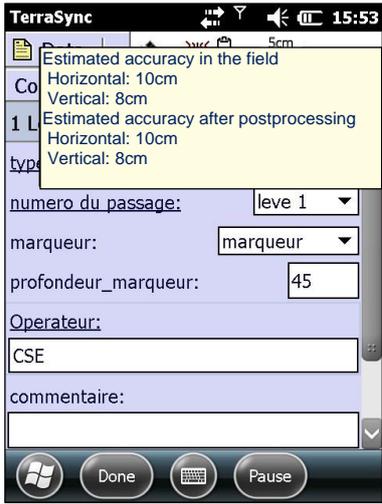
GPS surveys should not be delayed when the estimated accuracy is good: the survey quality varies under forest cover throughout the day. For this reason, additional surveys are also required, spaced a few hours apart from the first survey (see **6.5.1. Completing a point already surveyed with a 2nd or 3rd pass**)

The presence and depth of passive markers can be set in the GPS file, at the time of the survey when the markers have been placed beforehand, or by modifying the characteristics of the file (see **6.5.2. Modifying the characteristics of a field *a posteriori***)

The use of a **tripod is strongly recommended** for longer surveys if the accuracy is average.



**If the distances and azimuths do not correspond to the RMQS-BioSoil layout sheet and/or the precision estimated by the GPS is higher than 30 cm, it is necessary to include them in the sampling report.**

<p>Open TerraSync, select the "Data" tab in the menu and return to the file previously created for the site:</p> <p>Tab "New", select "Existing File"</p> <p>Select the previously created file from the list and click on "Open"</p>	
<p>Choose "Levé BIOSOIL"</p> <p>Fill in the following fields:</p> <p><b>"Type"</b>: it corresponds to the central stake, reference markers 1 and 2 and the new pit.</p> <p><b>"Numéro du passage"</b>: 1 for each survey over all the points to be surveyed, and an increment for the following surveys when their accuracy values are insufficient (&gt; 30 cm)</p> <p><b>"Marqueur"</b>: presence or absence of a buried passive marker</p> <p><b>"Profondeur du marqueur en cm"</b>: marker depth in cm</p> <p><b>"Nom de l'opérateur"</b>: mandatory field</p> <p><b>"Commentaire"</b>: to comment on the surveys and explain the situation</p>	
<p>Be careful to <b>stay level</b> with the bubble spirit of the rod or tripod during the lift</p> <p>The quality of the simulated position after post-processing is given in cm on the top right screen by clicking on the icon </p> <p>The duration of the survey depends on the estimated accuracy: a minimum of 15 seconds per point, until an estimated post-processing accuracy of less than 30 cm is obtained when real-time correction is not available (flashing  symbol or motionless  symbol).</p> <p>At the end of the measurement, click on the "Done" button to validate it.</p>	

-  If the estimated accuracy at the time of the survey is higher than 15 cm, check that the telephone network and the external source are activated on the GPS (see 8.1. Starting the device, calibrating and checking connections).
-  Under forest cover, **let the GPS recalculate its position in a more open area before returning to the point to be surveyed.**
-  If the 30 cm accuracy value is not reached after 5 minutes, carry out a GPS survey 2 hours later, and a third one if necessary.

The device returns to the RMQS-BIOSOIL window and you can go to B1 and survey it as well. Repeat the operation for B2 and the new pit.



*(The second figure on the right is in French)*

Validate the closing of the file, then click on the GPS on/off button to turn off the device.



**8.5. Deliverables**

- GPS survey files
- Information on survey conditions recorded in the survey report

Please refer to Chapter 6, paragraph 6.5 for:

- Completing a point already surveyed with a 2nd or 3rd pass
- Delete or restore a point
- Check all the surveyed points on the map

## 9. How to install passive markers on an RMQS and RMQS-BioSoil site

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**This instruction describes how to install passive markers at an RMQS and RMQS-BioSoil site to ensure long-term site geolocation when GPS survey conditions are difficult.**

This instruction concerns:

- Forest sites (RMQS-BioSoil or not)
- Sites with poor GPS coverage (e.g., in the mountains)
- Sites where the canopy is closing and where GPS reception may be difficult in the future.

### 9.1. Prerequisite

Passive markers are buried passive antennas that can be detected at a depth of 50 cm to 1 m, depending on the type of marker. The purpose of their installation is to allow the precise location of the RMQS device in the absence of a satisfactory signal from the GPS receiver, thus enabling returning to the site.

The markers can therefore be placed in any situation where there is doubt concerning the possibility of reimplanting the device precisely with a GPS receiver alone, during a subsequent intervention or campaign.

Detection principle: The markers are passive antennas with no internal power source. The robust polyethylene case is resistant to minerals, chemicals and extreme temperatures. The detector transmits a "Radio Frequency" signal to the buried marker, which reflects the signal back to the detector and gives a reading of the location on a screen and with an audible signal. Two models will be used: a round marker (purple) for soil pits and a stick marker (green) for reference markers.



## 9.2. Location of markers

- On RMQS-BioSoil sites: at the location of the central stake of the BioSoil plot, of reference markers B1 and B2 of the RMQS-BioSoil device, and of the pit.
- On RMQS forest sites and in other justifiable situations (sites in the process of vegetation closure, sites for which the GPS does not receive any real-time correction): at the location of the four corners of the sampling area, of the pit and, if applicable, of the external reference markers that were installed during the first campaign and from which the distances and azimuths of the four corners of the sampling area were measured.

## 9.3. Method for placing the markers

### 9.3.1. On the pit

A marker is placed at the location of the pit to accurately locate it and avoid digging a new pit at the same location when returning to the site. The marker for locating the pit is a purple round marker. It is placed at the bottom of the pit before backfilling, at a maximum depth of 1.5 metres.

### 9.3.2. On the sampling area and on the external reference markers

The markers for locating the central stake and reference markers are green sticks.

This type of marker is set up using an EDELMANN auger with a diameter of 4 or 7 cm and a PVC tube. The tube is used to slide the stick marker into the auger hole and guide it so that it remains perfectly vertical for detection.

**The recommended depth for burying stick markers is 50 cm. It should not exceed 60 cm.**

At the location of the central stake and the reference markers, buried iron rods (RMQS-BioSoil) or surveyor's markers (RMQS) are supposed to be present. The markers should be placed as close as possible to these markers, without destabilising them. **In situations where the central stake, B1 and B2 reference markers, or outer markers are not found, the markers will be installed at the location of the newly placed markers.**



## 9.4. Markers geolocation

### 9.4.1. GPS surveys of marker locations

The location of the markers must be traced by a GPS survey during the implementation of the device in the second campaign. As the range of the passive marker magnetic detector is limited to a few metres, finding the markers later will require the use of a GPS receiver to get closer to them.

### 9.4.2. Distance and azimuth measurements

GPS surveys of marker locations should be completed by taking distances (in metres) and azimuths (in degrees or grades, specifying the unit) between the following elements:

RMQS-BioSoil sites
<ul style="list-style-type: none"> <li>from the central stake to the numbered trees</li> </ul>
<ul style="list-style-type: none"> <li>from the central stake to reference markers B1 and B2</li> </ul>
<ul style="list-style-type: none"> <li>from reference marker B1 to reference marker B2</li> </ul>
<ul style="list-style-type: none"> <li>from the central stake or nearest reference marker to the pit</li> </ul>
RMQS forest sites and special cases
<ul style="list-style-type: none"> <li>from the outer reference markers to the four corners of the sampling area and the pit</li> </ul>
<ul style="list-style-type: none"> <li>from the two nearest corners of the sampling area to the pit</li> </ul>

**Make a precise diagram of the device's implantation in the intervention report in the "device diagram" section.** Indicate the location, depth, and nature (stick or round type) of the passive markers installed. Complete the intervention report with the measurements of distances and azimuths carried out (paragraph 2.2 of the RMQS-BioSoil intervention report and directly on the diagram of the intervention report for the RMQS sites).

### 9.5. Case of very stony or shallow soils

In the case of shallow or very stony soils, it may be difficult to place the markers with an auger. A hole can be dug with a pickaxe or crowbar to ensure that the device is located insofar as the site has been sampled. If the markers cannot be placed at the intended location (central stake or reference markers) it will be necessary to survey these points with a GPS and take their location with distances and azimuths from the central stake and reference markers.

### 9.6. Deliverables

- Scheme of the device and position of the passive markers indicated in the intervention report.

## 10. How to constitute a composite sample of holorganic horizons?

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**This procedure describes 1) how to take the elemental samples of the holorganic horizons on the sampling surface, 2) how to constitute a composite sample for physico-chemical analyses from these samples.**

It concerns soils where a holorganic horizon is present: **O horizon of forest or grassland soil root mats**. This horizon must be sufficiently thick (more than 1 cm thick) and continuous over the sampling area so that it can be sampled. Only the OF and OH horizons will be sampled. Litter (OL) whose thickness varies greatly during the year will not be sampled.

This procedure makes it possible to take a volumetric composite sample, used for the determination of the **bulk density of the O horizons** and for **the physico-chemical analyses**.

### 10.1. Material

- Intervention report (see INFOSOL\_RMQS2\_M\_24-4\_rapports\_intervention in annex)
- Thickness measurement sheet (see INFOSOL\_RMQS2\_M\_24-6\_relevés\_epaisseurs\_horizons\_O in annex), corresponding to the configuration of the 5×5, 6×4 or 8×3 device
- Knife
- Metal cylinder + sinking matrix + mallet + wooden board
- Hand shovel
- Folding rule
- Cleaning equipment: jerry can of tap water + jerry can of demineralised water + sponge + brush + paper towels
- Large mixing container
- Single-use latex gloves
- Labels + RMQS type sampling bags + rubber bands + marker
- Transport boxes for returning the sample bags

**Sampling conditions:** avoid periods of drought and excessive humidity, refer to Chapter 4 which describes the appropriate periods for intervention.



### 10.2. Operating procedure

#### 10.2.1. Principle of composite sample constitution and measurement of sample thickness

Twenty-four or 25 samples (depending on the device configuration) shall be taken with cylinders from the number 2 elementary plots of the sampling area. **Within each elementary plot, the sampling location shall be randomly selected within a 1 m radius around each stake, with no preference given to any location (hollow, bump, or proximity to the stake).**

The thickness of each individual sample is measured and recorded on the "humus thickness record sheet" in millimetres.

### 10.2.2. Method for collecting holorganic samples



1. Remove the litter (OL) and then push the cylinder vertically to a depth sufficient to pass through all the O horizons (OF + OH). A cylinder is 9 cm high, so if the organic layer is thicker, sample in two stages. Use a sharp cylinder and, if necessary, use a mallet to drive it in.
2. Carefully remove the cylinder with a knife. Usually, the organic layer cut by the cylinder remains inside. If not, remove the cylinder and then lift out the previously cut organic layer.
3. Remove mineral or organo-mineral fragments from the underlying horizon as needed.
4. Measure the average thickness of the sample and record it in mm on the surface organic horizon thickness record sheet (see example in **Figure 18**) and place the sample in a bucket.

The elemental samples are then collected in a container previously washed with tap water, rinsed with demineralised water and then carefully dried with paper towels. After each sample has been coarsely disaggregated, mix it carefully together to form the composite sample that will be delivered as a whole.

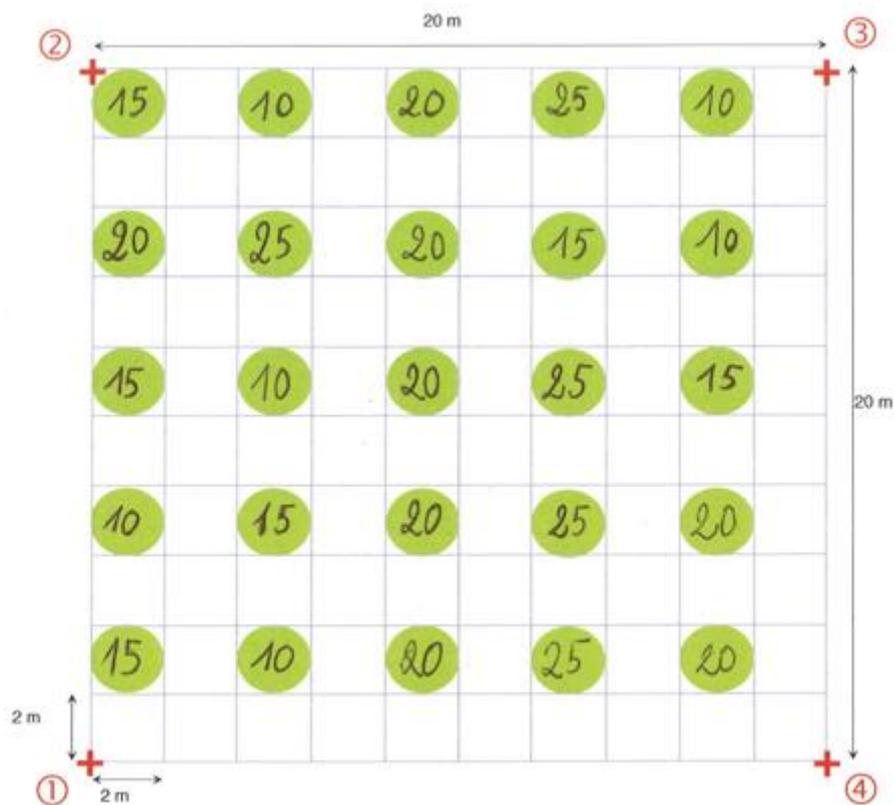
**Note: do not handle the samples barehanded** to avoid any DNA input into the samples: use single-use latex gloves to take the samples and make up the composite sample.

Record sheet for the thickness of the sampling area holorganic horizons (OF + OH)

RQMS site No.	0333	Date	
Department Municipality	95 St BRICE	Samplers	

Horizons sampled (OF, OH)	OF + OH
Sampling method (core or excavation method)	CYLINDRE

For each sample unit sampled, record the thickness in millimetres of the surface organic horizons sampled.



INFOSOL\_RMQS2\_M\_27\_releve\_epaisseurs\_horizons\_0

Figure 18 – Example of a survey of the thicknesses of surface holorganic horizons on a 5x5 configuration

### 10.2.3. Special precautions

To optimise horizon analyses, it is imperative to sample the entire OF and OH horizons and to separate the mineral or organo-mineral elements from the underlying horizons.

When calculating the sample mass, it is important to ensure that no material is lost during the transfer of the sample to the sampling bag.

**Individual auger samples for the following composites (1, 2, 3 and 4) can be taken from the same locations, in continuity with the O horizon samples, providing that the top of the A horizon is still intact and fully present. If not, sample from another location, taking care to carefully remove the O-horizon.** If an auger sample is blocked, a second or third sample can be attempted nearby, taking care to remove the holorganic layer.

### 10.3. Deliverables

- Samples packaged in accordance with good practice
- The record sheet for the thickness of the holorganic horizon, to be attached to the intervention report
- The completed intervention report for this sample



## 11. How to constitute the composite samples of organo-mineral and mineral horizons?

---

This procedure describes 1) how to carry out the elemental sampling of the surface, sub-surface, and depth samples on the sampling area, 2) how to constitute the composite samples intended for the physico-chemical analyses

### 11.1. Material

- Intervention report (see INFOSOL\_RMQS2\_M\_24-4\_rapports\_intervention in annex)
- two plastic buckets
- one knife
- one auger with a 7 cm  $\varnothing$
- Cleaning equipment: jerry can of tap water + jerry can of demineralised water + sponge + brush + paper towels
- RMQS type sampling bags
- Labels + rubber bands + marker
- Hand shovel
- Single-use latex gloves
- Large mixing container
- Transport boxes for returning the sample bags

**Sampling conditions:** avoid periods of drought and excessive humidity, refer to chapter 4 which describes suitable conditions for intervention.



### 11.2. Operating procedure

#### 11.2.1. Principle

The principle of constituting a composite sample is to mix **in equal parts** the 24 or 25 elemental samples of each soil layer taken from the sampling area.

Several sets of elemental samples shall be taken from elementary plots number 2 of the sampling area, at different depths. **Within each elementary plot, the sampling location is randomly selected within a one-metre radius around each marker, with no preference given to any location (hollow, bump or proximity to the marker).** The elemental samples from each set are then mixed to form a composite sample. Depending on the depth of the soil, we will have one, two, three or four composites up to a maximum depth of 1 m.

The number of composites to be collected, provided in the file listing the sites by year, is **indicative** (estimated from the names of the horizons in the profile described in campaign 1). It is intended to provide information on the level of difficulty of the site (time and manpower required). **The number of layers that can be sampled must be determined by the reality of the terrain.** The objective is to sample up to 1 m of any layer that can be sampled, including loose lithological horizons.

In the case of forest or grassland soils, where O horizons are present, an additional sampling series is taken from the soil surface to form a composite sample of these organic horizons (see Chapter 10).

### 11.2.2. Sampling depths for surface and sub-surface composite samples

The general rule to apply is to use the sampling depths that were defined in the first campaign, so as to maximise comparability between the two campaigns.

1) If the land use between the two campaigns has not changed.

The sampling depths for composite samples 1 (surface) and 2 (sub-surface) were defined during the first campaign based on profile observation. Please refer to the depths indicated in the annual site selection file (selection\_sites\_rmqs\_France\_entiere). **Unless otherwise specified by InfoSol, these depths must be reused for this second campaign, even if the tillage depth has changed.**

2) If the land use between the two campaigns has changed:

- Field crops (cultivated soil) → Forest, fallow land, natural environments, permanent grassland (uncultivated soil): **alter the sampling depths** of the first campaign to:
  - Composite sample 1: 0 to 30 cm
  - Composite sample 2: 30 to 50 cm
- Forest, fallow land, permanent grassland, natural environments, vineyards and orchards (uncultivated soil) → field crops (cultivated soil): **keep the sampling depths** of the first campaign:
  - Composite sample 1: 0 to 30 cm
  - Composite sample 2: 30 to 50 cm

### 11.2.3. In case of installation of a new RMQS site

If a new site is established, and regardless of land use and agricultural or forestry management practices (cultivated or uncultivated land), collect:

- Composite sample 1: 0 to 30 cm
- Composite sample 2: 30 to 50 cm

In the presence of O horizons, an additional holorganic composite should be collected as described in Chapter 10. If the surface vegetation is very dense, e.g., under grassland, it should be removed with a knife before augering, so as not to incorporate vegetation debris into the surface of the composite sample.

### 11.2.4. Sampling depths of depth composite samples

**In all situations and if the soil thickness allows it**, the sampling depths for composite samples 3 and 4 are as follows:

- Composite sample 3: 50 to 75 cm
- Composite sample 4: 75 to 100 cm

**The sampling depths of the different composite samples must be respected while considering the actual depth of the soil.** Ideally, a sampled layer should have a minimum thickness and allow for a sufficient number of samples to be taken so that the composite sample is sufficiently large to be analysed (1.5 to 2kg). **Whatever**

**the thickness of the layer and the number of samples taken, keep the whole composite sample, even if it is in very small quantities, and send it to InfoSol.**

If some of the elemental samples could not be taken (e.g., impenetrable bedrock in some of the plots), use the diagram in the field report to locate the elementary plots that could not be sampled and indicate the sampling depth reached.

#### **11.2.5. Method for sampling the organo-mineral and mineral horizons**

The organo-mineral and mineral composite samples are taken from the elementary plots number 2 of the sampling area using a helical soil auger (EDELMANN or French type). The diameter of the auger is about 7 cm to take a sufficient amount of composite sample (8 to 16 kg of fresh sample). The handle of the auger should be graduated to check the sampling depth. This can be done by attaching a piece of coloured tape every 10 cm along the handle.

If the surface vegetation is very dense, e.g., under grassland, remove it with a knife before augering, so as not to incorporate vegetation debris into the sample.

**Systematically remove the edges and the auger 'tip' with a knife** (see *Figure 20*, *Figure 21* and *Figure 22*). This precaution is imperative for two reasons: 1) to avoid any risk of **cross-contamination** between horizons when the core sample is in contact with the augerhole wall and 2) to collect a **constant volume** of soil to constitute an unbiased composite sample, by mixing the 24 or 25 elemental samples in equal parts.

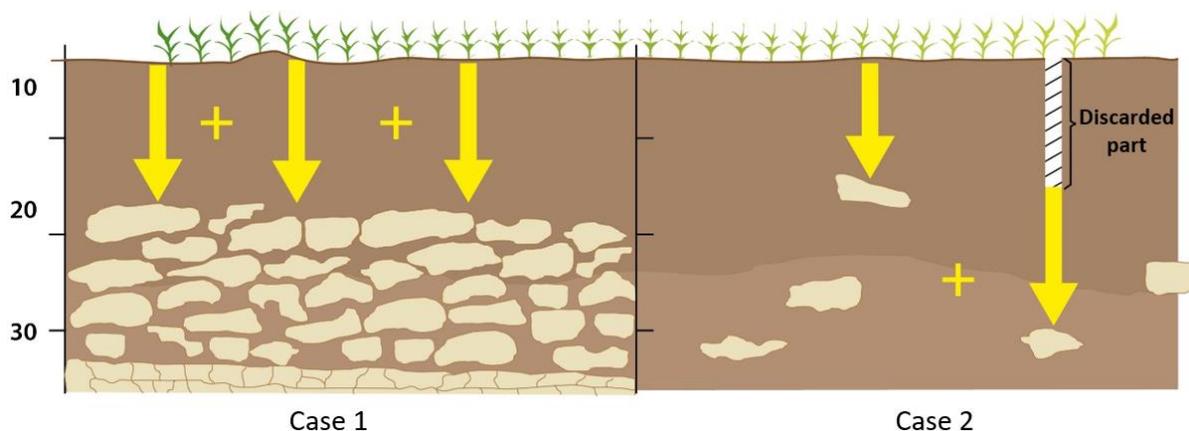
**Note: do not handle the samples barehanded** to avoid any DNA in the samples: use single-use latex gloves to take the samples or use a clean knife to level the auger and place the sample in the collection bucket.

If the samples must be taken in several stages to reach the defined depth, the upper part of each core (about 10 cm) should also be removed. A helical auger with a diameter of 7 cm allows the removal of only 20 cm of soil when starting from the soil surface. After that, this type of auger only allows an advance of 10 cm at each "auger turn". The first 10 cm of the upper part of the core, which corresponds to soil that falls to the bottom of the augerhole when removing and reintroducing the auger, must be removed at each "auger turn". Also take care not to "stuff" the auger. It is better to carry out the sampling in several stages to avoid the risk of biasing the sampling depth.

**Two buckets per operator are used to collect each composite sample:** the elemental samples intended for the composite sample are placed in a first bucket, which was previously washed with tap water, rinsed with demineralised water, and then carefully dried with paper towels. The sample waste is placed in a second bucket so as not to contaminate the sampling surface. This waste is removed from the sampling area and disposed of as part of the soil pit spoil. Between each layer sampled, the buckets used for sampling are washed with tap water, rinsed with demineralised water, and then carefully dried with paper towels. **These essential precautions prevent cross-contamination between soil layers.**

In **stony or shallow soils** (< 15 cm, *Figure 19*, case 1), it may be difficult to collect a sufficient amount of sample in one pass. **In this case, take two or more elemental samples from each elementary plot, ensuring that enough material is collected to make up the surface composite sample (around 8 kg for each layer taken).** The use of a smaller diameter auger (4 cm) is possible if it makes sampling easier, but in that case, plan to multiply the samples (four to six samples) to obtain a sufficient quantity of composite sample.

**Caution:** in the event of an occasional blockage of the auger, remember to discard the upper part of the sample during a second auger boring so as not to over-sample the upper part of the soil (**Figure 19 case 2**).



**Figure 19** – Sampling of composite samples in stony and shallow soils.

#### 11.2.6. Method for the homogenisation of a composite sample

Collect the elemental samples from the collection buckets onto a tray that has been previously washed with tap water, rinsed with demineralised water, and carefully dried with paper towels. **Carefully swab the soil using single-use latex gloves, then mix it thoroughly to form a composite sample.** ☀

The whole of each composite sample is bagged as follows:

- composite 1: **After homogenisation**, three 150 g aliquots are quartered (diagonal method) and then bagged separately for the GenoSol and BioChemEnv platforms and the LAS. Use the **white laboratory scoops** to quarter these three samples. The rest of the sample is bagged for the CEES.
- composites 2, 3 and 4: **After homogenisation**, the samples are entirely bagged for the CEES.

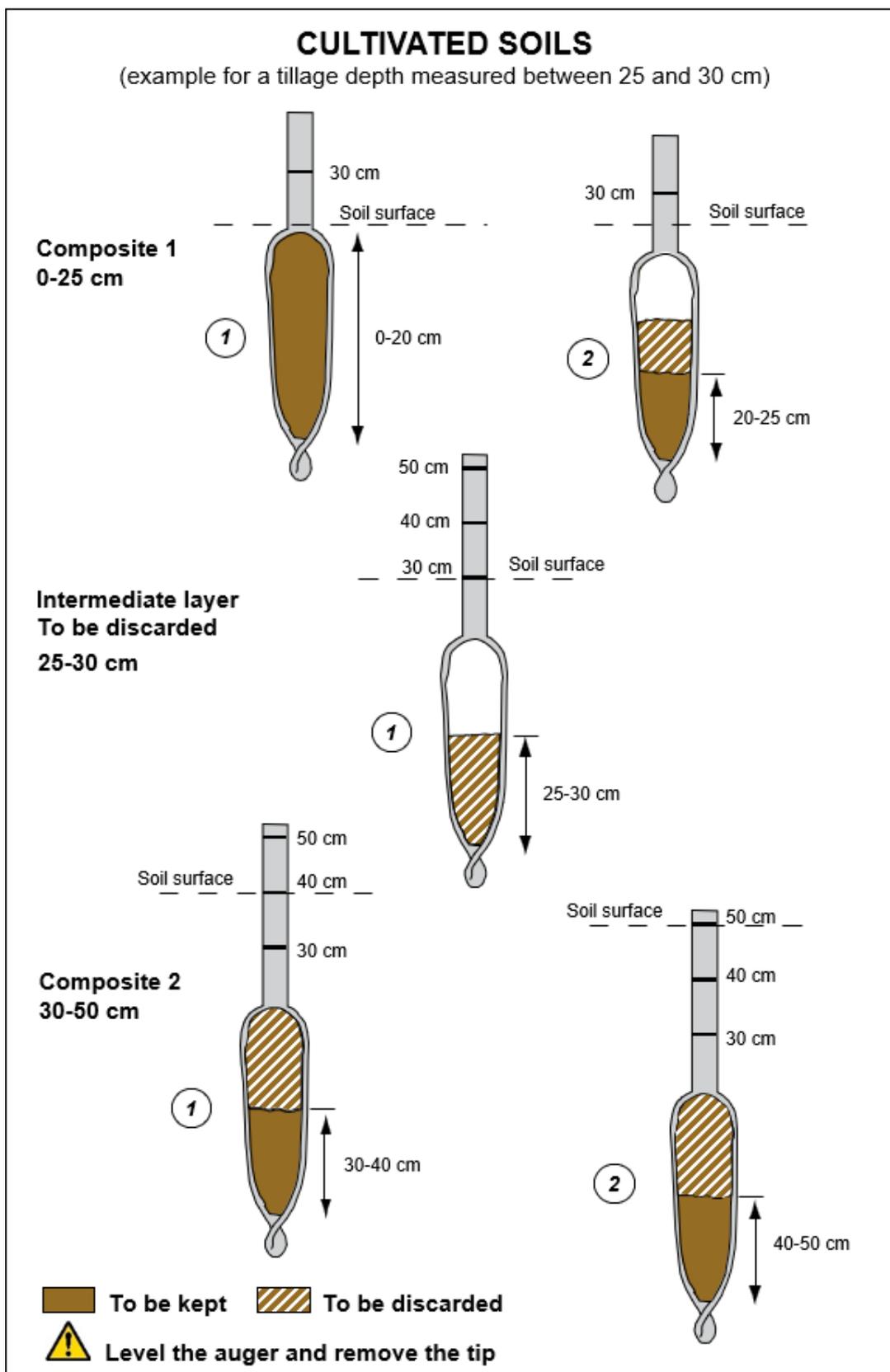


Figure 20 – Auger sampling method on the sampling area: composites 1 and 2 in cultivated soils.

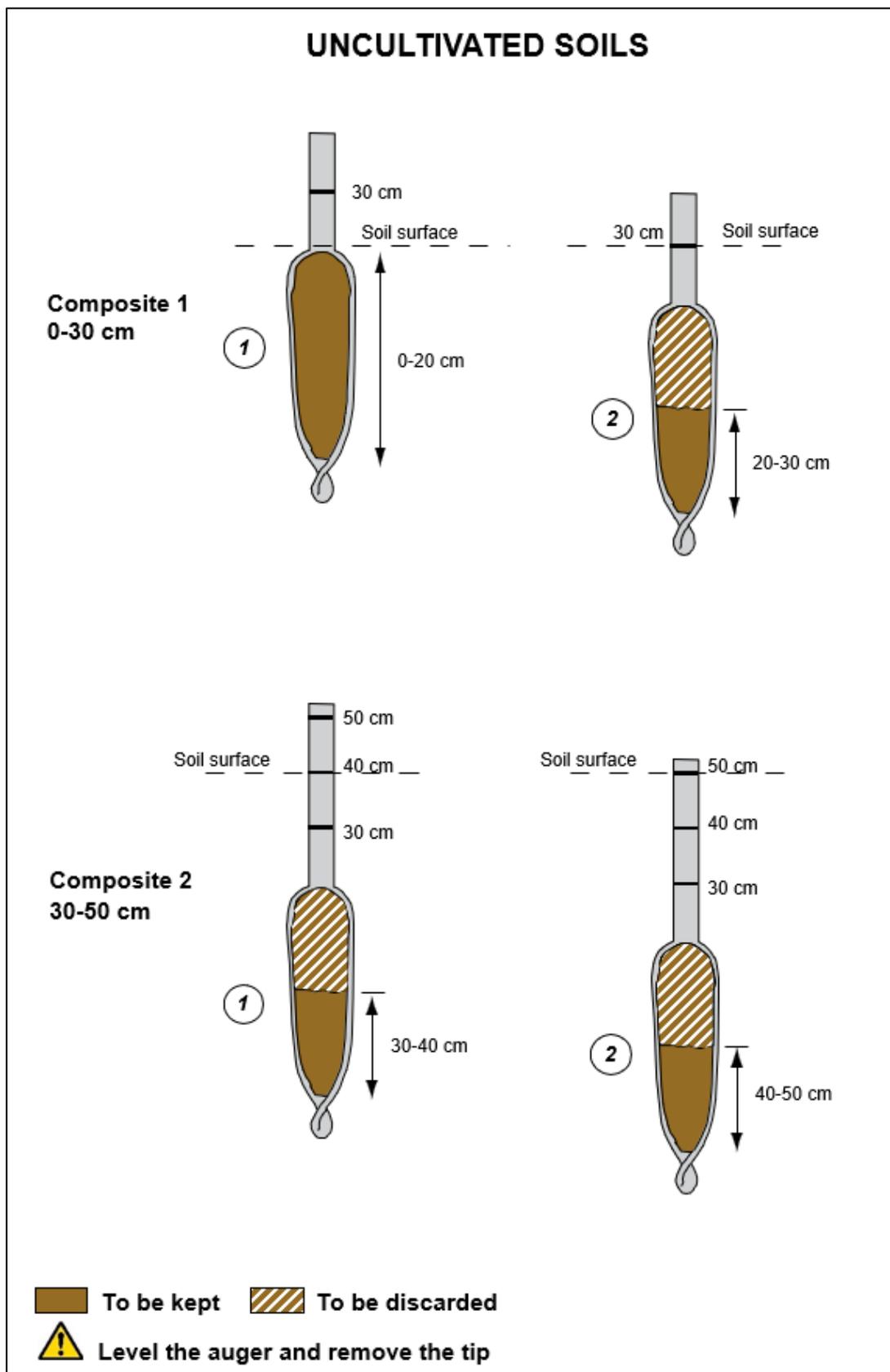


Figure 21 – Auger sampling method on the sampling area: composites 1 and 2 in uncultivated soils.

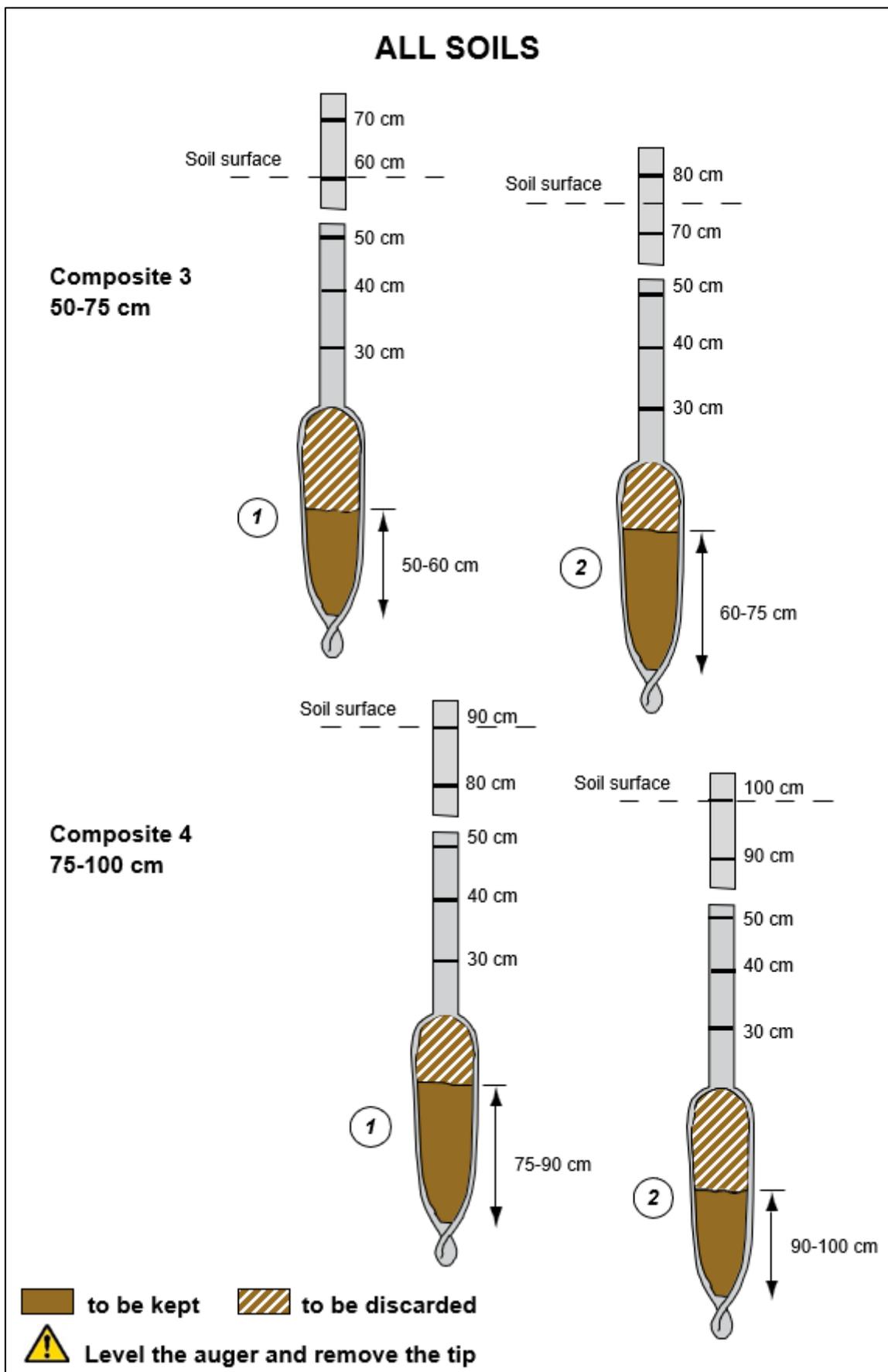


Figure 22 – Auger sampling method on the sampling area: composites 3 and 4 for all soil occupations.

### 11.3. Deliverables

- Completed intervention report for all the composite samples taken.
- Composite samples bagged and labelled in accordance with good practices.
- These samples should be sent to:



#### 1) Aliquot of composite 1 for GenoSol:

##### Plateforme GenoSol

INRAE/Université de Bourgogne  
Bâtiment CMSE  
17 rue de Sully  
BP 86510  
21065 DIJON CEDEX  
FRANCE

#### 2) Aliquot of composite 1 for BioChemEnv:

##### Plateforme BioChemEnv

INRAE Versailles  
Bâtiment 6  
RD10, Route de St Cyr  
78026 VERSAILLES CEDEX  
FRANCE

#### 3) Aliquot of composite 1 for LAS (with a specific label for storage at -20°C):

##### Laboratoire d'analyses des sols

INRAE Arras  
273 rue de Cambrai  
62000 ARRAS  
FRANCE

#### 4) The rest of composite 1 and composites 2, 3 and 4 for the CEES:

##### Conservatoire européen des échantillons de sols

INRAE Centre Val-de-Loire  
Bâtiment Qualiforsol  
2163 Avenue de la Pomme de Pin  
CS 40001 Ardon  
45075 ORLEANS Cedex 2  
FRANCE

## 12. How to excavate the soil pit?

**This procedure describes how to position and size the soil pit and the precautions to be taken when excavating the pit to respect the integrity of the site for future sampling campaigns.**

### 12.1. Positioning of the soil pit

A rectangular soil pit is dug five metres from the sampling area. Its position depends on the RMQS1 pit, which was generally positioned to the south of the device but may have been placed on another side of the system depending on the characteristics of the site. **For this new campaign, unless constrained by vegetation or local geomorphology, the soil pit diverts from the first pit by turning a quarter turn clockwise around the sampling area.**

### 12.2. Dimensions of the soil pit

Its dimensions must allow for photography of the profile, its description and all the planned samples. As an indication, the desirable dimensions are approximately 120 cm long (east-west), 90 cm wide (north-south) and deep enough to allow a complete description of the profile, **if possible, down to the parent soil material.** For sites where samples are to be taken for physical measurements, **plan to dig a pit large enough to take all the samples.**

### 12.3. Excavation of soil pit

The pit is excavated by hand or with a mechanical shovel. For manual digging, the recommended tools are: a spade, a digging fork (for clay or compacted horizons), a pick mattock (for stony or heavy clay soils), a pickaxe or crowbar (to break up stony levels), shovels (to remove spoil).

If an excavator is used, the partner must ensure that a **protective perimeter is established around the sampling area** to avoid soil disturbance (ruts, settlings, damage to the vegetation or crops).



The excavation of the pit must respect the following principles:

- **Work with clean equipment** to avoid contamination: between two RMQS sites, wash tarpaulins and digging tools (shovels, spades, picks, etc.). If a backhoe is used, make sure that it does not spread around the sampling area exogenous soil, stuck to its tracks or tyres when driving on the plot. Whatever the method of excavation, **avoid at all costs scattering spoil and trampling in the area around the pit.**



- Make two piles of spoil on either side of the pit, sparing the side to be described and **separating the deep horizons from the humiferous or worked surface horizons**. To avoid contamination of the site, **place the spoil on tarpaulins and do not place it between the pit and the sampling area**.
- **The establishment of a protective perimeter next to the main side (north)** is strongly recommended to avoid trampling over the area that will be used for the collection of undisturbed volumetric samples.
- Finally, when refilling the pit, it is imperative to put the soil layers back in order and take care not to leave any deep material on the soil surface.



**All these precautions are imperative** in order not to compromise certain descriptions (vegetation, humus shape, surface conditions) and certain samples (volumetric samples). They are also essential in order not to contaminate the soil surface with deep materials, which could bias the measurements that will be carried out during subsequent campaigns. The deep horizons are likely to contain levels of certain elements that are very different from those contained in the surface horizons. In addition, in cultivated soils, agricultural practices can take up the spoil from the pit and gradually carry it towards the sampling area.

#### 12.4. Deliverables

- Information on soil conditions and position of the pit, recorded in the intervention report.

## 13. How to take quality photographs of the soil profile?

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**The description of the soil must be completed by taking photographs. The quality of the photographs is therefore of paramount importance. This procedure describes how to take quality photographs of a soil profile.**

### 13.1. Material

- Camera
- Tripod stand
- Parasol or white tarpaulin
- Slate and chalk pencil
- Knife and smoothing trowel
- Depth scale (GIS Sol measuring tape)

### 13.2. Operating procedure

**Properly prepare the pit wall to be photographed**, taking care not to carve an artificial structure with a knife; smoothing is sometimes preferable when the texture is suitable. It is often interesting to divide the sampling wall into two parts, one where the structure is highlighted and the other where the colours are highlighted by smoothing.

Allow the **photo to be identified** by placing a slate with the RMQS site identification number and place the GIS Sol measuring tape as a depth scale, preferably on one side.

**Pay attention to framing and inclination.** Centre on the profile, leaving a strip of vegetation visible. Avoid taking photos from the ground surface, as this will distort the perspective. The distortion will be minimised if you stand parallel to and at the same level as the wall being photographed. To do this, it is necessary to stand back and dig a sufficiently large pit.

**Avoid at all costs having some parts of the wall in the shade and others in the sun at the same time**, or having the photographer's shadow in the middle of the photo. Otherwise, you will obtain totally or partially under- or over-exposed photos, which, in any case, will be unusable. If necessary, wait until the sun illuminates the entire wall or else, shade the entire area to be photographed with a parasol or white tarpaulin, if possible.

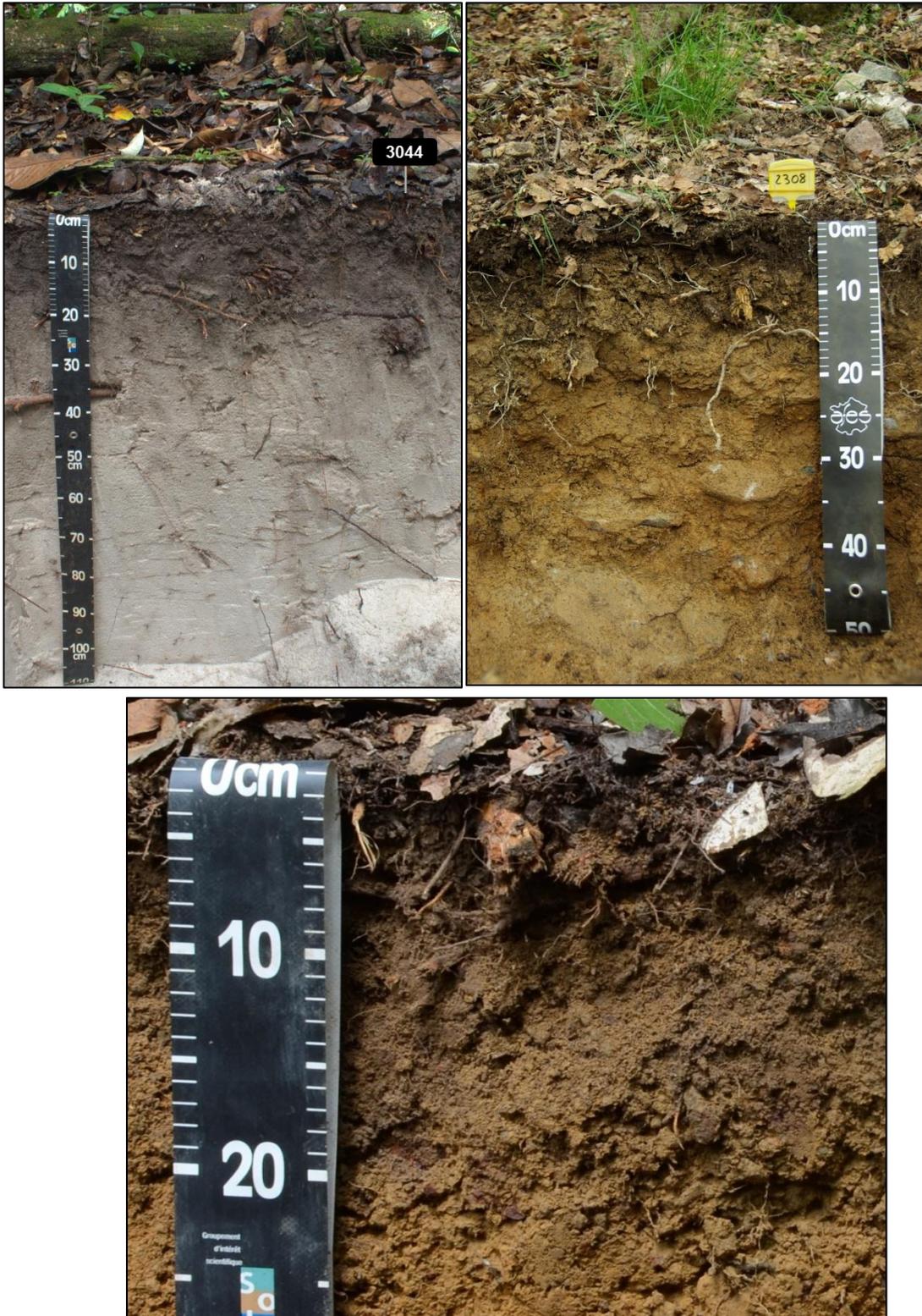
Generally, photos taken in automatic mode are of poor quality. Avoid using the flash as much as possible as it crushes the relief and alters the colours. **Preferably opt for shooting in natural light, in aperture priority mode and with the help of a tripod if the light is insufficient for hand-held photography.**

Finally, do not hesitate **to take several shots and detail shots.**

The JPEG format is standard, widely used and will be given preference. However, it is interesting to also take high-resolution pictures using the RAW format. The file contains all the data recorded by the sensor and can be likened to a negative. The data cannot be used directly, but must be converted later into, for example, JPEG or TIFF files. The advantage of this is that you can choose the transformations to be applied (e.g., for

white balance) and will be limited to the camera's default or automated settings. The disadvantage, however, is having to manage very large files.

Some examples:



### 13.3. Identification of photos



Back in the office, it is important to identify the photos clearly and consistently. The photos are named according to the following rule:

RMQS2\_sitenumbr\_profile\_ordernumber (example: RMQS2\_1591\_profile\_1)

For detail photos of the profile, additionally indicate the upper (psup) and lower (pinf) depths of the photographed detail:

RMQS2\_sitenumbr\_profile\_ordernumber\_psup\_pinf (example: RMQS2\_1591\_profile\_2\_80\_90)

### 13.4. Deliverables

- Photo files of the soil profile in jpeg format (+ raw if necessary) sent by file transfer system.

## 14. How to observe, describe and enter the soil profile?

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**This procedure describes how to observe the profile, compare it with the description made during the first campaign, validate the description or, if necessary, re-describe the soil profile and enter the description into DoneSol database.**

### 14.1. Material

- Literal description of the profile extracted from DoneSol
- RMQS1 profile description sheet
- Blank DONESOL3 profile description sheet, downloadable from the following address:  
[https://dw3.gissol.fr/fichiers/fiche\\_description\\_fosse.pdf](https://dw3.gissol.fr/fichiers/fiche_description_fosse.pdf)
- Pedological repository 2008
- Profile description material
- DoneSol-Web account

### 14.2. Comparison of the RMQS1 profile description with the new profile

Use the literal description of the profile extracted from DoneSol to compare by observation the variables described during the first campaign. There are three possible scenarios:

- **Conformity with the RMQS1 profile:** if the new profile does not include any significant variation of the variables described when compared to the first campaign, the partner will indicate on the intervention report that the description of the first campaign is validated and that it is in conformity with the profile of the second campaign
- **Partial variation with the RMQS1 profile:** if the new profile contains significant variations in some of the variables described but is globally identical to the profile of the first campaign, record the significant variations on a new DONESOL3 pit description sheet, targeting the variables concerned (soil name, horizon names, horizon depths, textures, structures, biological activity, etc.). It is also possible to annotate the original description sheet (STIPA 2000) if the variables described are close to the description of the first campaign. In that case, the partner will indicate on the intervention report that the description of the first campaign is validated with a partial redescription.
- **Complete variation with the RMQS1 profile:** if the new profile is different from the profile of the first campaign, or if the description of the first campaign is not validated, carry out a complete description of the profile using a new DONESOL3 pit description sheet. In this case, the partner will indicate on the intervention report that a new description of the profile was carried out, specifying the situation: RMQS1 description not validated or RMQS2 soil profile different from the RMQS1 profile.

### 14.3. New description of the profile or horizons

If the new soil profile is different from that of the first campaign or if the description of the first campaign is not validated by the soil scientist, then a new description of the complete profile or of certain horizons will be conducted according to the following procedure.

### 14.3.1. Operating procedure

The north wall of the pit (facing south) is usually reserved for profile description. Before describing it, refresh and clean the wall from top to bottom and from left to right (from right to left for left-handed people) to **highlight the succession of horizons and their natural structure.**

### 14.3.2. Principle

The description is done by filling in the fields of the DONESOL3 "profile" sheet. The definitions of the codes of the variables described in the sheet are available in the DONESOL3 data dictionary.

This sheet has several sections. The first five pages concern the description of the soil profile and its environment: occupation, parent materials, geomorphology, water regime, etc. The next seven pages allow the classic profile description variables to be filled in for each horizon:

- depth and variation of boundaries between horizons, importance of the transition between two horizons (the transition is the thickness of soil over which it is not possible to distinguish two successive horizons)
- texture in the chosen texture triangle
- effervescence (dilute hydrochloric acid test)
- horizon structure, aggregation mode
- horizon moisture and mechanical properties at different moisture states
- colour of the matrix, description of the spots
- description of skins and aggregate faces
- characterisation of organic materials
- traces of biological or anthropogenic activities
- pedological features: crystals, nodules, cements
- description of rooting
- description of intra- and inter-aggregate porosity (cracks, worm channels) and overall porosity
- description of the abundance and nature of rock fragments

The description is completed by drawing a diagram on the last page of the DONESOL3 profile sheet.



#### 14.4. Observation of tillage depths

In cultivated soils, where the depth of the main tillage operation is observable, **measure 10 depths of the current tillage operation** at regular intervals on the pit walls, so as to incorporate lateral variations related to the direction of tillage. If a former tillage operation can be observed on the profile, measure 10 depths of this former tillage operation using the same method. **These measurements are very important for the calculation of the element stocks and are to be recorded on the intervention report.**

#### 14.5. Entering the soil profile description in DoneSol database

The partner is responsible for entering the description of the profile observed during the second campaign into DoneSol. To facilitate the partner's task, RMQS1 profiles are duplicated in case of conformity or partial variation of the description, and in the absence of profile samples registered by the CEES. In all cases, certain mandatory information must be entered.

##### 14.5.1. Compliance of the new profile with the RMQS1 profile

Duplicate profile fields that must be modified in DoneSol:

- date of observation
- name of the author (list of collaborators)
- coded land use
- free land use

Do not modify the other fields that have been validated.

##### 14.5.2. Partial variation from the RMQS1 profile

Duplicate profile fields that must be modified in DoneSol:

- date of observation
- name of the author (list of collaborators)
- coded land use
- free land use

Modify the fields for which significant variations have been observed. Do not modify fields that have been validated.

##### 14.5.3. Full variation from the RMQS1 profile

A new complete profile must be entered into DoneSol.

**Note: In any of the cases described above, do not change the geographical coordinates, or enter "0" if these mandatory fields are empty. InfoSol will update these coordinates automatically.**

#### 14.6. Deliverables:

- DONESOL3 profile description sheet for the new profile or annotated RMQS1 sheet.

## 15. How to collect horizon samples from the soil profile?

This procedure describes how to sample horizons on the soil profile.

**Note: horizon samples should only be taken in the case of a new profile or horizon description, additional sampling requested by InfoSol, or the installation of a new site.** If one horizon is to be sampled, then sample all the horizons to ensure continuity of sampling across the profile.

### 15.1. Material

- knife
- scraper (Berthelet trowel)
- small shovel
- RMQS sampling bags, labels, rubber bands
- auger
- graduated plastic trough



### 15.2. Precautions

Before sampling, clean the pit wall thoroughly by working from top to bottom. Then take samples from the bottom up to avoid any further soiling of the cleaned wall while the samples are taken.

### 15.3. Operating procedure

If possible, within each horizon (organic, organo-mineral and mineral), **take a sample of about 2 kg** (= 1 RMQS sample bag half or two thirds full depending on the density of the horizon), **sampling across the entire width of the profile wall so as to obtain a representative sample of the horizon.**

**Any horizon described must be sampled, and any horizon sampled must have been described** (except for horizons that cannot be sampled, such as R horizons). In the event that a described horizon has no associated sample, the intervention report must **clearly explain the lack of sampling**. The numbering of the samples taken from the horizons must be consistent with the numbering of the horizons described.

Example of an extract from the intervention report:

Origin (profile, area, density)	Identifier (order number, horizon name)	Sampling depths (cm)	Sampling method/volume	Number of bags	Comments
PROFILE	N° 1 Aca	0-20	Knife	1	
PROFILE	N°2 Sca	20-30	Knife	1	
PROFILE	N° 3 Cca	30-50	Knife	1	
PROFILE	N° 4 Rca			0	Described > 50 cm but not collected

**Note: the depths given are the real sampling depths and not the limits of the horizons described.**

### 15.4. Additional pit bottom survey

If the depth of the pit does not allow the parent material to be reached, an auger boring should complete the soil profile. An interesting possibility is to auger into the bottom of the pit, which allows deeper horizons to be reached, up to 1.50 m and beyond. The survey is carried out with a metal auger (EDELMANN Ø 7 cm or French type). As the auger boring is made, the cores are placed in a graduated trough. The cores are described and photographed, with the depths marked on the trough or with two labels. The described horizons are sampled. Ensure that the horizons are described and sampled in a continuous way, so that there is no break in the succession of horizons from the soil surface.



### 15.5. Deliverables

- Completed intervention report for all the samples taken from the profile.
- If applicable, the survey photos numbered according to the following rule: RMQS2\_sitenummer\_survey\_ordernumber
- Samples of horizons bagged and labelled with reference to good practice.
- These samples should be sent to:



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INRAE Centre Val-de-Loire  
Bâtiment Qualiforsol  
2163 Avenue de la Pomme de Pin  
CS 40001 Ardon  
45075 ORLEANS Cedex 2

## 16. How to collect volumetric samples from the soil profile?

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This procedure describes how to take volumetric samples for density determination using several methods depending on the soil characteristics.

### 16.1. Material

- **Generic material**
  - Shovel, spade, digging fork, crowbar
  - knife, scraper (Berthelet trowel)
  - spatulas and trowels
  - pruning shears, scissors, pocket saw (for cutting roots)
  - folding metre
  - RMQS sample bags, labels, rubber bands
- **Material for the cylinder method (core method)**
  - 500 cm<sup>3</sup> cylinders + sinking matrix
  - plates for laying the cylinders
  - small and large mallets
  - wooden strips
- **Material for the water-based method (excavation method)**
  - short level (20 cm) to check the flatness of the prepared surface
  - annular template
  - nails for fixing the template
  - soup spoon, ladle, brush
  - transparent, thin, strong, waterproof plastic bags
  - 500 mL measuring cylinder graduated in 5 mL increments
  - water canister (5 L)
  - funnel
- **Material for the sand method**
  - Dry sand calibrated between 0.8 and 1 mm (supplied by InfoSol)

### 16.2. Sampling conditions

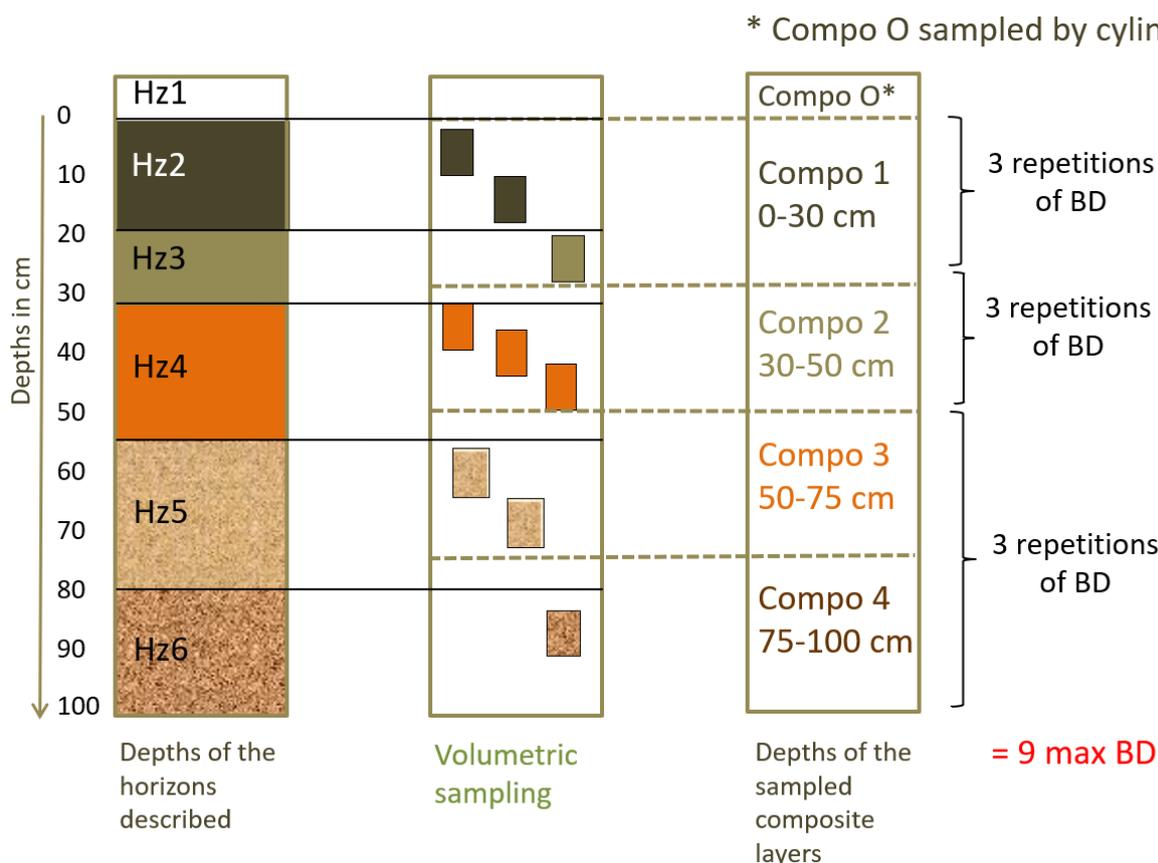
Volumetric samples should be taken under moisture conditions close to field capacity and in stabilised soil, i.e., not recently worked (ploughed, stubbled, subsoiled). See Chapter 4 for a description of suitable conditions for intervention.

### 16.3. Operating procedure

Three methods can be used: **cylinder method, water method, sand method**. Depending on the constraints of the soil (rock fragments load, root density, slope), it is up to the sampler to choose the most suitable method. **The method used can be different between two soil layers, but only one method should be used within a composite soil layer.**

It must be possible to use the density values to characterise both the layer corresponding to the composite samples and the profile horizons. Therefore, they must meet four conditions (**Figure 23**):

- To a depth of 50 cm, take at least three volumetric samples per composite layer sampled (three samples for composite 1 and three samples for composite 2).
- Above 50 cm, take at least three volumetric samples regardless of the depth reached by the composite samples (three samples for composite 3 or three samples for composites 3 and 4).
- Spread the samples vertically in the thickness corresponding to each composite layer.
- Do not position a volumetric sample between two soil horizons.
- The lower limit of the volumetric samples must not exceed the maximum depth of the last composite collected.



**Figure 23** – Principle of volumetric sampling on the soil profile, BD = Bulk density.

**Record the position of each volumetric sample on the diagram on the last page of the intervention report, indicating the limits of the soil horizons and the depths of the composite layers.**

**Note:** This example illustrates the situation in a non-tilled soil for composites 1 and 2, collected between 0-30 cm and 30-50 cm respectively. The depths at which the volumetric samples are taken must be adapted to the situation at each site and to the depths of the composites collected. These depths do not necessarily have to be identical to the depths of the volumetric samples taken during the first campaign.

**16.3.1. The cylinder method (core method)**

The cylinder method is suitable for soils with little or no gravel, stones or roots. For a precise description of the method, refer to the standard NF EN ISO 11272 (Determination of dry bulk density). InfoSol supplies 500 cm<sup>3</sup> cylinders, which are given preference. Smaller cylinders can be used, but in that case, more repetitions per layer are required.

- **Steps of the method**

<p>1. The measurement can be carried out on the surface of the soil or in the deep horizons, working on the wall of a pit cut into a step. Prepare a horizontal surface using a trowel or scraper.</p>		
<p>2. Push in the cylinder vertically. Use a sharp cylinder and, if necessary, one or two mallets to drive it in.</p>		
<p>3. Gently remove the cylinder with a knife and a spatula or trowel.</p>		
<p>4. Gently flatten the two ends of the cylinder with a knife, using a plate to place the sample.</p>		

5. Empty the cylinder into the sampling bag.	
6. Measure the depths of the sample (top and bottom) and record them on the sample bag and on the intervention report.	

**Note:** Vertical sinking of the cylinder is strongly recommended. It is mandatory in surface horizons, but horizontal sinking of cylinders is also possible at depth.

**16.3.2. The water method (excavation method)**

The water method is an excavation method adapted to gravelly or rocky soils, or in the presence of a high density of roots. It corresponds to an adaptation of the method described in standards NF X 31-503 and NF EN ISO 11272. The methodological modifications concern the principle, the material and the field procedure. Everything related to the definitions, the expression of the results and the laboratory procedures (material and operating mode) is in accordance with the mentioned standard.



In the field, after the soil has been levelled, the operation consists of creating a cavity, collecting all the soil (to measure its mass and water content in the laboratory), placing a watertight plastic bag in the cavity and then filling the bag with water to determine the volume of the cavity.

- **Steps of the method**

1. The measurement can be carried out on the surface of the soil or in the deep horizons, working on the wall of a pit cut into a step. Prepare a horizontal surface using a trowel or scraper. A perfect flatness (checked with the level) must be obtained, using the knife and the scraper, before digging the cavity.		
2. Place the template on the floor and secure it with nails. Check the flatness with the level.		

<p>3. Dig a cavity, collecting all the soil extracted in the sampling bag, without losses (use the brush to collect any losses that have fallen onto the template and any small aggregates remaining at the bottom of the cavity). Depending on the condition of the soil, dig with a knife, spoon or ladle. The diameter of the cavity should correspond to the template and the depth of the cavity should be adjusted according to the thickness of the horizon. Be sure to take a volume between 1,000 and 1,500 cm<sup>3</sup>. The shape of the cavity is not important, but its edges should be as regular as possible: avoid indentations and outcrops of sharp or pointed rock fragments that could puncture the bag used to measure the cavity volume.</p>	
<p>4. Place the plastic bag in the cavity and press it against the walls. Fill the bag with water using the measuring cylinder until the surface level is reached. Ensure that the plastic bag adheres well to the walls of the cavity by correcting the adhesion with the spoon as you fill it. The volume of soil removed corresponds to the total volume of water poured into the cavity. Record the measured volume on the sampling bag and on the intervention report.</p>	
<p>5. Measure the depths of each sample (top and bottom) and record them on the sampling bag and on the intervention report.</p>	

- **Precautions and special cases**

The main difficulty with this method is to obtain a surface that is sufficiently flat to allow the water level to be adjusted precisely to the ground surface. Therefore, this method is not suitable for small volumes. On the other hand, it should be used when the cylinder method is difficult to use i.e., in the presence of gravel or stones, in the presence of roots, or in very clayey horizons. The stonier the soil and the larger the pebbles

(stones or boulders), the larger the volume of the cavity should be to improve the accuracy of the measurement: favour a volume close to 1,500 cm<sup>3</sup>.

**Tip:** A second sampling and measurement can be conducted using the first cavity made. In fact, the cavity can be deepened again, and the extracted soil collected, and the volume can be measured over the entire cavity. The volume of the second sampling will be deducted from the total volume measured, minus the volume of the overlying sample measured. This method does not require a flat surface. It is only feasible for two successive repetitions, due to the difficulty of extracting soil beyond 20 cm and a 3 L bag of water.

### 16.3.3. The sand method

**The sand method is an excavation method suitable for gravelly or stony soils, or where there is a high density of roots.** The sand method is described in the standards NF X 31-503 (Measuring of the bulk density - Sand method) and NF EN ISO 11272 (Determination of dry bulk density). It differs from the water method in that calibrated sand is used instead of water to measure the volume of the sampling cavity (step 4). All other steps of the method (steps 1, 2, 3 and 5) are identical. Its main advantage over the water method is that it does not require a perfectly flat surface to accurately measure the volume of the cavity. This is because the sand can be adjusted to the surface of a cavity where the edges are not level. Up to a certain degree, corresponding to the flow limit of the sand, the measurement can be carried out on a sloping ground.

- **Measuring the volume of the cavity with the calibrated sand (step 4)**

4. Place the plastic bag in the cavity and press it against the walls. Fill the cavity with calibrated sand using the measuring cylinder until the surface level is reached, pouring in the sand from a height of 5 cm to ensure an even distribution. Ensure that the plastic bag adheres well to the walls of the cavity by adjusting the adhesion as you fill it. The volume of soil collected is the total volume of sand poured into the cavity as measured with the measuring cylinder. Record the measured volume on the sampling bag and on the intervention report.



- **Precautions for using calibrated sand**

The calibrated sand can be reused without time limit. Make sure it is completely dry before each new use. Dry it at 105°C before the start of each year's campaign.

### 16.3.4. The clod method (special cases)

The measurement of the density of certain hardened horizons (iron pan, iron crust, etc.) requires the collection of small fragments of horizons of a few cm<sup>3</sup> and the use of the clod method (NF EN ISO 11272). Collect and condition the samples according to the method described in chapter 17. Specify the nature of the samples and their destination on the sampling box and on the intervention report. Inform the CEES rapidly: [conservatoiredeessols@inrae.fr](mailto:conservatoiredeessols@inrae.fr)

#### 16.4. Deliverables

- Intervention report completed with the details of the volumetric samples collected and the diagram positioning the samples on the profile.
- Volumetric samples bagged and labelled in accordance with good practice.



**Note: To facilitate the registration of the samples by the CEES, the numbering of the volumetric samples (BD) should be from BD1 to BDI9 on the labels and on the bags.**

- These samples should be sent to:

**Conservatoire européen des échantillons de sols**

INRAE Centre Val-de-Loire

Bâtiment Qualiforsol

2163 Avenue de la Pomme de Pin

CS 40001 Ardon

45075 ORLEANS Cedex 2

## 17. How to collect clod samples?

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**This procedure describes how to take volumes of soil from a horizon while maintaining the natural macroscopic structure to estimate the available water content of a profile horizon.**

These samples only concern the RMQS sites **selected** in the annual sampling plan to perform water content measurements at different water potentials to estimate the available water content.

**Note: when a site is selected, all organo-mineral and mineral horizons at least 10 cm thick should be sampled.**

### 17.1. Material needed

- Spade, shovel, digging fork
- rubber mallet, hammer
- pickaxe, toothed scraper, knives
- measuring tape
- wide adhesive tape
- permanent markers
- sealed rigid plastic boxes with a minimum volume of 4 L to 5 L (supplied by InfoSol)
- transport box
- synthetic foam/bubble wrap
- gloves are recommended



### 17.2. Sampling conditions

**The ideal soil moisture conditions for sampling correspond to those of the field capacity** (see Chapter 4 for a description of suitable conditions for intervention).

In fact, in the field, the structural state observed largely depends on the moisture content of the horizon. Thus, a horizon rich in swelling clays, which presents a massive aspect in a wet state, is likely to shrink and divide strongly in a dry period. Therefore, structure is a property that expresses itself more, or less, and also differently over time, according to seasonal cycles or according to meteorological events.

In addition to the indications given above, sampling in conditions that are too dry would not be in compliance with the measurement methodology, which consists of extracting water from the soil at different potentials. Conversely, sampling under too wet conditions, apart from the fact that it would not allow the release of ideally expressed structural elements, would lead to the settlement of the collected samples during their transport.

### 17.3. Operating procedure

Samples are taken from the top to the bottom of the profile.

<p>1. Remove a layer of soil of about 2 cm on the upper limit of the horizon with a knife.</p>	
<p>2. Use a toothed scraper to obtain a horizontal plane.</p>	 A person wearing a blue jacket and boots is standing next to a soil profile. They are using a toothed scraper to level the top surface of the soil. A black measuring tape is visible on the left side of the profile. The number 2 is in the bottom right corner of the image.
<p>3. Push the blade of a knife onto the lower limit of the horizon.</p> <p>4. Crumble some soil from the horizon to be sampled into the bottom of the sample box (this crumbled soil layer will somewhat dampen the shaking when the samples are transported in the box).</p>	 A person wearing a blue jacket and gloves is kneeling next to a soil profile. They are using a knife to push soil into a white sample box. A black measuring tape is visible on the left side of the profile. The number 3 is in the bottom right corner of the image.
<p>5. Carry out a superficial scraping / picking of the vertical surface of the horizon to be sampled to remove any particles that have fallen from the overlying horizon. This action also enables the identification of any rodent galleries or other small burrowing animals, as well as the presence of pebbles, rocks, buried residues, etc.</p>	
<p>6. Position the digging fork vertically, set back 20 cm from the wall of the profile, and drive it in <math>\pm</math> 15 cm with a rubber mallet. Gently tilt the digging fork towards you while holding the volume(s) taken.</p>	 A person wearing a blue jacket and gloves is kneeling next to a soil profile. They are using a red digging fork to take a sample from the soil. A black measuring tape is visible on the left side of the profile. The number 6 is in the bottom right corner of the image.

<p>7. Place volumes of soil of decimetric size into the box, if the structure allows it.</p>	
<p>8. The box will then be filled up with smaller volumes (bearing in mind that the smallest size on which measurements are made in the laboratory is: <math>\pm 3</math> cm).</p> <p>Note: add only soil from the horizon and do not add paper, moss or any other material that can spoil or absorb soil moisture to fill up the box, as this may compromise the validity of the usable reservoir measurement.</p>	

When packing volumes of soil into the box, manually remove as much as possible from the areas smoothed by the tines of the digging fork or by the blade of the knife.

#### 17.4. Specific cases

The collection of coherent clods may be difficult to achieve in the following cases:

- Horizons with a structure that does not offer sufficient cohesion to collect clods (e.g., particulate structure).
- Horizons with a high proportion of gravel, pebbles and/or stones.
- Horizons with high root density.
- Significant presence of plant debris.

In this case, **take the horizon as it appears** by simply removing stones and large roots. Fill a sample box as completely as possible. Another method (fine soil protocol) will be used in the laboratory to measure the water content at different water potentials.

**Whatever the situation, the quantity of samples needed to make the measurements is one box per horizon.**

#### 17.5. Packaging

- Make sure that the lid is correctly positioned on the transport box and that the box is tightly closed all around the box/lid contact.
- Mark on the wide adhesive tapes, affixed on the side and lid of the box, the references of the horizon regarding the following three items: Name of the site / Upper and lower depth of the horizon / Date of sampling.

- Place the boxes in the designated cartons with foam packing.
- The boxes containing the samples taken are best kept in a cold room at 4°C, or, failing that, in a cool room (to limit biological activity and condensation) and in the packaging intended for their dispatch.

### 17.6. Deliverables

- Intervention report completed for these samples of clods
- Sample boxes packed in designated cartons with foam packaging in accordance with good practice.
- These samples should be sent to:



#### **Conservatoire européen des échantillons de sols**

INRAE Centre Val-de-Loire

Bâtiment Qualiforsol

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*This protocol is based on the following document: Gaillard H., Giot G., 2008. Mode opératoire INRAE UR 0272  
Reference: MO-MET-26. Prélèvement d'échantillons de mottes de sol d'un ou plusieurs horizons, 8 p.*

## 18. How to collect samples to determine the rock fragments content?

---

**This procedure describes the method for taking samples for the determination of the rock fragments content of the profile horizons.**

These samples only concern the RMQS sites identified during the first campaign as having a **rock fragments content greater than 10% and selected in the annual sampling plan for the conduction of measurements to estimate the soil useful water reservoir**. The number of horizons to be sampled in the file listing the sites by year is **indicative** (estimated from the profile horizons described in campaign 1) and this number must be adjusted according to the reality of the field. If, in the field, the soil scientist finds a rock fragments content below 10%, the sampling will be useless for the horizons concerned.

### 18.1. Material

- Shovel, spade, digging fork, crowbar
- Plastic rubble bags and woven over-bags
- Hose clamps (Colson clamps)

### 18.2. Sampling conditions

Sampling will be facilitated when the soil moisture is close to field capacity (drained soil).



The pit should be wide and deep enough to collect a sufficient quantity of samples that are representative of each horizon in the profile.

### 18.3. Operating procedure

This involves taking soil samples of **20 kg** per horizon. The horizons to be sampled were previously selected from the rock fragments contents measured during the first campaign. The value recorded in the first campaign within a horizon may not exactly correspond to the new profile opened, due to the variability of the terrain. Samples must still be taken for any horizon of the new description recording a rock fragments content greater than 10%.

#### 18.3.1. Implementation

Due to the high level of soil disturbance associated with these samples, they should be taken last in the profile. Start sampling from the surface.

On the first horizon, use a spade or digging fork to mark out the area to be sampled. Pour the shovelfuls of the horizon into the rubble bag. Weigh the sample on the scale and note the mass on the report.

Between two samples, be careful to avoid mixing horizons, by neatly clearing the underlying horizon. After the surface sampling, a roughly flat area should be marked out again from the upper part of the underlying horizon and then, proceed as for the previous horizon.

**Note: The sample should not be taken during the digging of the pit. It should be carried out according to the horizons described, without sorting or discarding rock fragments so as not to bias the determination of the gravel, pebbles, stones and blocks content.**

Do not overload the bag, use one bag for the entire horizon. We recommend a **20 kg bag**. **Woven rubble bags will be provided by InfoSol to double up on the sampling bags**, so that they are more durable.

### 18.3.2. Identification of samples

The samples will be identified by double labelling: one label placed inside the bag and the other one hung on the hose clamp.

### 18.4. Deliverables

- Completed intervention report for these samples.
- Samples bagged and labelled according to good practice. These samples should be sent to:



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## 19. How to observe and describe the surroundings of an RMQS site?

---

**This procedure describes the method to be used to observe and describe changes that have occurred in the surroundings of the site since the first campaign.**

The objective of the observation of the site surroundings is to characterise the environment and the occupation of the plots in the immediate vicinity of the site. The aim is to detect possible sources of contamination in the vicinity of the site and to record any changes that may have occurred between the first and second campaigns. This information will be used to interpret the analytical results.

### 19.1. Observation equipment and supports

- Camera
- Compass (GPS compass can be used)
- Photos from the first campaign
- Depending on availability, orthophotos at the date of the first sampling (RMQS1) or more recent ones

### 19.2. Operating procedure

#### 19.2.1. Taking new photographs of the surroundings:

The photographer stands in the centre of the sampling area and takes pictures in the eight cardinal directions (N, NE, E, SE, S, SW, W, NW), to cover the entire field of view around the site (360°). Take the first photo in the northern direction and then turn clockwise. **Additionally, take one or more general photos of the whole site** from a distance, when the perspective allows it.

**Note:** Take care to choose the right time of day to take the photos to avoid backlighting effects. Several series can be taken at different times of the day so that the eight best photos can be selected.

Back in the office, it is important to identify the photos clearly and consistently. The photos are named in the direction in which they were taken, i.e., starting from the north and turning clockwise, according to the following pattern:

#### RMQS2\_sitenumbr\_envt\_photonumber\_direction

Example:

RMQS2\_1591\_envt\_1\_N  
RMQS2\_1591\_envt\_2\_NE  
RMQS2\_1591\_envt\_3\_E  
RMQS2\_1591\_envt\_4\_SE  
RMQS2\_1591\_envt\_5\_S  
RMQS2\_1591\_envt\_6\_SW  
RMQS2\_1591\_envt\_7\_W  
RMQS2\_1591\_envt\_8\_NW



### 19.2.2. Comparison of observations with previous documents

This work can be initiated in the office and completed in the field. The aim is to compare the available orthophotos over the period between the two intervention dates with the observations made during the intervention on the site. The objective is to identify changes in:

- urbanisation (housing, road and rail infrastructures, etc.).
- industrial activity as a potential source of contamination.
- the use of the surrounding plots.
- landscape features and structures: disappearance or establishment of hedges, ditches, etc.

**All the changes observed should be recorded on the most recent orthophoto possible by circling or positioning new features in relation to the previous campaign. Complete the intervention report as well.**

### 19.3. Deliverables

- Photos of the surroundings, in jpeg format and named according to the rules defined above. The photos should be sent to InfoSol by file transfer as soon as possible after the intervention and, at the latest, within 3 months after the intervention date, referring to good practice. 
- Annotated orthophotos digitised according to the following model:  
**RMQS2\_sitenummer\_orthophoto\_photonumber**
- Completed intervention report.

## 20. How to carry out the surveys on history and management practices?

---

**This procedure describes how to carry out surveys on the history and management of the plot since the first campaign intervention.**

The aim of the survey is to collect information on the history and the past and current management of the plot since the first campaign intervention. It also allows the validation or completion of information collected during the first campaign. The purpose of this survey is to collect auxiliary data, which will be used in the analysis of the RMQS data and for various modelling studies, in particular those aiming to evaluate the soil capacity to store carbon. The results of the first campaign surveys were also used to calculate pressure indicators related to cropping practices, to carry out a typology of cropping systems, and to analyse the representativeness of cropping systems.

This survey can also be used to check that the conditions are right to intervene, in terms of plot accessibility, cultivation stage and soil tillage.

### 20.1. Material

- Main survey form for occupations:
  - field crops
  - permanent grassland
  - vineyards and orchards
- Survey form for forests (excluding RMQS-BioSoil sites)
- “Annual crop itinerary” form attached to the main survey form for field crops
- Appendix form for details of practices in permanent grassland
- Appendix form for details of practices under vines and orchards
- Surveyor’s guides for field crops, permanent grassland and vineyards and orchards occupations and surveyor’s guide for forestry.
- Survey carried out during the first campaign
- Orthophoto or location plan of the plot

**The blank survey forms, their annexes and the surveyor's guides (documents in French) can be downloaded from the GIS Sol website at the following address: <http://www.gissol.fr/le-gis/programmes/rmq-34>.**

### 20.2. The surveys include the following general headings:

- Methods for carrying out the survey
- Presentation/Validation of the survey content of the first campaign
- Identification of the owner/manager/forester or farmer and personal details
- General information on the farm (survey of field crops, permanent grassland and vineyards-orchards)
- General information about the plot
- Stand characteristics and management (forest survey)
- Details of practices (headings depend on occupations) in the inter-campaign interval
- History of occupations and practices

- Future of the plot
- Investigator's perspective

### 20.3. Operating procedure

The interviewer should be a person competent in management or farming practices for a given occupation and able to judge the relevance of the information collected.

The interviewee is the plot farmer or manager, or any person with access to the practice records.

**The most effective way to complete the questionnaire is with the farmer or manager, by asking the questions orally in the manner of an interview.**

When making an appointment or during the first contact, it is recommended that the interviewer presents the content of the survey to the respondent and asks them to prepare the records of their practices on the plot **since the last intervention for the RMQS.**

To optimise and limit the duration of the interview, the interviewer can prepare the interview by pre-filling in the questions for which the information is known and by selecting the questions concerning the plot and the farm. It is also possible to request the records in advance, to pre-fill the survey and to devote the interview with the farmer or manager to the further completion of the survey.

The interviewer will ensure that the information collected relates to the plot where the first campaign site is located, by presenting an orthophoto or the plot location plan to the respondent.

In the event of a change of farmer or manager since the first campaign, the interviewer should check the number of successors since the last intervention for the RMQS. To ensure continuity of information on practices since the last campaign, the interviewer will meet with the successors as needed to collect missing information on practices.

The survey may be carried out after the day of the intervention on the site. In that case, a certain amount of information will have to be collected before the intervention, such as the crop or occupation of the plot, the last soil tillage or inputs carried out, ongoing grazing, the crop stage, or any developments affecting the soil:

- to check the accessibility of the plot,
- to find out about any change of occupation,
- to determine the most relevant intervention period.

The form will be filled in according to the relevant parts (technical itineraries, details of practices) based on the farmer or manager's records as far as possible, and the headings will be filled in as accurately as possible. We leave it to the interviewer to judge whether it is useful to carry over certain information from the records into the survey or whether the record is clear enough to answer the question asked.

The interviewer should refer to the survey guide and ensure that the information provided is consistent.

The survey materials are in paper format. The questionnaires can be filled in manually, in which case it is expressly requested that the **handwriting be legible** to facilitate the reading of the answers (for example, avoid writing outside the boxes or on the back). The survey tables can be duplicated, if necessary, to provide additional information. The annual crop itinerary form will be duplicated to fill in the technical itinerary of each crop surveyed.

InfoSol will be responsible for analysing the responses and may contact the interviewer again for further information if necessary. The survey will be considered completed by the partner when the requested further information has been provided.

Copies of the records obtained in paper or digital form will be forwarded to InfoSol.

**Note:** Personal data concerning the farmer, manager or owner will be entered into a secure database held by InfoSol and declared to the CNIL. The respondent will have the right to access, modify or delete this data in accordance with the regulations in force.

#### 20.4. Deliverables

- The scanned survey forms completed and any copies of the recordings will be sent to InfoSol by file transfer as soon as possible after the intervention and within a maximum of 3 months after the intervention date, referring to good practice. 
- **Format for naming scanned survey form files:**
  - RMQS2\_sitenumbr\_survey, for the main survey body
  - RMQS2\_sitenumbr\_survey\_annex\_ITK, for the crop itinerary form
  - RMQS2\_sitenumbr\_survey\_annex\_pp, for the permanent grassland annex
  - RMQS2\_sitenumbr\_survey\_annex\_vv, for the vineyards and orchards annex
  - RMQS2\_sitenumbr\_survey\_records, if a copy of a farmer's record is provided (soil analyses, practice records, copy of a logbook, etc.)
  - RMQS2\_sitenumbr\_survey\_forests, for surveys of forest plots outside BIOSOIL

## 21. How to transfer GPS data?

This document is both an instruction manual for the GEO7X GPS and an operating manual describing how to download the GPS files and import the waypoints transmitted each year.

### 21.1. Material

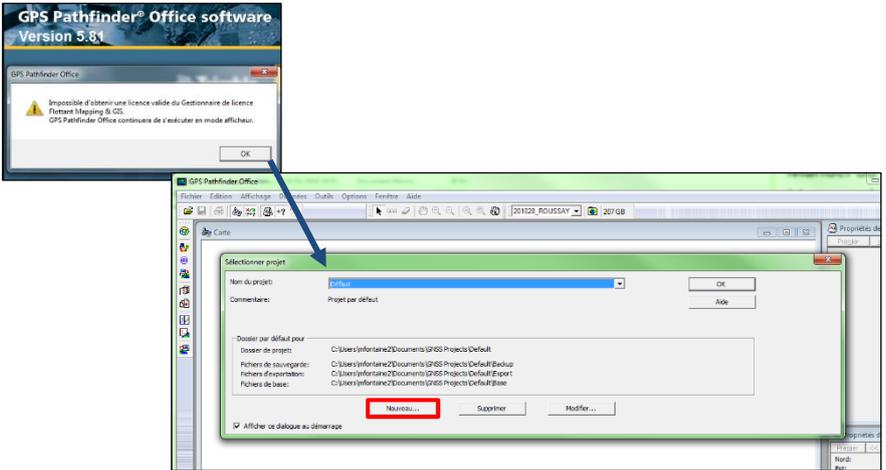
First install the Windows Mobile Device Manager, which can be downloaded from the following addresses

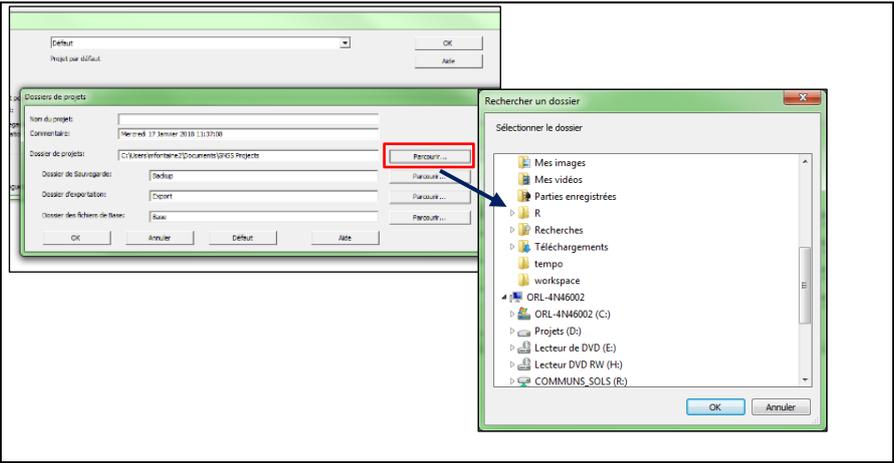
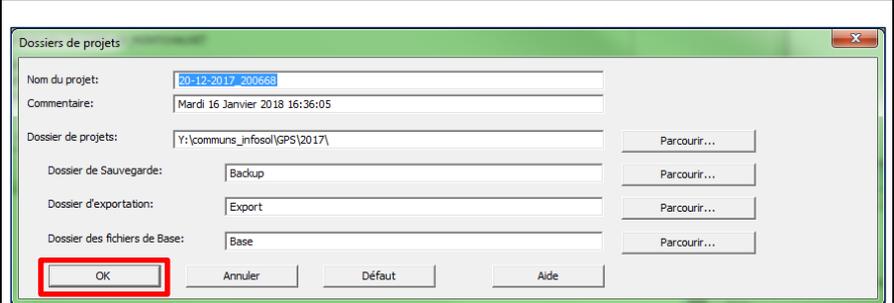
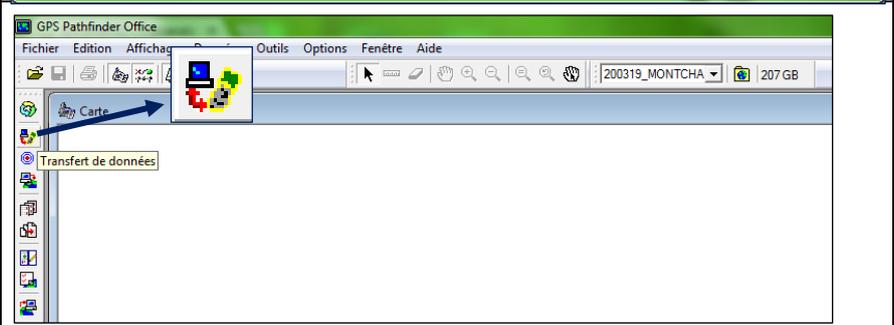
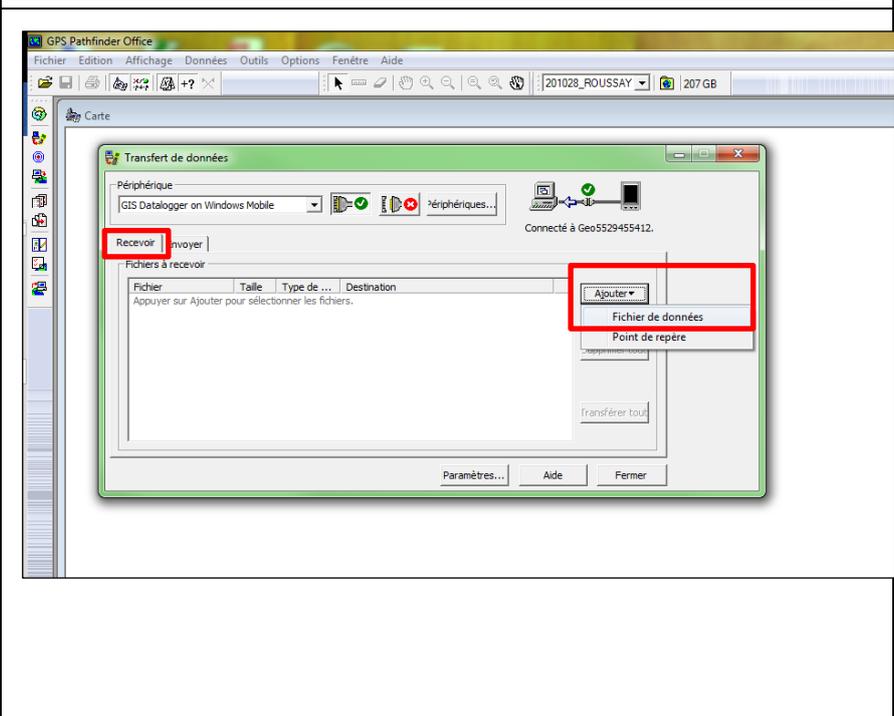
64 bits: <https://www.microsoft.com/fr-fr/download/confirmation.aspx?id=3182>

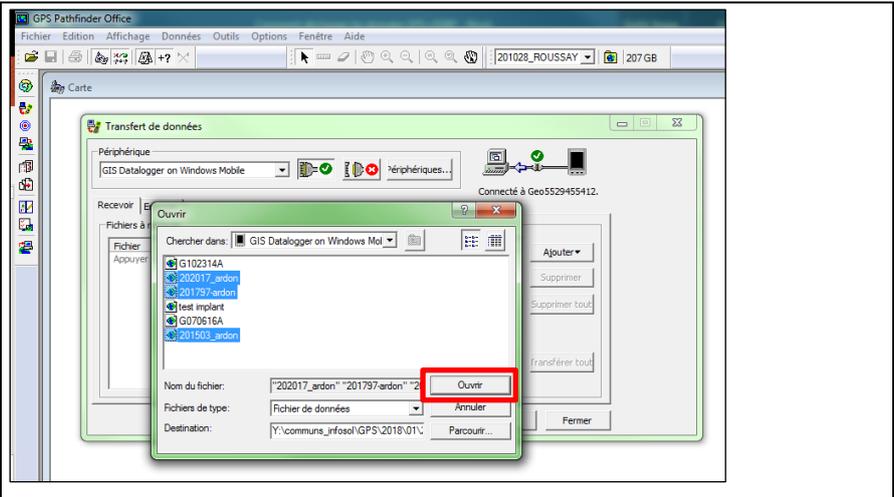
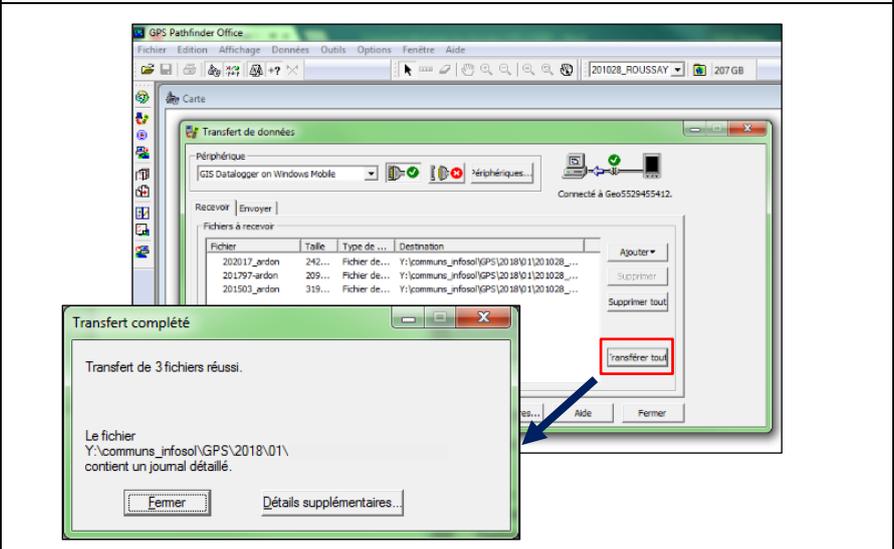
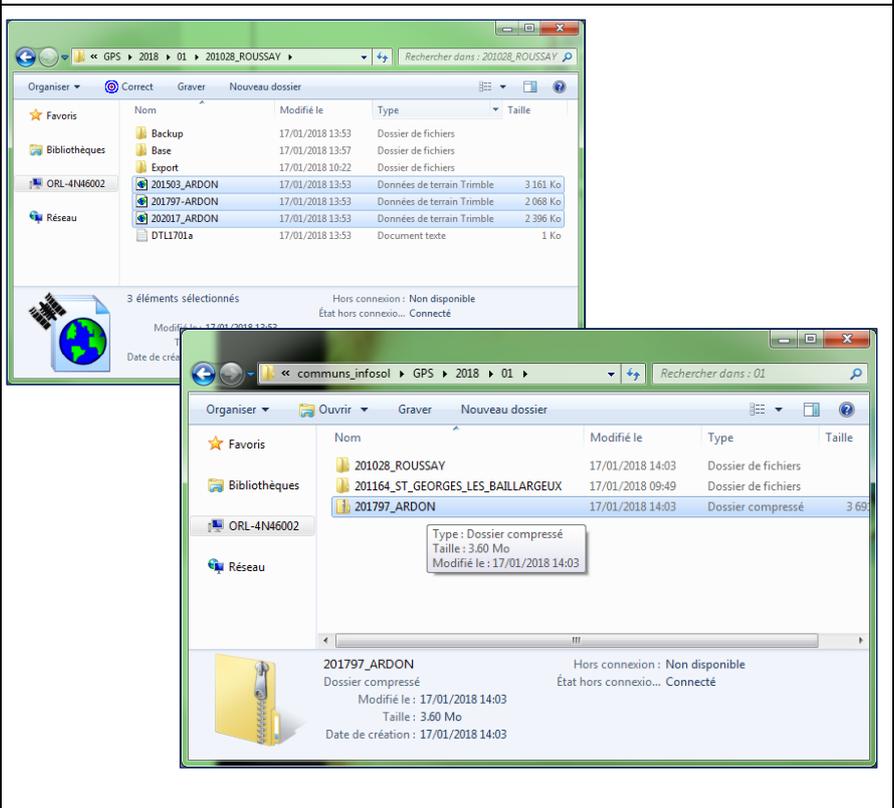
32 bits: <https://www.microsoft.com/fr-fr/download/details.aspx?id=14>

### 21.2. Downloading GPS survey files

(In the following section, all the computer screenshots are in French)

<ul style="list-style-type: none"> <li>&gt; Connect the GPS receiver to your computer via the USB cable</li> <li>&gt; Switch on the receiver</li> <li>&gt; A <b>Windows Mobile Device Manager</b> window appears on the screen</li> <li>&gt; Wait a moment for the GPS to be recognised by the computer: the image of the GPS appears on the left of the window with the words "<b>Connected</b>"</li> </ul>	
<ul style="list-style-type: none"> <li>&gt; Launch the GPS Pathfinder Office software: </li> <li>&gt; The window opens, and a message appears: click on "<b>OK</b>" to use the software in display mode</li> <li>&gt; GPS Pathfinder launches and opens a "<b>Sélectionner projet</b>" window, click on "<b>Nouveau</b>".</li> </ul>	

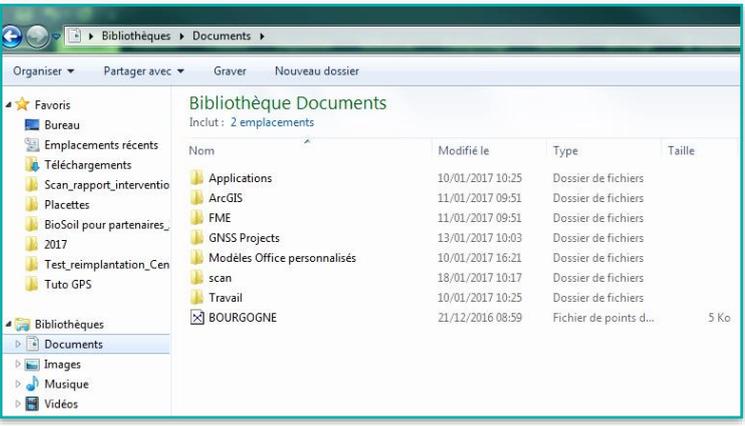
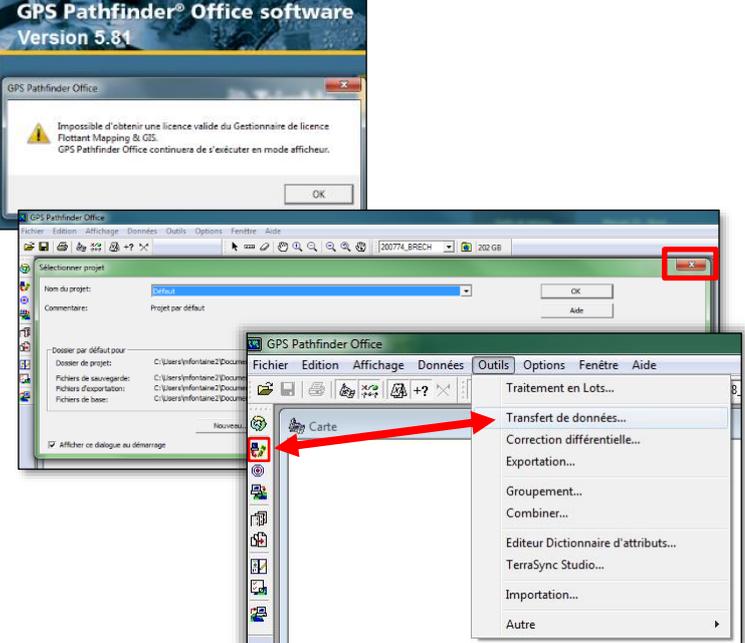
<p>&gt; Click on "<b>Parcourir</b>" and choose the appropriate place to store the files to be transferred</p>	
<p>&gt; Name your project in a way that it can be easily identified later, for example in the format: <b>dd-mm-year_site-number</b></p> <p>&gt; Validate by clicking on "<b>OK</b>".</p>	
<p>&gt; Then click on the data transfer icon in the bar on the left of the screen.</p>	
<p>&gt; The window "<b>Transfert de données</b>" opens</p> <p>&gt; Click on the tab "<b>Recevoir</b>"</p> <p>&gt; Then "<b>Ajouter</b>" &gt;&gt; "<b>Fichier de données</b>"</p>	

<p>&gt; Select the files to be transferred</p> <p>&gt; Click on "Ouvrir"</p>	
<p>&gt; Select "Transférer tout"</p> <p>&gt; Once the download is complete, close the software</p>	
<p>&gt; Go to the address of the folder containing the transferred GPS files</p> <p>&gt; Compress this folder</p> <p>&gt; Send the resulting archive by e-mail or by a file transfer module for attachments larger than 5 MB to the following address <a href="mailto:correspondants-gps@inrae.fr">correspondants-gps@inrae.fr</a></p> <p><i>Please specify in the email which sites correspond to the attached files and the days of the surveys.</i></p>	

**21.3. Import a waypoint file into the GPS**

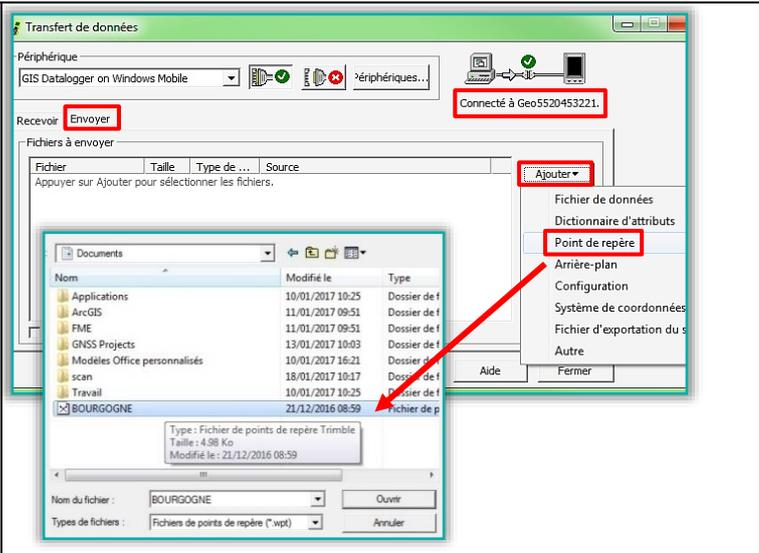
This tutorial allows you to load waypoints onto the GEO7X GPS from a file received by email. It will allow you to navigate and implement the RMQS and RMQS-BioSoil sites of the year. It is based on a video available on Youtube at the following address: <https://youtu.be/bqVkf1D3fGA>

(In the following section, all the computer screenshots are in French)

<p>&gt; After receiving the email with the attached RMQS and RMQS-BioSoil waypoint files, download the files named by region, for example "<b>BOURGOGNE.wpt</b>" then, save them onto your disk in "<b>Téléchargements</b>"</p> <p>&gt; Copy and paste the file "<b>BOURGOGNE.wpt</b>" in a working directory, such as "<b>My documents</b>"</p>	
<p>&gt; Open the tool "<b>Gestionnaire pour appareils Windows Mobile</b>"</p> <p>&gt; Connect the GPS and wait a moment for the device to be recognised by the software</p>	
<p>&gt; Launch the software <b>GPS Pathfinder Office</b></p> <p>&gt; The window opens, and a message appears: click on "<b>OK</b>" to use the software in display mode</p> <p>&gt; GPS Pathfinder launches and opens a window "<b>Sélectionner projet</b>"</p> <p>&gt; Close the window as it is not necessary to be in a specific directory for this operation.</p> <p>&gt; Go to "<b>Outils</b>", then "<b>Transfert de données</b>"</p>	

> Make sure the GPS is connected to the PC, select the tab "Envoyer" and go to "Ajouter", "Point de repère".

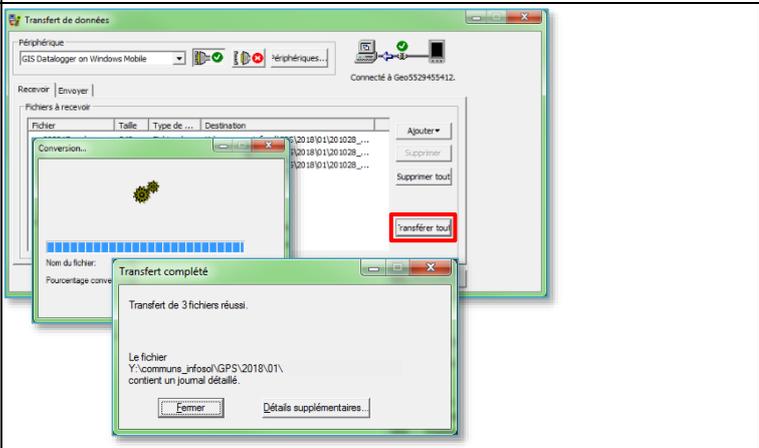
> Select the file "BOURGOGNE" containing the waypoints located in "Mes documents" and click on "Ouvrir"



> Click on "Transférer tout"

> After loading onto the device, a message indicates that the file has been successfully transferred to the GPS.

> Close the GPS Pathfinder software.



> To check the data transferred to the GPS, disconnect the GPS from the PC and start TerraSync

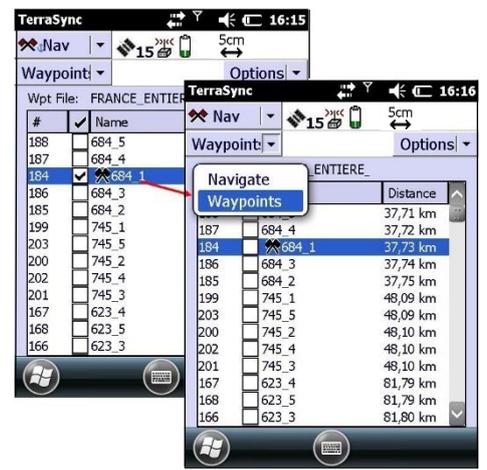
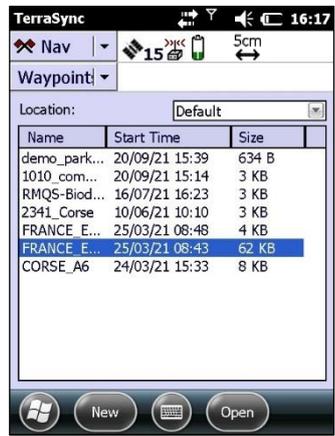
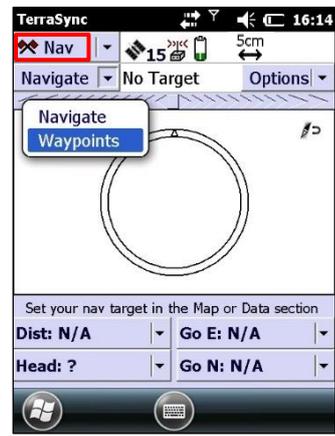
> Go to the menu "Nav", then "Waypoints"

> Click on the wanted region, then on "Open"

*At this point, all the waypoints of the RMQS sites in the selected region are displayed on the screen, it is possible to sort them by name or by distance.*

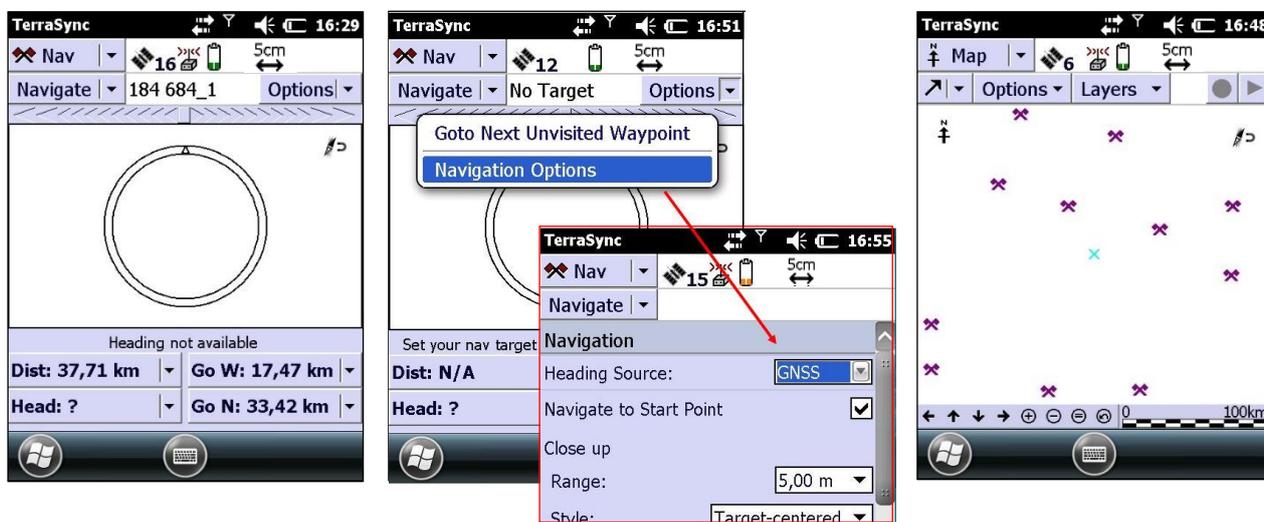
> Double click to select the point to navigate to

> Then go to the tab "Waypoints" and select "Navigate"



> At this point, a navigation window appears and TerraSync defines your distance to the selected point.

> By selecting "Navigation" and then "Map", the points can be viewed on a background map:



If you have any questions, please send an e-mail to the following address: [correspondants-gps@inrae.fr](mailto:correspondants-gps@inrae.fr)

## 22. How to return the results to the owners/managers/foresters and farmers of the RMQS plots?

---

**This procedure describes the reporting of results and information by the regional partner and by InfoSol.**

### 22.1. Annual reporting of results

In accordance with the agreement with the owner/manager/forester or farmer, the partner is responsible for returning the physico-chemical analyses and the field observations carried out (soil description and agronomic interpretation if applicable).

In the first instance, direct interaction is usually highly valued by the owners/managers/foresters and farmers on the day of the site installation, when the soil pit is opened. The soil scientist may present a soil description and agronomic interpretation, if appropriate.

In a second phase, when the analytical data are available, the partner will be able to return these data, together with the pedological observations. The modalities and format of the restitution of these data will be at the discretion of the partner. A commentary on the analyses can be made by the partner. Otherwise, InfoSol will provide partners with a formatted document presenting the results per site and accessible *via* the DONESOL-WEB interface (document in PDF format).

### 22.2. Final restitution

At the end of the campaign, InfoSol will organise a national presentation of the results obtained during the campaign to all the owners/managers/foresters and farmers of the plots concerned by an RMQS site.

### 22.3. Information on the RMQS2 programme

InfoSol will regularly inform the owners/managers/foresters and farmers of plots related to an RMQS site about the progress of the national RMQS2 programme, by means of an annual newsletter that will be sent to them by e-mail or by post.

### 22.4. Deliverables

- Documents returned to owners/managers/foresters and farmers



## 23. Guide to good practice at an RMQS site

### General guidelines

#### Optimal sampling conditions

Weather conditions: **Work should be avoided during periods of drought or excessive humidity, not only because of the physical difficulty of taking quality samples, but also for reasons of observation accuracy.**

Soil condition, cover: in cultivated soils, ideal conditions for description and sampling are achieved when the soil is settled. Allow the soil to settle naturally after tillage for a few weeks before taking samples. **Avoid sampling in soil that has been recently ploughed, stubbled or subsoiled.**

#### Orientation of the device

In the RMQS2 campaign, the site is oriented as in campaign 1 in all cases, using the orientation corresponding to the numbering of the corners of the sampling area provided by the GPS.

#### Sampling depths for composites 1 and 2

Sample composites 1 and 2 at the same depths as in campaign 1, unless there is a change in land use, or unless we advise against it. Refer to chapter 11 and in case of doubt, contact InfoSol.

#### Washing of the equipment

Before any sampling, it is necessary to ensure that the equipment used (augers, knives, sampling shovels, buckets, mixing containers, etc.) does not cause any interference (pollution or loss) with the elements being analysed and does not contaminate the sample with trace elements: equipment made of copper, brass, galvanised or chromium-plated steel or covered with paint should therefore be avoided. Plastic or raw steel tools should be given preference. Plastic buckets and tubs (polyethylene or polypropylene) that can be carefully washed are to be used for sampling.

**To avoid any risk of direct or cross-contamination, all sampling tools must be washed thoroughly with water and then rinsed with demineralised water: between two horizons of the profile, between two composites of the sampling surface and, of course, between two sites. Composite samples are collected and crumbled with latex gloves to avoid any exogenous DNA in the sample.**

#### Conditioning of samples

Composite, profile horizon and volumetric samples are packaged in RMQS type collection bags, annotated with their content information. All this information is repeated on the yellow label. The clod samples are packed in plastic boxes. The samples for the rock fragments measurements are packaged in large specific bags. A summary of the samples is recorded in the intervention report.

**After collection and before dispatch, store the samples at a temperature close to that of the sampling, i.e., a sample taken in winter should not be stored near a radiator in the office and conversely, a sample taken in summer under high temperatures should not be stored in a refrigerator but in a temperate place. Caution: avoid leaving samples in a vehicle in direct sunlight. Always favour a rapid dispatch of samples, no storage in the refrigerator (except for the clods).**

#### Tips for bagging samples:

- Empty the air from the bags, to prevent them from bursting.
- Do not fill the bags beyond the top level of the white inset.
- Close the bags with the rubber bands by placing them in the upper part of the bag so that the information written on the white inset remains visible for easy reading by the conservatory staff.

#### Tips for packaging samples:

- Put the bags upright in the boxes.

- Check that the rubber bands are in place and properly tightened.
- Fill in the gaps in the boxes with newspaper.
- Composite, pit and BD samples from the same site can be packed together in the same box to optimise box filling, but **do not mix samples from different sites in the same box.**

Check that the plastic boxes used to pack the clods are closed, and tape them up if necessary.

## Deliverables (see list on page 127)

### The samples:

Send samples by noon on Thursday at the latest, for delivery to destination on Friday.

**The original Intervention Report (IR) or a hard copy of the IR must be sent along with the samples** to allow the conservatory to accept the samples. As soon as the samples are sent, **please also send a scanned version of the IR (3-page PDF)**, indicating the number of the site sent in the "subject of the email" to [conservatoiredeessols@inrae.fr](mailto:conservatoiredeessols@inrae.fr)

**For the shipment of the samples, you will have a user account on the selected carrier's website, which will allow you to print shipping labels for each recipient:**

-  : 200g (one white shovel) of homogenised composite 1
-  : 200g (one white shovel) of homogenised composite 1
-  : 200g (one white shovel) of homogenised composite 1
-  : homogenised composites, profile horizons, volumetric samples, clods and samples for the rock fragments measurements

### Digitised documents:

Paper documents should be scanned and named as follows:

- Intervention report: RMQS2\_sitenumbe\_r\_municipality\_IR
- Authorisation letter: RMQS2\_sitenumbe\_r\_authorisation
- Profile description form: RMQS2\_sitenumbe\_r\_description\_profile
- O horizon thickness record form: RMQS2\_sitenumbe\_r\_survey\_thickness\_horizons\_O
- Surrounding photos: RMQS2\_sitenumbe\_r\_envt\_photonumber\_direction
- Profile photos: RMQS2\_sitenumbe\_r\_profile\_ordernumber
- Horizon photos: RMQS2\_sitenumbe\_r\_profile\_ordernumber\_psup\_pinf
- Survey photos: RMQS2\_sitenumbe\_r\_survey\_ordernumber
- Orthophotos: RMQS2\_sitenumbe\_r\_orthophoto\_photonumber
- Surveys:
  - RMQS2\_sitenumbe\_r\_survey, for the main survey body
  - RMQS2\_sitenumbe\_r\_survey\_annex\_ITK, for the crop itinerary form
  - RMQS2\_sitenumbe\_r\_survey\_annex\_pp, for the permanent grassland annex
  - RMQS2\_sitenumbe\_r\_survey\_annex\_vv, for the vineyards and orchards annex
  - RMQS2\_sitenumbe\_r\_survey\_records, if a copy of a farmer's record is provided (soil analyses, practice records, copy of a logbook, etc.)
  - RMQS2\_sitenumbe\_r\_survey\_forests, for surveys of forest plots outside BIOSOIL

All these documents should be sent by e-mail to your partner manager. The original paper documents will be sent to InfoSol at the end of year n.

## GPS

### To initialise the unit correctly:

- When creating the GPS data file after arriving at the site, the GPS is able to estimate an accuracy value for your position. To achieve centimetric accuracy, the **telephone network and the external Teria source must be activated**.  

- Under forest cover, the GPS may have difficulty picking up a signal: it is advisable to **move to a more open area** so that it can refine its position for 5 to 15 minutes (depending on the estimated accuracy of the device) before returning to the BioSoil plot or RMQS site to navigate or survey.
- If the value of the accuracy estimated by the GPS is higher than 15 cm for no apparent reason, check that **the connections to the telephone network and to the external source have not been disabled** and that **the external antenna** of the GPS is correctly connected to the unit.

### The GPS surveys:

- Carry out **the point-by-point implementation survey while navigating** to the corners of the site for an RMQS device
- RMQS sites: surveys are to be carried out on the **four corners of the sampling area** and the **new pit**.
- RMQS forestry sites: GPS surveys are taken of the **four corners of the sampling area**, the **new pit** and the **reference markers outside** the site, if present. Register on the sampling report the **distances and azimuths** taken between the pit and the device and between the external reference markers and the device, where possible.
- RMQS-BioSoil sites: GPS surveys are to be carried out on the **central stake, reference markers B1 and B2** and the **new pit**.
- Carry out the final survey after installing the device, repositioning the points, if necessary, and **implanting the passive markers** for **sites with poor GPS coverage** (avoid modifying the existing data file to inform the depth of the markers after their implantation).
- A **second and third surveys** are necessary when the **accuracy** estimated by the GPS is **greater than 30 cm**, it is important to **space the surveys about 2 hours apart**.

### Compass:

- Before using the GPS to find, locate, or survey the points of a site, the internal compass of the device must be calibrated with the "**Compass**" application, see **6.1. Starting the device, calibrating and checking connections**.
- Before making distance and azimuth measurements with the **RangeFinder** software, the **GPS must also be calibrated**.
- The device should not be calibrated near metal elements (poles, site markers, etc.), and take care not to carry a telephone or camera.

### Deliverables:

- The sampling report must be completed with the site conditions implementation (trees and markers found), and a repetition of the distances and azimuths with the laser rangefinder is requested if the precision estimated by the GPS is higher than 30 cm and/or when they do not correspond to the RMQS-BioSoil location sheet:
  - ➔ central stake to marker trees
  - ➔ central stake to reference markers B1 and B2
  - ➔ reference marker B1 to B2.

## 24. Annexes

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No.	Operational table a: Actions per RMQS site of arable crops, grasslands, vineyards and orchards	Mass collected (kg)	Action duration (minutes)	Number of interveners needed	Total action time on site (minutes*worker)
<b>1</b>	<b>Before the intervention</b>				
1.1	Constitution of the site file and preparation of the intervention		60	1	60
1.2	Contact with the site owner/operator/manager for authorisation to intervene		30	1	30
1.3	Preparation of the material		30	1	30
<b>2</b>	<b>The day of the intervention</b>				
2.1	Site relocation and installation and new survey				
2.1.1	Relocation with the assistance of a GPS (with real time correction) and conduction of new surveys		30	1	30
2.1.2	Installation of the sampling device		30	3	90
2.2	Sampling and constitution of composite samples				
2.2.0	Root mats: 25 samples per cylinder (with measurement of each sample thickness for continuous horizons $\geq 1$ cm thick under permanent grassland) on 1 to 2% of the sites	5	45	2	90
2.2.1	Surface (worked layer or 0-30 cm): 25 auger samples	15	45	3	135
2.2.2	Sub-surface (30-50 cm): 25 auger samples	15	45	3	135
2.2.3	Depth 1 (50-75 cm): 25 auger samples	15	60	3	180
2.2.4	Depth 2 (75-100 cm): 25 auger samples	15	60	3	180
2.3	Observations and sampling of the soil profile				
2.3.1	Digging of the pit		120	2	240
2.3.2	Profile observation: measurement of tillage depths, validation of RMQS1 description and photographs		45	1	45
2.3.3	Profile description with horizon sampling on about 25% of the sites	15	120	1	120
2.3.4	Samples for physical measurements on the soil profile				
2.3.4.1	Volumetric undisturbed samples for determination of the bulk density (BD): three at the surface, three at the sub-surface, three at depth	15	180	1	180
2.3.4.2	Undisturbed samples (clods) to determine the available water content: one per horizon over 10 cm thick on 25% of the sites	5	30	1	30
2.3.4.3	Large volume disturbed samples for rock fragments determination (soils with rock fragments > 10%): one per horizon over 10 cm thick on 25% of the sites	120	30	1	30
2.3.5	Backfilling of the soil pit		30	2	60
2.4	Conditioning of samples, drafting of the intervention report		60	1	60
2.5	Updating the description of the site's environment and taking photos		30	1	30
2.6	Survey of history, land use and management practices since the first campaign		180	1	180
2.7	Cleaning and storage of the material		30	3	90
<b>3</b>	<b>After the intervention</b>				
3.1	Sample dispatch to InfoSol		60	1	60
3.2	Entering profile descriptions into DoneSol on about 25% of the sites		60	1	60
3.3	Data transmission to InfoSol		30	1	30
<b>4</b>	<b>Summary</b>				
		<b>Basic list</b>	<b>Basic list + Useful reservoir measurements</b>	<b>Basic list + Soil description</b>	<b>Basic list + Soil description + Useful reservoir measurements</b>
	Working time before the intervention (hours)	2.00	2.00	2.00	2.00
	Working time on the day of the intervention (hours)	28.75	29.75	30.75	31.75
	Duration of an on-site intervention with four people (hours)	07:11	07:26	07:41	07:56
	Working time after the intervention (hours)	1.5	1.5	2.5	2.5
	Total working time per site (hours)	32.25	33.25	35.25	36.25
	Mass of soil collected (kg)	80	205	95	220

No.	Operational table b: Actions per RMQS site of forests, fallow land and natural environments	Mass collected (kg)	Action duration (minutes)	Number of interveners needed	Total action time on site (minutes*worker)
<b>1</b>	<b>Before the intervention</b>				
1.1	Constitution of the site file and preparation of the intervention		60	1	
1.2	Contact with the site owner/operator/manager/DSF correspondent-observer for authorisation to intervene		30	1	
1.3	Preparation of the material		30	1	
<b>2</b>	<b>The day of the intervention</b>				
2.1	Site relocation and installation and new survey				
2.1.1	Relocation from permanent markers in the forest (measuring tape, tacheometer, compass ...) + new survey (GPS, passive markers)		60	3	180
2.1.2	Installation of the sampling device		60	3	180
2.2	Sampling and constitution of composite samples				
2.2.0	Horizon 0: 25 samples per cylinder (with measurement of each sample thickness for continuous horizons > 1 cm thick) on 5-6% of the sites	5	45	2	120
2.2.1	Surface (worked layer or 0-30 cm): 25 auger samples	15	45	3	135
2.2.2	Sub-surface (30-50 cm): 25 auger samples	15	45	3	135
2.2.3	Depth 1 (50-75 cm): 25 auger samples	15	60	3	180
2.2.4	Depth 2 (75-100 cm): 25 auger samples	15	60	3	180
2.3	Observations and sampling of the soil profile				
2.3.1	Digging of the pit		120	2	240
2.3.2	Profile observation: measurement of tillage depths, validation of RMQS1 description and photographs		45	1	45
2.3.3	Profile description with horizon sampling on about 25% of the sites	15	120	1	120
2.3.4	Samples for physical measurements on the soil profile				
2.3.4.1	Volumetric undisturbed samples for determination of the bulk density (BD): three at the surface, three at the sub-surface, three at depth	15	180	1	180
2.3.4.2	Undisturbed samples (clods) to determine the available water content: one per horizon over 10 cm thick on 25% of the sites	5	30	1	30
2.3.4.3	Large volume disturbed samples for rock fragments (soils with rock fragments > 10%): one per horizon over 10 cm thick on 25% of the sites	120	30	1	30
2.3.5	Backfilling of the soil pit		30	2	60
2.4	Conditioning of samples, drafting of the intervention report		60	1	60
2.5	Updating the description of the site's environment and taking photos		30	1	30
2.6	Survey of history, land use and management practices since the first campaign				
2.7	Cleaning and storage of the material		30	3	90
<b>3</b>	<b>After the intervention</b>				
3.1	Sample dispatch to InfoSol		60	1	
3.2	Entering profile descriptions into DoneSol on about 25% of the sites		60	1	
3.3	Data transmission to InfoSol		30	1	
<b>4</b>	<b>Summary</b>				
		<b>Basic list</b>	<b>Basic list + Useful reservoir measurements</b>	<b>Basic list + Soil description</b>	<b>Basic list + Soil description + Useful reservoir measurements</b>
	Working time before the intervention (hours)	2.00	2.00	2.00	2.00
	Working time on the day of the intervention (hours)	30.25	31.25	32.25	33.25
	Duration of an on-site intervention with four people (hours)	07:33	07:48	08:03	08:18
	Working time after the intervention (hours)	1.5	1.5	2.5	2.5
	Total working time per site (hours)	33.75	34.75	36.75	37.75
	Mass of soil collected (kg)	80	205	95	220

## List of recommended material and equipment for an RMQS site

Material provided by InfoSol at the beginning of the campaign

Material and consumables supplied by InfoSol every year

Note: Apart from the consumables, the material supplied by InfoSol will not be replaced during the campaign → use with care (especially density cylinders)

Layout and georeferencing material	Units	Comments
GPS rod and tripod	1	provided by InfoSol
Support rod for the sight	1	provided by InfoSol
GPS case complete with receiver, laser rangefinder and accessories	1	provided by InfoSol
Metal detector	1	essential
Compass in degrees and grades under forest	1	essential
Measuring tapes	3	essential
Measuring tape of 30 m	2	highly recommended, the most used
Measuring tape of 50 m	2	highly recommended (forests)
Baseline markers	10	essential
Orange flags and ribbons	25	essential
Coloured stakes	6	essential
RMQS2 staking cable	1	to be made, highly recommended
Surveyor's markers	4	highly recommended for tensioning the cable
Holder	1	recommended for storing surveyor's markers and possibly also other markers
Large and small billhooks	1	recommended in the forest
Passive markers (round and stick markers)	lot	provided by InfoSol

Digging material for the profile	Units	Comments
Pickaxe or flat pickaxe	1	essential
Spade	1	essential
Spade fork	1	recommended
Shovels	2	essential
Rakes for backfilling	1	recommended
Crowbar	1	recommended as it is more suitable for stony soils and less tiring on the back!
Tarpaulins (6 × 4 m)	2	essential (deep horizons)
Small tarpaulin (3 × 4 m)	2	essential (surface horizons)
Small shovels	2	recommended for mountain sites (lighter if carried)
Small spade	1	recommended for mountain sites (lighter if carried)
Hoe	1	recommended for mountain sites (lighter if carried)

Auger sampling material	Units	Comments
Buckets	8	essential

Trough	1	very useful for pit bottom surveys or qualification of a new site
Augers diameter 7 cm	4	essential (removable augers recommended for mountain sites)
Ratchet auger - extension	2	recommended for composites 3 and 4
Knives (small daggers)	4	essential

Toolbox	Units	Comments
Felt pens	4	essential
Pencils	4	essential
HCl acid (1/5)	1	recommended
Knives (small daggers)	2	essential
Coal shovel	1	recommended
Scraper (Berthelet trowel)	1	recommended
Folding measuring tape	1	recommended
pH metre	1	recommended
Spatula	2	recommended
Micrometric magnifier	1	recommended
Geologist's hammer	1	recommended
Munsell colour charter	1	essential
Spray bottle	1	essential
Writing board	1	essential
Slate board	1	provided by InfoSol
Chalk for slate	1	recommended
Measuring tape (GIS)	1	provided by InfoSol
Water bottle (wash bottle)	1	provided by InfoSol

Cleaning materials	Units	Comments
Rags		essential
Wipes		essential
Brushes	2	highly recommended
Sponges	2	highly recommended
Small 10 L and 50 L garbage bags for example		very useful
30 L jerrycans of tap water	1	essential
10 L jerrycans of demineralised water	1	essential

Sample conditioning material	Units	Comments
Garden spade (plastic)	1	essential
Single-use gloves	1 box	essential
Mixing tank	1	essential: 35 L trough recommended for good homogenisation of composite samples
Rubber bands		essential
White laboratory shovel	1	provided by InfoSol
Sampling bags	lot	provided by InfoSol

New model sampling bags	lot	provided by InfoSol
Yellow labels	lot	provided by InfoSol
Tupperware boxes	lot	provided by InfoSol
Woven rubble bags	lot	provided by InfoSol
Plastic rubble bags	lot	provided by InfoSol
Colson hose clamps or strong ties	lot	essential

Sample transport material	Units	Comments
Sample storage boxes	6	highly recommended for transporting samples
Cardboards	lot	provided by InfoSol
Envelopes (fresh laboratory samples)	lot	provided by InfoSol
Transport boxes with foam pad	lot	provided by InfoSol

Specific material for physical measurements	Units	Comments
Ladle or stewing spoons	1	recommended
Soup spoons	1	recommended
Plates for installing the cylinders	2	recommended
Pruning shears	1	recommended
Scissors	1	recommended, one pair will suffice
Coating knife	1	recommended
Painter's knife (spatula)	1	recommended
Cod tail brush	1	recommended
Spirit level	1	essential, a small level of 22.5 cm will suffice
Folding measuring tape	1	essential
Thin knife without teeth	1	Essential for levelling the cylinder
Saw (Pocket)	1	very useful in the forest for medium to large roots, even for digging the pit
Wooden battens	2	very useful for sampling the holorganic composite
Trowel	1	recommended, harder than painter's knife (spatula)
Nails for fixing the template		recommended, very useful for maintaining the template in place
Briefcase	1	provided by InfoSol
Rubber mallets	2	provided by InfoSol
Dagger	1	provided by InfoSol
Cylinders	2	provided by InfoSol
Sinking matrix	1	provided by InfoSol
Measuring cylinder of 500 mL	1	provided by InfoSol
Funnel	1	provided by InfoSol
Annular template	1	provided by InfoSol
Transparent, thin and strong plastic bags	lot	provided by InfoSol
0.8 to 1 mm calibrated sand	4 kg	provided by InfoSol
<b>Miscellaneous</b>	<b>Units</b>	<b>Comments</b>
First aid kit	1	essential

Camera	1	essential
Parasol	2	recommended
Chairs		optional
Headlamp	1	optional

<b>Materials required for the production of the staking cable:</b>
4 mm sheathed steel cable in coils of 25 or 50 m (68.28 m are required)
6 flat cable ties
coloured "electrician's tape" (red and blue) to mark the points for the base line and sampling
hose reel for garden hose

**AUTHORISATION FORM  
FOR SAMPLING AND DATA COLLECTION****RMQS or RMQS-BioSoil site number.....**

I, the undersigned, [Last name - First name] .....,  
authorise [Name of the collecting body] ....., to  
install an RMQS site with a soil pit and to take soil samples for further physico-chemical and biological analyses by the French  
National Research Institute for Agriculture, Food and Environment (INRAE), as part of the national programme Réseau de  
mesures de la qualité des sols (RMQS) of the GIS Sol, on land located in the municipality  
of..... (GPS coordinates: .....),  
of which I am the [delete as appropriate] forester/farmer/manager/owner, without exceeding my rights and obligations  
inherent to my status regarding the land from which the samples will be taken.

**Use of personal data**

*The personal data correspond to the nominative data of the owners/managers/foresters/farmers of the plots on which the  
RMQS sites are or will be located and the actual GPS coordinates of the RMQS sites.*

I authorise the use of the personal data associated with the RMQS site referenced above:

- by the regional partner and by INRAE for internal research purposes relating to the improvement of knowledge of  
soils and their properties and the long-term monitoring of national soil quality,
- to enable INRAE and its partners to find the site during a subsequent sampling campaign.

I authorise the dissemination to public research bodies of the aforementioned personal data, only in the context of research  
justifying their use and under conditions of use that preserve their confidentiality.

I am informed that these personal data, mainly collected through the questionnaires I am given, or through the questions I  
am asked, or by any other means, will be pseudo-anonymised in INRAE's "Soil" information system (which has been declared  
to the CNIL under n°1815891).

*In accordance with the amended "Informatique et Libertés" law of 6 January 1978, you have the right to access and rectify any  
personal data concerning you. If you wish to exercise this right and obtain information about you, or, for legitimate reasons,  
oppose the processing of your data, please contact*

INRAE, US 1106 InfoSol  
Centre de Recherches Val-de-Loire  
2163, avenue de la Pomme de Pin, CS 40001 Ardon  
45075 ORLÉANS cedex 2  
FRANCE

Email: [infosol@inrae.fr](mailto:infosol@inrae.fr)

**Use of non-personal data and soil samples**

I transfer to INRAE the ownership of the samples taken, as well as the ownership of all non-personal data (notably technical  
data) obtained from the analysis of the samples taken, from the observations made on the RMQS site or from the questions  
asked to me.

*The data and samples will not be resold or used for commercial purposes. INRAE will use the samples and data for its scientific  
research tasks of improving and disseminating knowledge about soils and their properties and for long-term monitoring of  
national soil quality. The soil samples will be stored at INRAE in the European Conservatory for Soil Samples.*

*In return for your authorisation, you will receive by e-mail or post the results of the physico-chemical and biological analyses  
carried out on the soil samples collected on the RMQS site installed on your land. In addition, you will be regularly informed by  
INRAE of the progress of the national programme Réseau de mesures de la qualité des sols.*

**DATE AND SIGNATURE:**

**INTERVENTION REPORT RMQS2 – RMQS site**

RMQS site number	Municipality and department	Date of sampling	Samplers and authors of the descripton (Full name and organisation)

**1 - General information about the site**

**Weather of the day:** .....

**Land use and current practices:**

Changes since Campaign 1:  of land use  of practices Specify: .....

**Stage of cultivation:** .....

**Surface condition, indications of soil disturbance:** .....

**Type of soil:** .....

**Pit described**  yes, entirety  yes, partially  no why: .....

Need for specific analyses  Andosol  Histosol  Salty soil  other (to be specified)

**Comments, difficulties encountered:** .....

**How to access the site:** .....

**Changes in the environment since campaign 1** (compare with RMQS1 photos and report the changes on a recent orthophoto):

**2 - Tillage**

**Tilled soil**  yes  no **Type of last observed tillage:** .....

**Report 10 observed current tillage depths (cm):**

**Report 10 old tillage depths, if observed (cm):**

**3 - Information on the location and GPS survey of the sampling device**

Describe the process of the GPS survey and the implementation of the device.

RMQS site number: .....

**4 - Characteristics of the sampling device**

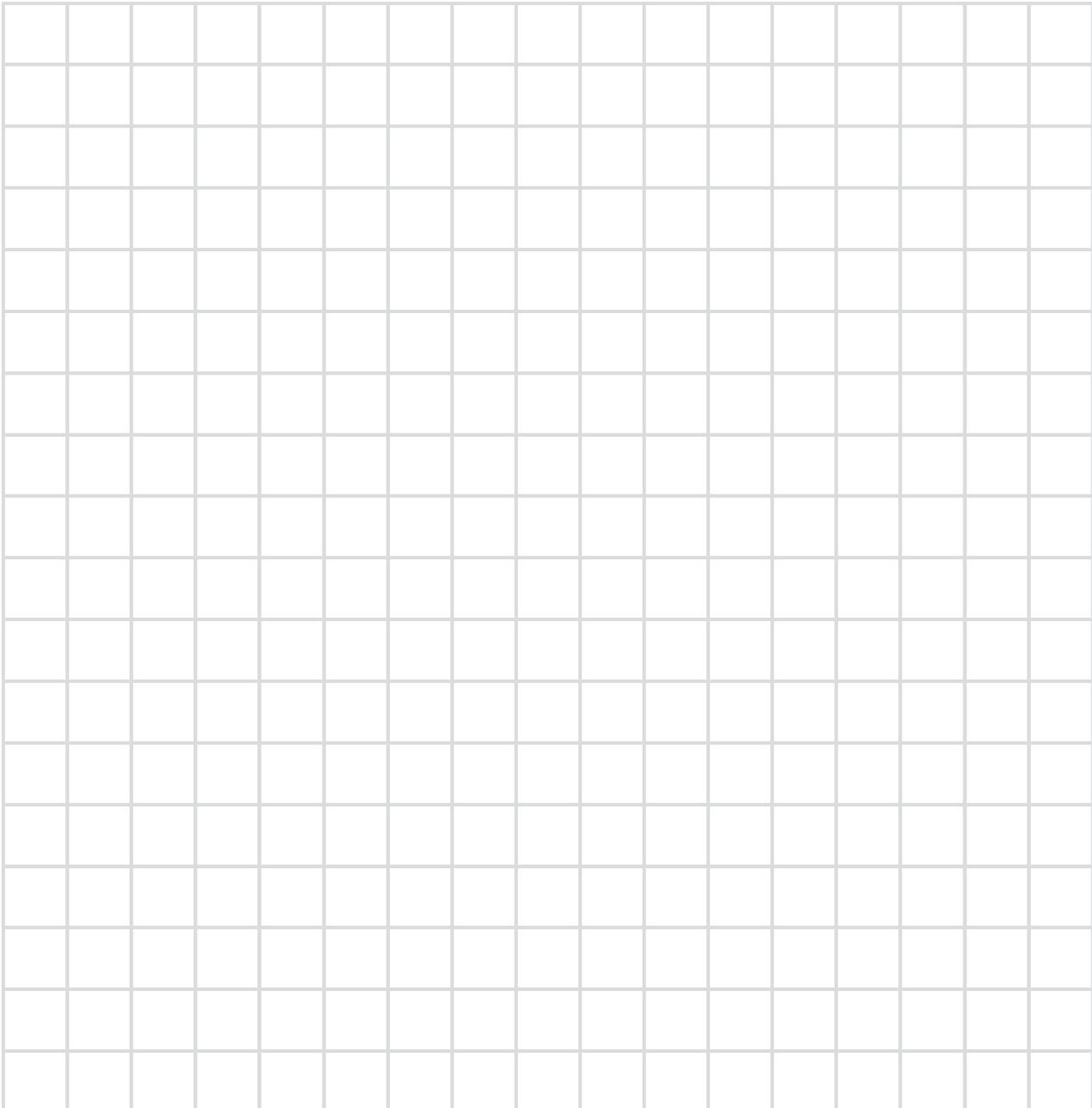
**Type of device (configuration):**  5 × 5 (dimensions  10 × 10 m  20 × 20 m)  other (specify) : .....

**Collecting composite samples on the sampling area:**

- **Samplings depths:**  identical to campaign 1  different from campaign 1  
Justify if different: .....
- **Blockages:**  no blockage  blockages – Origin of the blockages: .....

**Draw a diagram of the device (sampling area and pit) on the following grid indicating:**

- the orientation of the device
- elements of the immediate surroundings or characteristic landmarks enabling the site to be found
- the position of the markers for forestry sites outside the RMQS-BioSoil (distances and azimuths of the sampling area and the pit angles from the reference markers)
- the position of the passive markers (round and stick markers) and their depth (cm), if applicable
- the blocking depths per plot unit (cm), if applicable





RMQS site number: .....

**6 – Sampling diagram for volumetric samples**

Indicate on the diagram the depths of the composites, the limits of the soil horizons, and then place the volumetric samples taken, specifying their upper and lower depths.

<i>Surface</i>	
Composite 1	Legend:
Composite 2	
Composite 3	
Composite 4	
<i>Pit bottom</i>	Comments:

## INTERVENTION REPORT RMQS2 – RMQS-BioSoil sites

RMQS-BioSoil site number	Municipality and department	Date of sampling	Samplers and authors of the description (Full name and organisation)

### 1 - General information about the site

**Weather of the day:** .....

**Land use and current practices:**  
Changes since Campaign 1:  of land use  of practices Specify: .....

**Area condition, indications of disturbance or tillage:** .....

**Type of soil:** .....

**Pit described**  yes, entirely  yes, partially  no why: .....

Need for specific analyses  Andosol  Histosol  Salty soil  other (to be specified)

**Comments, difficulties encountered:** .....

**How to access the site:** .....

---

**Changes in the environment since campaign 1** (compare with RMQS1 photos and report the changes on a recent orthophoto):

### 2 - Information on the location and GPS survey of the sampling device:

**2.1 - Location**

**Numbered marker trees found:**  yes  no specify which, if any: .....

**Central stake (CS) found:**  yes  no specify in what form: .....

**Reference marker B1 found:**  yes  no **Reference marker B2 found:**  yes  no specify in what form:.....

**Method used to find CS, B1 and B2:**  metal detector  other (specify): .....

**Correct distances and azimuths between numbered marker trees and CS:**  yes  no

**Correct distances and azimuths between CS and B1 - B2:**  yes  no

**How the device was set up in the absence of numbered marker trees:** .....

---

**2.2 - Surveys**

**If the distances and azimuths between marker trees, CS, B1 and B2 are incorrect, repeat these measurements, specifying the unit:**

<b>CS → marker trees</b>	Tree no°	d (m) =	azimuth (unit) =	Tree no°	d (m) =	azimuth (unit) =
	Tree no°	d (m) =	azimuth (unit) =	Tree no°	d (m) =	azimuth (unit) =
	Tree no°	d (m) =	azimuth (unit) =	Tree no°	d (m) =	azimuth (unit) =
<b>Markers B1-B2</b>	CS → B1:	d (m) =	azimuth (unit) =	B1 → B2:	d (m) =	azimuth (unit) =
	CS → B2:	d (m) =	azimuth (unit) =			

**Useful information about the GPS survey:** .....

RMQS-BioSoil site number:

**3 - Characteristics of the sampling device**

Type of device (configuration):  5 × 5     6 × 4     8 × 3     other (specify): .....

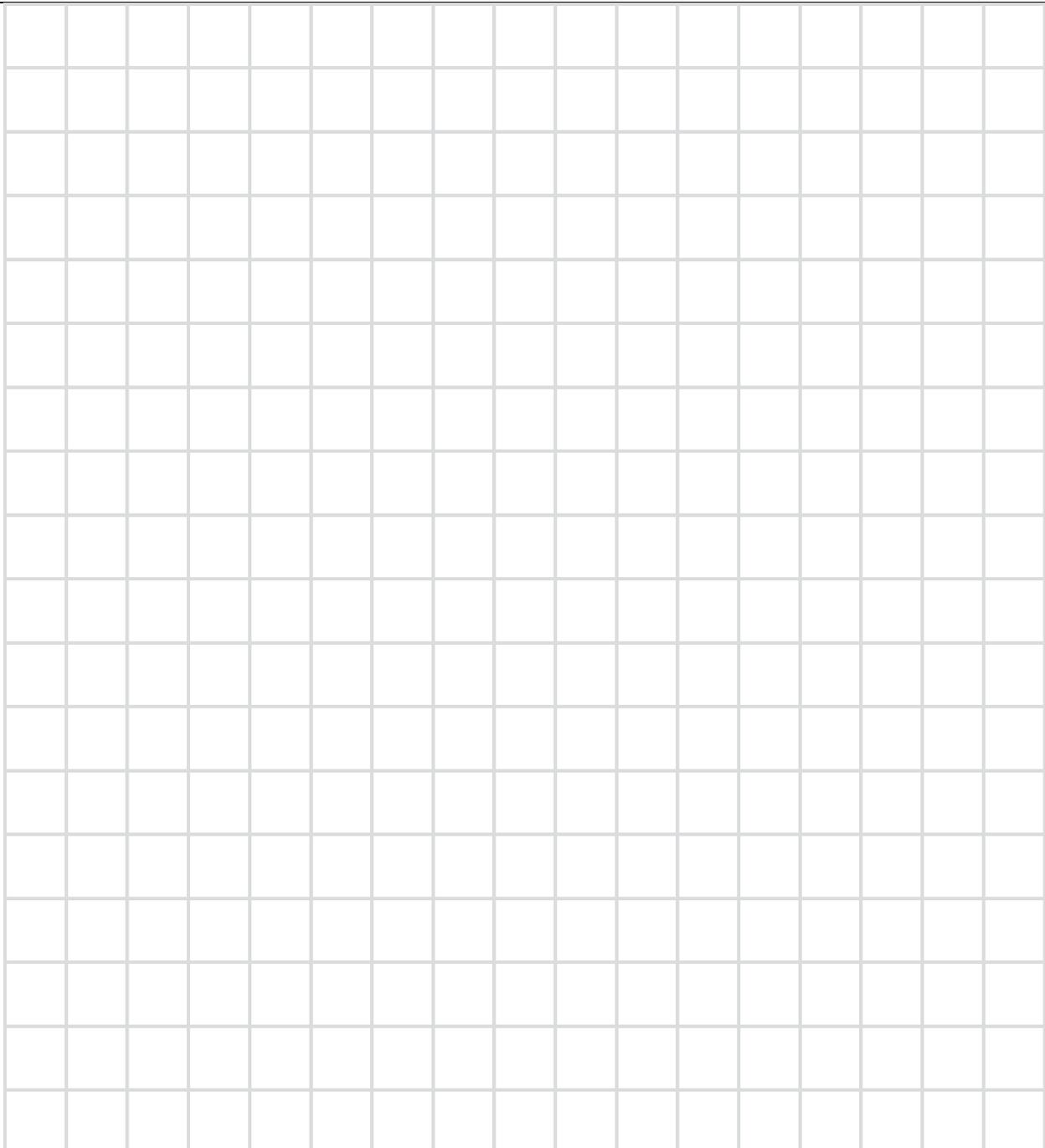
**Collecting composite samples on the sampling area:**

- **Samplings depths:**  identical to campaign 1     different from campaign 1  
Justify if different: .....

- **Blockages:**  no blockage     blockages – Origin of the blockages: .....

**Draw a diagram of the device (sampling area and pit) on the following grid indicating:**

- the orientation of the device
- elements of the immediate surroundings or characteristic landmarks enabling the site to be found
- the position of the numbered marker trees, the central stake, the reference markers B1 and B2 in relation to the sampling area
- the position of the passive markers (round and stick markers) and their depth (cm)
- the blocking depths per plot unit (cm), if applicable





RMQS-BioSoil site number: .....

**5 – Sampling diagram for volumetric samples**

Indicate on the diagram the depths of the composites, the limits of the soil horizons, and then place the volumetric samples taken, specifying their upper and lower depths.

<i>Surface</i>	
Composite 1	Legend:
Composite 2	
Composite 3	
Composite 4	
<i>Pit bottom</i>	Comments:

**List of samples and documents to be delivered to InfoSol and the laboratories**
**RMQS site: number.....**

What	How	To whom	Deadline	Conducted
Composite samples	Collection bags packaged in boxes Shipment by carrier	European Conservatory for Soil Samples (INRAE Orléans)  <b>In a single shipment</b>	At the latest during the week following the completion of the site	
Volumetric samples				
Horizon samples				
Clod samples <b>Attention: boxes to be stored horizontally</b>	Airtight box packed in foam-lined cardboard Shipment by carrier			
Large samples for rock fragments content measurement	Rubble bags packed in cardboard boxes Shipment by carrier			
Fresh sample from composite 1 ➔ BIOCHEMENV	Sample bag packed in a bubble envelope + "fresh sample" label Shipment by carrier	Platform BioChemEnv (INRAE Versailles)	At the latest the day after the site is completed or the following Monday for a site completed on Friday	
Fresh sample from composite 1 ➔ GENOSOL		Platform GenoSol (INRAE Dijon)		
Fresh sample from composite 1 ➔ LAS		Soil analysis laboratory (INRAE Arras)		
Complete intervention report *	By e-mail in .PDF format, in a single document	conservatoiredessols@inrae.fr	At the latest the day after the samples are sent	
GPS surveys of the device	By e-mail	correspondants-gps@listes.inrae.fr	As soon as possible after completion of the site	
Profile description sheet (annotations, partial or complete re-description)	By e-mail or via a file exchange platform or a collaborative space  + entry of profile descriptions in DoneSol	Your partner manager	Preferably as the sites are built  At the latest 2 months after the end of an RMQS2 year n (end of April)	
Photos of the profile and the surroundings				
Signed letter of authorisation				
Survey forms and records				
<b>Note: Original documents in paper format will be sent or brought to InfoSol at the end of year n</b>				

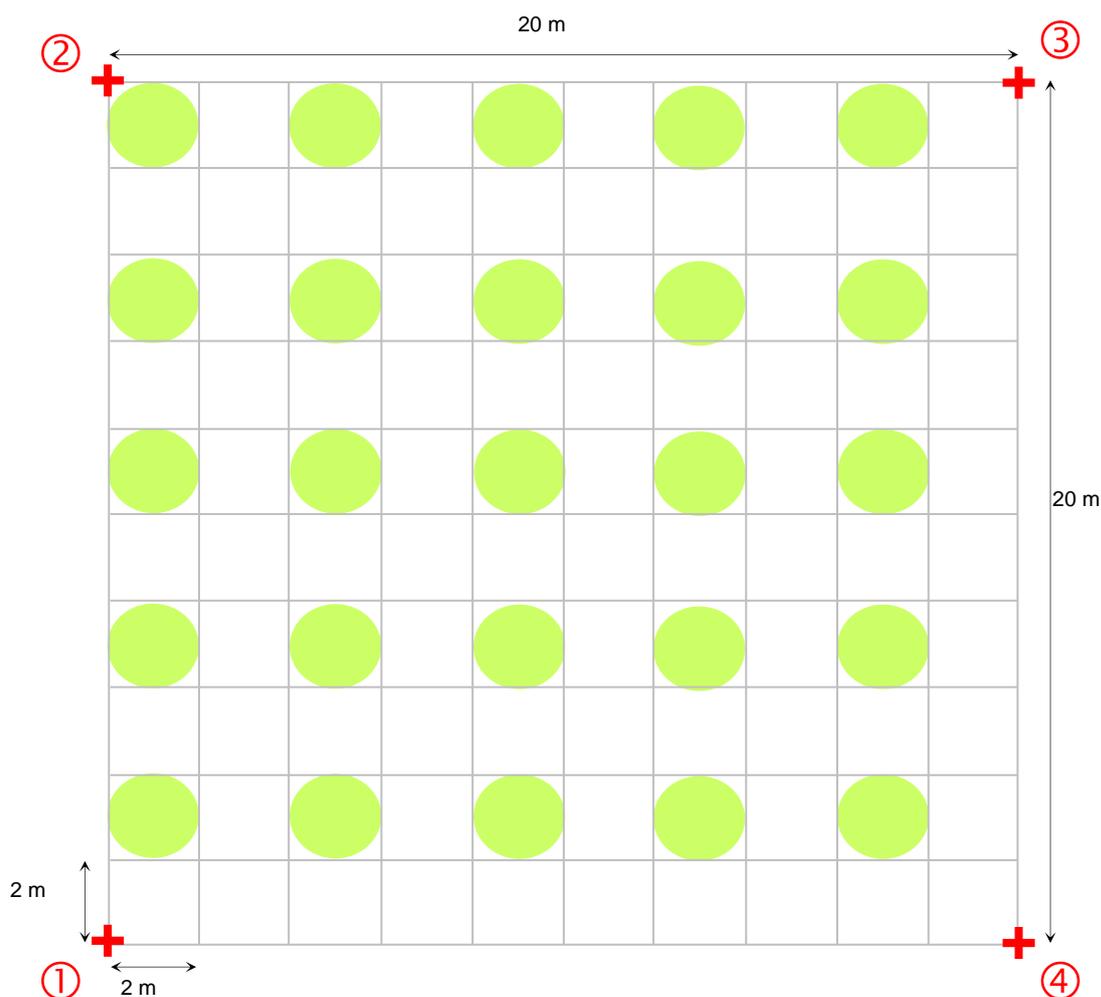
\*Complete intervention report: including information on the intervention, diagram of the device, distance and azimuth measurements under the forest, list of samples.

## Record sheet for the thickness of the sampling area holorganic horizons (OF + OH) – Configuration 5×5

<b>RMQS site number</b>		<b>Date</b>	
<b>Department Municipality</b>		<b>Samplers</b>	

<b>Horizons sampled (OF, OH)</b>	
<b>Sampling method (Core or excavation method)</b>	

For each sample unit collected, record the thickness **in millimetres** of the surface organic horizons sampled.

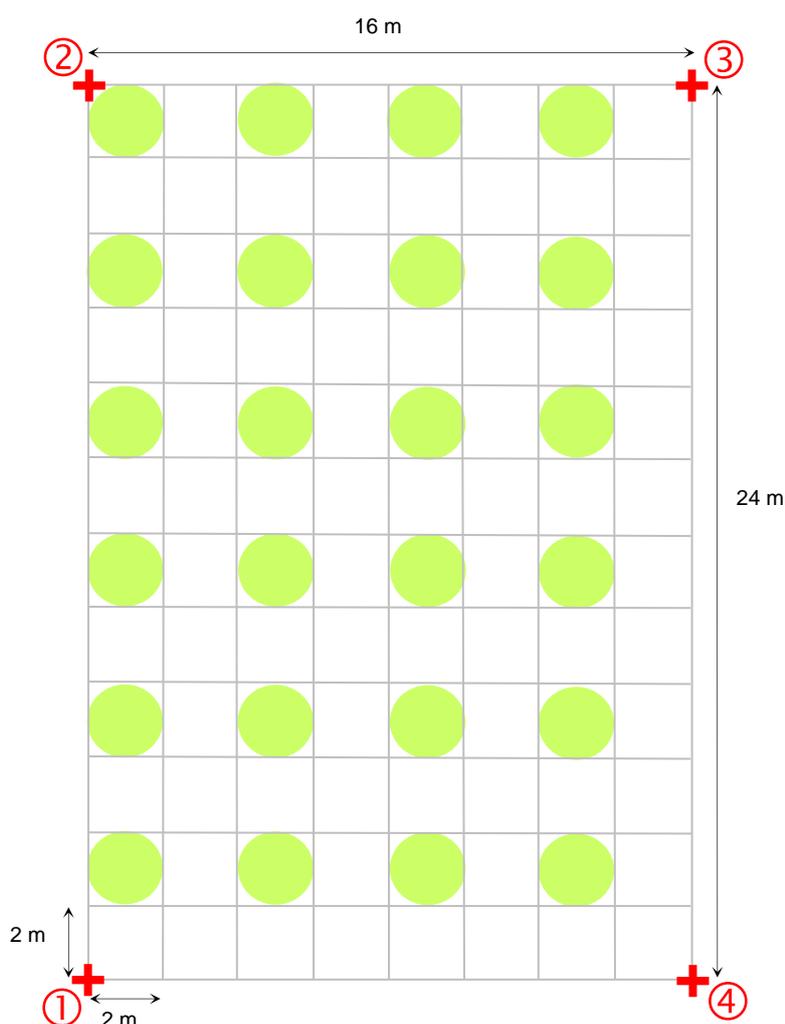


## Record sheet for the thickness of the sampling area holorganic horizons (OF + OH) – Configuration 6×4

<b>RMQS site number</b>		<b>Date</b>	
<b>Department Municipality</b>		<b>Samplers</b>	

<b>Horizons sampled (OF, OH)</b>	
<b>Sampling method (Core or excavation method)</b>	

For each sample unit collected, record the thickness **in millimetres** of the surface organic horizons sampled.

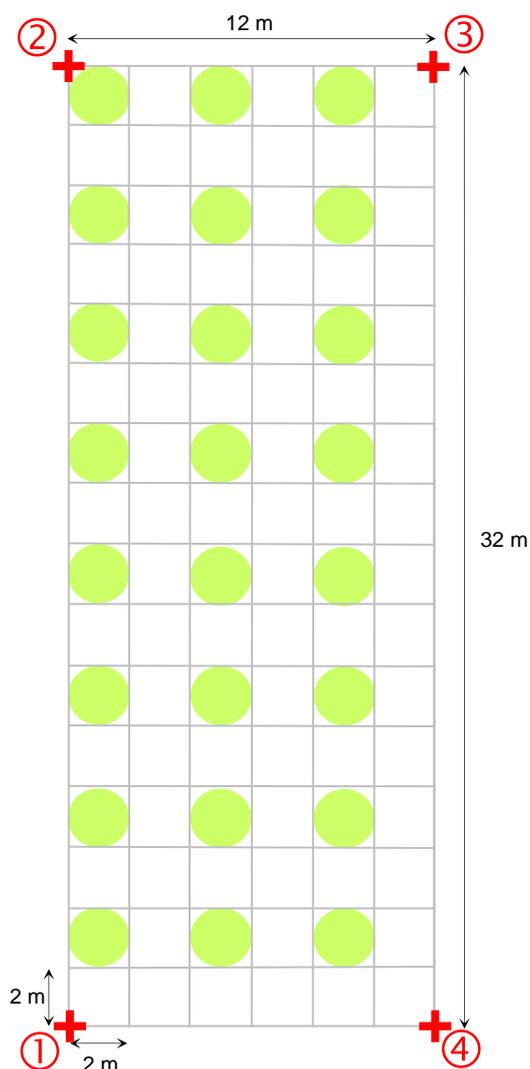


## Record sheet for the thickness of the sampling area holorganic horizons (OF + OH) – Configuration 8×3

<b>RMQS site number</b>		<b>Date</b>	
<b>Department Municipality</b>		<b>Samplers</b>	

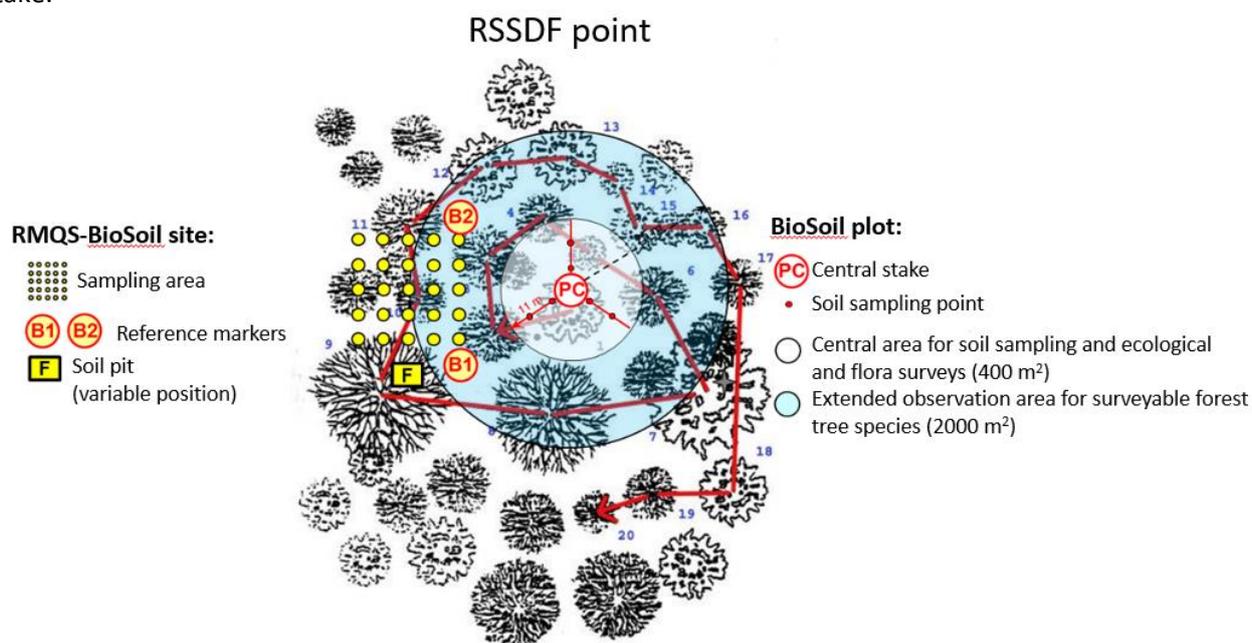
<b>Horizons sampled (OF, OH)</b>	
<b>Sampling method (Core or excavation method)</b>	

For each sample unit collected, record the thickness **in millimetres** of the surface organic horizons sampled.



## Memo for the implementation of the RMQS-BIOSOIL sites scheduled each year during the RMQS2 campaign (2016–2027)

The second campaign of the French Soil Quality Monitoring Network (RMQS2), coordinated by INRAE, involves the sampling of approximately 550 RMQS-BioSoil sites. These sites are located in the vicinity of BioSoil plots, on the points of the Systematic Network for the Monitoring of Forest Damage (RSSDF - Réseau systématique de suivi des dommages forestiers), coordinated by the Forest Health Department (DSF - Département Santé des forêts). The RMQS-BioSoil sites were installed and sampled in 2006-2007, at the same time as the BioSoil plots. The location of the RMQS-BioSoil site is materialised by the presence of two reference markers B1 and B2, whose position was measured (distances and azimuths) in relation to the central stake of the BioSoil plot, itself located in relation to several numbered marker trees of the RSSDF point. An iron rod was driven into the ground at the location of these two reference markers and the central stake.



The return to the RMQS-BioSoil sites during the RMQS2 campaign requires coordination between the **DSF**, the **correspondent-observers**, the INRAE **InfoSol** unit and the **RMQS2 partners** as follows:

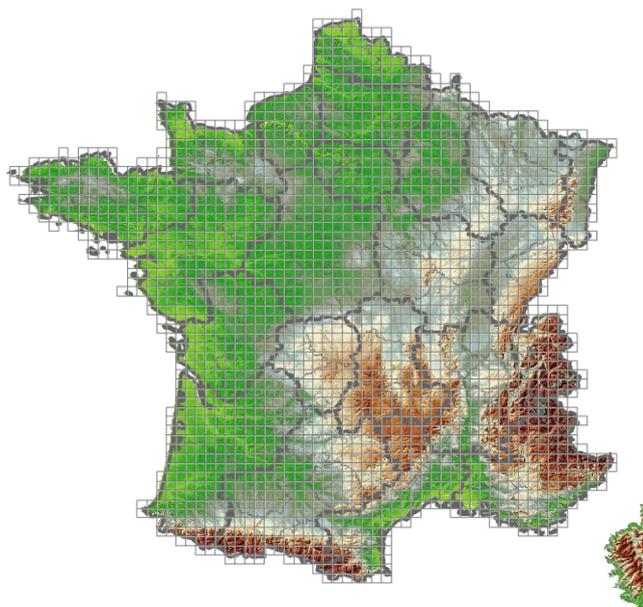
1. At the beginning of the year, **InfoSol** sends the list of RMQS-BioSoil sites for the year to the **DSF**.
2. The **DSF** informs the interregional centres and the relevant **correspondent-observers** and sends them the RMQS2 programme presentation brochure and the authorisation form.
3. The **DSF** provides **InfoSol** with updated data on the location of RSSDF points and BioSoil plots, as well as the list of **correspondent-observers**.
4. **InfoSol** sends to **RMQS2 partners** the list of **correspondent-observers**, location and access maps and the RMQS-BioSoil site location sheets.
5. The **correspondent-observers** collect the authorisations from the forest owners or managers and hand them over to the **RMQS2 partners**.
6. The **RMQS2 partners** contact the **correspondent-observers** to find out how to access the RSSDF points and their availability to accompany them.
7. The **RMQS2 partners** use the information provided by **InfoSol** and the **correspondent-observers** to find and relocate the RMQS-BioSoil sites.
8. The **RMQS2 partners** geolocate the RMQS-BioSoil sites (GPS surveys, distance and azimuth measurements, passive markers) and transmit this data to **InfoSol**.
9. **InfoSol** records these data in a geodatabase and transmits them to the **DSF** at the end of the year.

# French Soil Quality Monitoring Network: second metropolitan campaign

## 2016–2027



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A new campaign of the French Soil Quality Monitoring Network will take place in metropolitan France from 2016 to 2027 to measure the evolution of French soil quality

**Contact:** Claudy Jolivet | INRAE, US 1106, InfoSol, Centre de recherches Val de Loire, 2163 avenue de la Pomme de Pin, CS 40001 Ardon, 45075 ORLÉANS cedex 2. | [claudy.jolivet@inrae.fr](mailto:claudy.jolivet@inrae.fr) | 0238414824

The **Soil Quality Monitoring Network** (RMQS) is based on the monitoring of 2,240 sites regularly distributed over France (metropolitan and overseas), according to a square grid of 16 km sides. Soil samples, measurements and observations are taken every 15 years at the centre of each grid to monitor the long-term evolution of French soil quality.

## 1. Feedback on the first campaign (2000-2009)

The first campaign made it possible to **establish the reference state** of a large number of soil properties: evaluation of chemical fertility (pH, phosphorus, nitrogen, trace elements, etc.), new estimate of soil surface carbon stocks, first mapping of the microbial biomass of French soils. Focusing on soil contamination, this campaign also made it possible to map the levels of nine metallic trace elements (cadmium, cobalt, chromium, copper, molybdenum, nickel, lead, thallium and zinc) and to understand their distribution. Other mineral (As, Hg) and organic (PAHs, PCBs, pesticides, dioxins and furans) contaminants were also analysed.

A summary of the work carried out by the GIS Sol, including the results of the first RMQS campaign was published in 2011<sup>2</sup>. This report (in French) is available for download on the **GIS Soil website**: <https://www.gissol.fr/publications/rapport-sur-letat-des-sols-de-france-2-849>. An english synthesis is also available: <https://www.gissol.fr/publications/rapports/synthesis-resf-871>. <http://www.gissol.fr/RESF/>

These 10 years of sampling represent 1,600 soil pits dug throughout the country, from 0 to 2,500 m of altitude. This corresponds to 24,000 samples (60 tons of soil) and 1,800,000 data, collected from all types of soil occupations: field crops, permanent grasslands, forests, parks and gardens, vineyards and orchards, fallow land, natural environments, etc.

## 2. RMQS2: a new twelve-year campaign

The second campaign of the Soil Quality Monitoring Network will take place in metropolitan France from 2016 to 2027 to measure the evolution of French soil quality. The physico-chemical and biological analyses will be repeated during this new campaign to measure the evolution of soils between the two campaigns. Focusing on **climate change**, new parameters will be added to better assess the sensitivity of soils within the context of climate change (useful reserves, particulate organic matter, deep carbon stocks). New indicators of greenhouse gas emissions from soils and biodiversity will also be proposed.

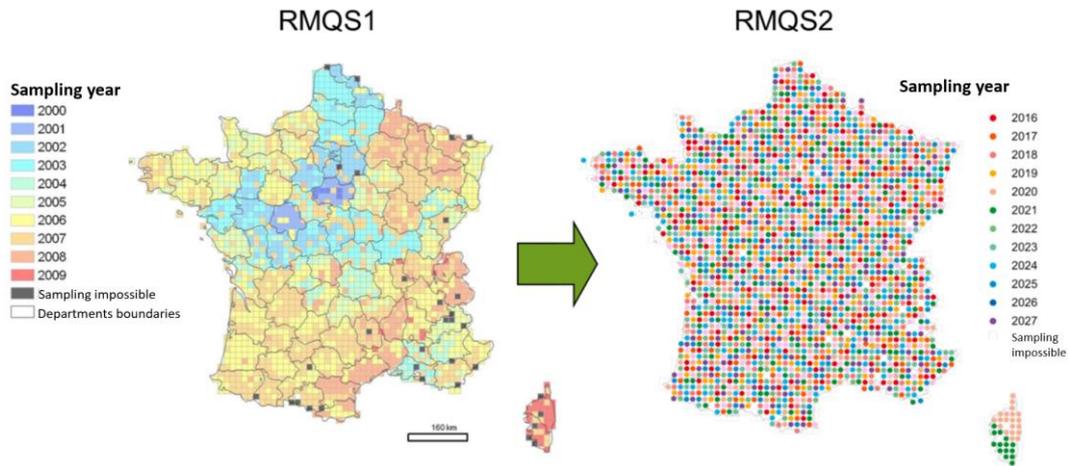
### 2.1. Conduction of the RMQS2 campaign

The objective of this second campaign is to enable the **rapid detection of changes throughout the country**. For this reason, the sampling strategy is different from the first campaign: instead of successively sampling each region in one or two years, 180 sites spread over the whole of France are drawn at random and sampled each year.

The fieldwork is entrusted to **12 regional teams** from chambers of agriculture, higher education and research institutions or consultancy firms, recognised for their skills in soil science and their field experience. The RMQS2 programme is coordinated by the INRAE's InfoSol Unit.

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<sup>2</sup> GIS Sol. 2011. *L'état des sols de France. Groupement d'intérêt scientifique sur les sols*, 188 p.

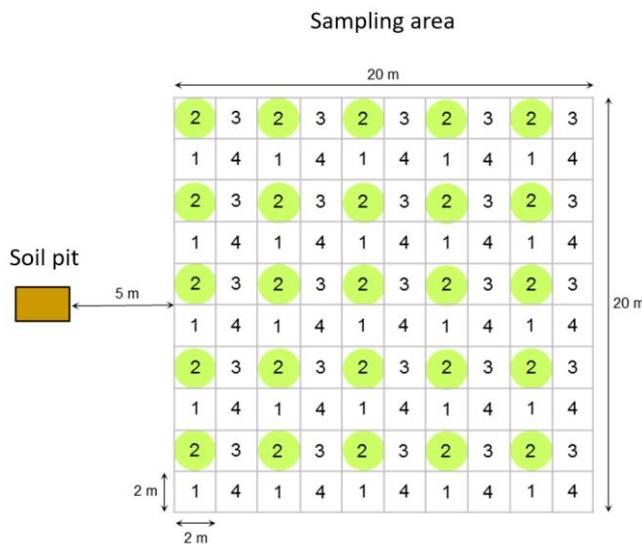


Two different sampling strategies: regionalised for RMQS1 and annualised for RMQS2.

## 2.2. Field measurements and observations

The sampling methods are similar to those of the first campaign. Each site includes:

- a **soil pit**, to describe and characterise the soil and its horizons down to the parent material. Several series of samples are taken: horizon samples for physico-chemical analysis and measurement of the rock fragments content, volumetric samples to evaluate the density, clods to characterise the available water content;
- a 20 × 20 m **sampling area** divided into 100 2 m × 2 m sampling units where soil samples are taken for temporal monitoring of soil properties. These samples are taken with a helical soil auger in the surface layer (0-30 cm) or within the ploughed layer, and then in the sub-surface (30-50 cm). Where the soil permits it, deeper samples are also taken (50-75 cm and 75-100 cm).



Sampling scheme of an RMQS site: in the first campaign, samples were taken from the 25 elementary plots with the number 1. In the second campaign, the samples will be taken on the elementary plots with the number 2. The elementary plots numbered 3 and 4 will be used for the RMQS3 and RMQS4 campaigns, respectively.

A **survey** carried out among owners/managers/foresters and farmers accompanies each intervention on a site. It aims to collect information on the history and past and current management mode of the plot. The focus will be on the period since the first campaign. The data collected will be used to interpret the analytical results.

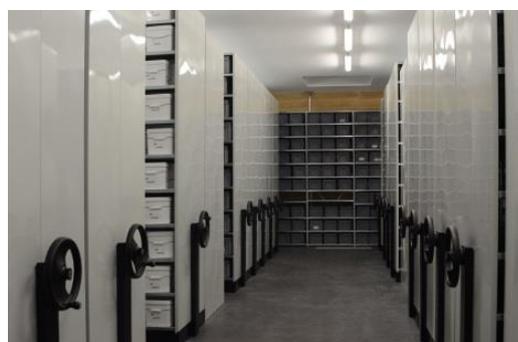
Each site is precisely marked in space so that the exact location of the site can be found during each sampling campaign. For the second campaign, the field teams are equipped with new GPS units that incorporate the latest technology and have **centimetric precision**. In addition, passive mini markers will be buried on forest sites.

### 3. Preservation of samples and data

The samples for the RMQS2 campaign will be received and prepared by the **Conservatoire européen des échantillons de sols (European Conservatory for Soil Samples)**, whose new premises are located at the INRAE Val de Loire centre (Orléans site).



The European Conservatory for Soil Samples (© Paul Kozlowski - photoarchitecture.com)



View of the conservatory storage room  
(© Claudy Jolivet INRAE InfoSol)

After analysis, the new samples will join the 24,000 samples from the first campaign and will be carefully archived on 4 km of shelves in a 370 m<sup>2</sup> storage area. Temperature and humidity are maintained at 18±1°C and 50±5% to ensure the integrity of the samples. Preserving these samples will allow new parameters to be analysed on old samples as well as comparing these results with data acquired during future campaigns.

All the data collected in the framework of the RMQS is managed by the InfoSol Unit, within a national database: **DoneSol**.

### 4. Data dissemination rules

The data from the RMQS programme will be accessible to all those who wish to obtain information on soils: the scientific community, managers or the general public. In accordance with current legislation on confidential data, the personal data associated with the sites (contact details of the owners/managers/farmers of the selected plots and the precise location of the sites) will not be disclosed. The signature of an **authorisation form for sampling and data collection** by the owner/manager/forester or farmer of each plot before any access to the site will act as an acknowledgement of their participation in the RMQS programme, it will set out the conditions for the use of the data and soil samples collected and guarantee the confidentiality of their personal data as well as their access to the results concerning their plot.

Written by: Elodie Schellenberger, Line Boulonne, Céline Ratié et Claudy Jolivet | InfoSol unit INRAE Orléans



