DATA QUALIFICATION METHODOLOGY IN THE LITERATURE SURVEY STAGE

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Key words; Quality Management System, site investigation

Abstract

The site selection for a deep geological repository in Japan will be undertaken by means of a three-stage process. The initial literature survey (LS) aims at selecting areas for the next preliminary investigation (PI) only on the basis of data from the existing literature. The results of geological characterisation in the PI stage lead to the final detailed investigation.

Key to the LS stage and the evaluation process is the development of a qualified assessment basis for each area. The challenge at this stage is that the vast amount of data in the assessment basis originates from a wide spectrum of activities by third parties – field investigations, laboratory tests and underground constructions – none of which has been performed under NUMO's Quality Management System.

NUMO has been executing a project to develop a strategy on how to evaluate, qualify and include data and information collected by the third parties in the assessment basis. The basic policy for data qualification was defined and a qualification methodology was derived and applied to the data.

1. Introduction

The site selection for a deep geological repository of high-level radioactive waste in Japan will be undertaken by means of a three-stage process. The three-stage process consist of literature survey (LS), preliminary investigation (PI) and detailed investigation (DI) (Figure 1). The initial LS aims at selecting areas for the next PI only on the basis of data from the existing literature. The results of geological characterisation in the PI stage lead to the final DI.

The Nuclear Waste Management Organization of Japan (NUMO) initiated the siting process in 2002 with open solicitation of volunteer host municipalities for the identification of a suitable repository site in three-stage processes as specified in the Act on Final Disposal of Specified Radioactive Waste. A logical and progressive basis for the siting process has been developed, which involves explicit exclusion criteria[1)]. With an amendment to the Basic Policy (22nd May, 2015), the Government committed to making a fresh start towards the initiation of the site selection process and is taking the following steps:

- Identifying geoscientific criteria and on this basis areas where a geological disposal facility (GDF) could potentially be located;
- Undertaking information activities so that each municipality can understand whether its area is suitable for inviting a survey of the geological environment for a GDF.

Through this process, it is expected that municipalities in the potential areas will invite NUMO to carry out feasibility studies to verify, for example, that the geological stability of the potential repository sites is not affected by volcanic activity, active faults or other geological phenomena, as defined in the exclusion criteria.

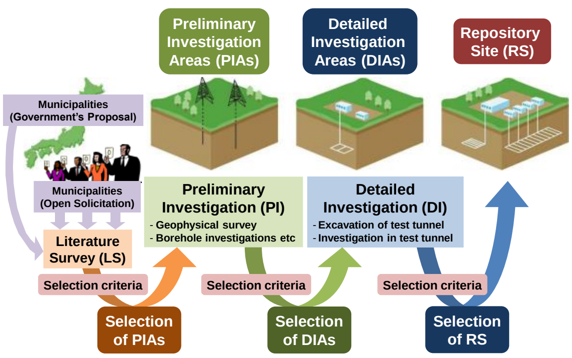

Figure 1 Site selection process in Japan

2. Quality assurance in the LS stage

The first stage in the site selection process is the LS stage, during which NUMO will collect available information from the literature, analyse it and compile it in such a way that the different areas can be evaluated against the site selection criteria defined by the expert groups of the government. The result of this evaluation will be the selection of a number of areas for further investigations to be conducted under the auspices of NUMO in the PI stage.

Key to the LS stage and the evaluation process is the development of a qualified assessment basis for each area. The assessment basis includes a wide range of empirical data from field investigations in the areas, laboratory tests on, for example, cores from boreholes in these areas, or underground constructions and studies. The data from the assessment basis will support the development of the site descriptive model (SDM) (*eg* conceptual model of hydrogeological structure, such as main types of water-conducting features, domains with different average hydraulic properties *etc*) to be used in the evaluations and the derivation of the input parameter values for any analytical or numerical models used. For all these data used, it must thus be shown that they are qualified and are appropriate for their intended use (fit for purpose). The challenge at this stage is that the vast amount of data in the assessment basis originates from a wide spectrum of activities by third parties – field investigations, laboratory tests and underground constructions – none of which has been performed under NUMO's Quality Management System [2].

3. Strategy and General approach for data qualification

As mentioned in chapter 2, the data qualification methodology is intended for data used as input for the development of the SDM; this includes neither data related to geological phenomena nor the geological map. The basic policy for data collection and qualification consists of the following five principles:

- All data found during the LS stage will be documented;
- Before using such data for the purpose of evaluating sites for the next phase, each data set will have to be qualified;
- The evaluation will be graded (level of QA);
- Data not considered further will be kept in the database and the reason for not using them will be described;
- A stepwise qualification process will be followed.

As the first step, NUMO will collect all available information without undertaking an evaluation of its quality, in order to have as a complete a database as possible. Each information or dataset entering NUMO's database will be characterised as 'not qualified' until the qualification process has been undertaken. It is recognised that, whilst a certain dataset may not be qualified in its entirety, it may still contain information that qualifies it for a specific application. A graded qualification to enable use of the maximum information contained in a given dataset is chosen.

Records that are not qualified will be designated as such and the reasons for their disqualification will be documented for future reference. In order to optimise the resources allocated for the qualification, a stepwise process was proposed[3] (Figure 2).

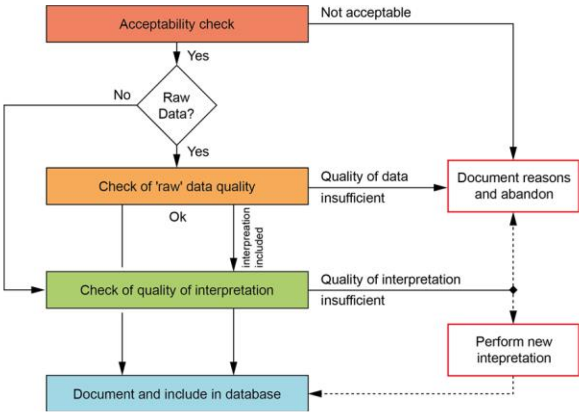

Figure 2 Basic qualification process for literature data

The basic qualification process consists of three steps, summarised below.

Step 1 Acceptability check

The basic acceptability check aims at assessing whether there is sufficient information about the data and it is in an acceptable form to allow initiation of the technical qualification process. The checklist for such a test is to a large extent independent of the type of data to be evaluated and consists of:

- Description of the data and creation of metadata information: The description includes information such as author of data, time and date of creation, original purpose or project for which the data were collected (later referred to as 'provenance');
- Form of data: For example, paper copy, analogue data and digital data.

If Step 1 is successful, *ie* sufficient information and in an acceptable form is available, then one can proceed with the next steps. If not, the data and information should be kept but identified as not qualified and the reasons for the data rejection should be documented. Note that the level of information may vary among different records and it will be useful during this step to also indicate the level of information (in broad terms – low, acceptable, high).

Step 2 Qualification of raw data

The qualification of raw data, if the raw data are available and accessible, is discipline-specific but, in general, includes information on:

- Equipment and methods used;
- Protocols and QA followed;
- Conditions during the laboratory tests or field investigations;
- Graphic tests;
- Consistency checks.

Raw data of this type include, for example, laboratory tests for the determination of petrophysical or hydrochemical properties. The qualification level is related to the reliability, or degree of certainty, of the resulting values.

Step 3 Qualification of interpretation

In the majority of the cases a dataset from the literature will not include raw data, but rather information derived from these data. Examples of this type of data are hydraulic conductivity or transmissivity values derived from borehole investigations, or geological sections interpreted from geophysical campaigns. The checks to assess the qualification are discipline-specific. These include, for example:

- Assessment of the methods used for the generation and in case of no raw data, the method used for the interpretation of the field data;
- Plausibility tests;
- Graphical tests (*eg* diagnostic plots using different normalised parameter sets);
- Internal consistency checks.

If access to raw data is possible, even if the qualification level of the existing interpretation is low, the possibility exists to perform a re-analysis. Such a decision will be affected by the potential role of the data for a given application, for example, development of an SDM in an area with scarce data, the chances of a successful re-interpretation as well as the amount of resources and time that would be needed.

In terms of qualification grading, four qualification levels are considered as below:

- Level A: Qualified - this is the highest level and would imply that there is a high degree of reliability to the dataset;
- Level B: Qualified but can be used with some restrictions – for example, a geological cross-section interpretation;
- Level C: Qualified but can only be used in a limited way.

Not qualified or Level D: Assigned by default to any dataset being collected before it undergoes evaluation. If the evaluation is negative, it would remain at this level and be tagged with a short description of the reasons.

General methods for evaluation of data reliability

Four alternative methods or a combination thereof can be used to assess the quality of the literature data and determine whether more specific technical evaluation is required. These are shown in Figure 3 and can be thought together with the discipline-specific processes as part of a tool-box for the evaluation[4]. The result of their application can be graded into different levels bounded by the two end-members – fully qualified and not qualified. With the exception of the qualification at the lowest level, which would lead to discarding a particular dataset, the qualification levels can contribute to the decision as to whether additional analysis or interpretation (discipline-specific) should be performed.

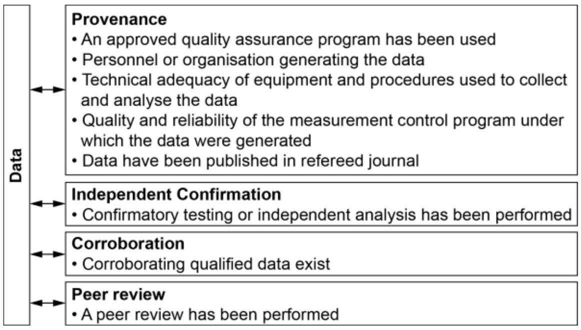

Figure 3 Qualification tool-box

The provenance category groups information that is directly related to the data, *ie* how the data have been collected, QA programme followed, and QC applied for the generation of the data, the reliability – experience, track record, recognition – of the personnel or organisation responsible for the data, or, finally, if the data are from a refereed publication.

The other three categories correspond to: (a) further actions that have been performed to or with the data, such as confirmatory testing, independent analysis or a formal peer review, or (b) existence of additional information from other qualified sources that would provide confidence in the data quality. Note that confirmatory testing, independent analysis or a formal peer review can also be performed as a result of the qualification level determined for a dataset, if it is expected that the qualification level through one of these actions could increase.

4. Application to the in-situ hydraulic conductivity dataset

An example of application of the general methods shown above is described in this section. It focuses on the acceptability check for one of the hydrogeological properties (hydraulic conductivity) collected from existing literature.

Work flow

The workflow presented in this section focuses on the qualification of in-situ hydraulic test data and will use some of the attributes of the corresponding database. The main three steps are shown in Figure 4 and consist of: the assessment of the level of information (acceptability level); the assessment of the reliability of the value; and, the assignment of a qualification level.

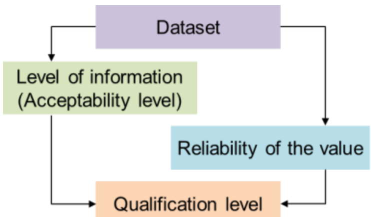

Figure 4 Main steps for the qualification of in-situ hydraulic test data

Level of information

Each record in the NUMO's database is described with a large number of attributes. Among these attributes, the following are considered for the acceptability step:

- Formation and rock type (referred to in the following as 'geological information');
- Location and depth of the test interval for the hydraulic test (referred to in the following as 'geographical information');
- Source of data (referred to in the following as 'reference').

Geological information

In order to use hydraulic test data as input for the SDM, NUMO needs to assess whether the data are representative of the rock types used in the model. Table 1 shows the matrix of the attributes considered. The information given on the rock formation is rated in three levels. The lowest quality rating is assigned to records with no information on the rock type (*eg* attribute field left blank or designated as unknown); the highest quality rating is given to those records where the information provided is unequivocal and as detailed as possible. The level of information on the rock type attribute is given four quality levels (Table 1). The lowest level comprises all records for which this attribute is described as unknown or left blank, whereas the best level those with a complete description of the rock type.

Table 1 Rating of the level of information for the geological information

Geological information		Formation		
		Complete	Incomplete/Partial	Blank
Rock type	Complete	4	3	2
	Partial (eg argillaceous rock)	3	2	1
	Rudimentary (eg sedimentary)	2	2	0
	Blank	2	1	0

Geographical information

Four attributes are relevant for the location of a borehole in the dataset: latitude, longitude, municipality and prefecture. The highest level of information is the exact coordinates (latitude and longitude) and it decreases as the number of attributes left blank increases (Table 2).

Depth information is provided by four attributes: Upper, lower, and middle depth of the testing interval, and interval length. The dataset is split between records with no depth information, records with indication of the middle of the interval, and records with all four attributes provided. These three categories of data will receive respectively the lowest, intermediate and highest grade for the level of depth information (Table 2).

Table 2 Rating of the level of information for the geographical information

Geographical information		Depth		
		Known depth and interval length	Only middle of interval known	Blank
Location	Lat./Long. Address Borehole #	4	3	1
	Municipality	3	2	0
	Prefecture	2	2	0
	Blank	0	0	0

Reference

The third component for the qualification of the level of information is the source or reference for a record and is used to discriminate data according to the reliability of the original reference. The highest information level is assigned in general to peer-reviewed publications, as well as to data extracted from databases that are considered as reliable (Table 3). The lowest level is assigned to data which have been found in a non-peer-reviewed document and stem from a reference which is not available.

Table 3 Rating of the level of information for the reference

Reference	
Peer-reviewed journal Peer-reviewed report Qualified database	4
Quality certified data producer (eg ISO or JIS)	3
Conference abstract	2
Non peer-reviewed and referring to an unavailable source	1

The information level ratings defined above for the different categories of geological and location information are combined in rating matrices which provide on a scale from 0 (lowest) to 4 (highest) the level of information for these two groups of information (Tables 1 and 2). The sum of the matrix outputs for geological and geographical information feeds into Table 4 which determines, depending on the quality of the data source, the rating of the level of information.

Table 4 Rating of the level of information

Level of information		Sum of geological and geographical information								
		8	7	6	5	4	3	2	1	0
Reference	4	A_{AL}	B_{AL}	B_{AL}	B_{AL}	C_{AL}	C_{AL}	D_{AL}	D_{AL}	Disqualified
	3	A_{AL}	B_{AL}	B_{AL}	C_{AL}	C_{AL}	C_{AL}	D_{AL}	D_{AL}	
	2	B_{AL}	B_{AL}	B_{AL}	C_{AL}	C_{AL}	D_{AL}	D_{AL}	D_{AL}	
	1	C_{AL}	C_{AL}	C_{AL}	C_{AL}	D_{AL}	D_{AL}	D_{AL}	D_{AL}	

Reliability of the value

The reliability of the value is evaluated mainly on the test method and the interpretation method used. Note that a record can include information on both attributes, only on one and in some cases on neither. The workflow discussed below considers all these possibilities. A four-level qualification is also used for the two attributes, as discussed in this section.

A two-step procedure was followed to estimate the reliability level of a documented value. The first step aimed at grouping the methods registered in the database to a much smaller number of types of methods keeping in mind the ultimate use of the data values, namely the derivation of parameters for SDM. Thus, the categories used were chosen to represent, to the degree possible, the standard type of field tests and interpretation methods used in site characterisation in the context of SDM development. The second step was to assign the rating of hydraulic testing method between 4 (highest) and 1 (lowest) to each of the categories. A similar approach, *ie* grouping the methods, in categories, was also followed for the interpretation methods.

The sum of the ratings of the test method and of the interpretation is used to define the reliability level (Table 5) in four levels between A_R (highest) and D_R (lowest).

Table 5 Rating of the reliability of the value

Sum of rating of test and interpretation method						
8	7	6	5	4	3	2
A_R	A_R	B_R	B_R	C_R	C_R	D_R

Figure 5 shows the complete workflow that allows determining the reliability level of the hydraulic test result. The workflow has two distinct branches, depending on whether there exists information on the two attributes. All data that have not been disqualified in the workflow for the level of information start the workflow at the top. The first step is to determine if the test method and/or interpretation attribute are provided in the dataset, for hydraulic conductivity.

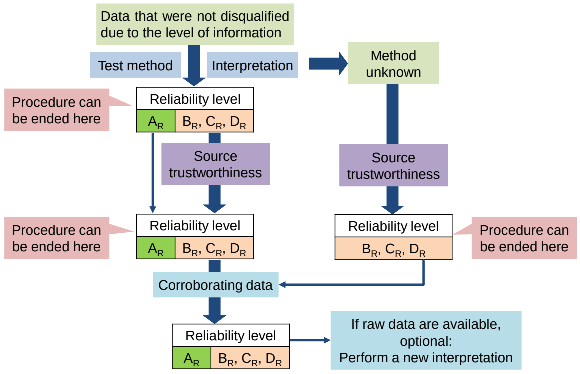

Figure 5 Workflow for the reliability of the value

If either or both are provided, a reliability level can be assigned, as described in Table 5. The procedure can be stopped at this stage with a preliminary reliability level. This would be useful for a first screening of the data, selecting only the data points with a reliable testing method. It is, however, possible to continue the procedure to potentially increase the level of reliability for tests that were rated B_R, C_R or D_R at the first step. The second test considers the trustworthiness of the source or the producer of the data. Finally, if raw data are available, a new interpretation can potentially be performed.

For data where no method is specified, the only resource is to consider the data provenance and the value itself (workflow to the right on Figure 5). The quality of the data provenance is the same as that used for a known method, but the maximum level obtained with this method will be B_R.

Qualification of a record

Both the level of information and the reliability of the value ratings are combined to provide the final qualification level of the data. The qualification levels, on a scale from A (highest) to D (lowest), are shown in Table 6, and their relative definitions in Table 7.

Table 6 Qualification level based on the rating of the level of information and the reliability of the value

Qualification level		Level of information			
		A_{AL}	B_{AL}	C_{AL}	D_{AL}
Reliability of the value	A_R	A	A	B	B
	B_R	A	B	B	C
	C_R	B	B	C	C
	D_R	B	C	C	D

Table 7 Description of the qualification levels

A	**Qualified data** Qualified data, high-degree of reliability
B	**Use with limitations** Qualified data, with some degree of uncertainty or limitation in the level of information
C	**Restricted use** High uncertainty in the data value or the matadata, for specific purposes only
D	**Disqualified** Data cannot be used in the current stage

This process is being tested on the actual database and the results are promising in terms of correct record screening and ease of application.

5. Summary

In the initial LS stage, NUMO will collect available information from the literature and compile it in such a way that the different areas can be evaluated against the site selection criteria. The challenge at this stage is that the vast amount of data in the assessment basis originates from a wide spectrum of activities by third parties none of which has been performed under NUMO's Quality Management System. NUMO has been executing a project to develop a strategy on how to evaluate and qualify such data in the assessment basis. The basic policy for data qualification was defined and a qualification methodology was derived and applied to the in-situ hydraulic conductivity dataset. In this case, the assessment of the level of information considers the availability of information on the geology, the location and depth of the test and the reliability of the data source. The assessment of the reliability of the value focuses on the value reported and its reliability. The final step combines both level of information and reliability of the value to obtain the qualification of the record in the assessment basis. A full application of these methods to existing and updated databases is expected to take place in the near future with the initiation of the LS stage.

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