NUMO's Strategy for HLW Repository Siting based on a Volunteering Approach

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Abstract

There is a growing international consensus that the implementation of a deep geological repository for high-level radioactive waste (HLW) may be more determined by the degree of acceptance by stakeholders – particularly local communities – than by particular technical issues. For NUMO, the organisation responsible for HLW disposal in Japan, the critical importance of such acceptance led to the decision to initiate a volunteering approach to siting. This decision influences the entire implementation program, resulting in particular challenges for site characterisation, developing repository designs and the associated programme of performance assessment and supporting R&D. It also, however, leads to special need for openness and transparency in the decision-making process, particularly that associated with the gradual narrowing in to a favoured site and design for licensing. This paper outlines NUMO's strategy for planning this project, which balances the requirements to maintain a clear focused programme while, at the same time, assuring the flexibility to respond to the inevitable surprises and changes in constraints and boundary conditions. Particular emphasis is placed on practicality, ensuring that ambitious goals can be achieved despite somewhat limited resources.

Introduction and background

Following legislation in the "Specified Radioactive Waste Final Disposal Act", the Nuclear Waste Management Organization of Japan (NUMO) was established in October 2000, with responsibility for implementing a disposal programme for vitrified HLW from the reprocessing of spent fuel. The complex geological setting and active tectonics of the Japanese archipelago bring challenges for the repository implementer; even though the fundamental feasibility of safe disposal has been demonstrated in the generic H12 study (JNC, 2000), siting such a repository is a sensitive issue. In particular, acceptance by the host community will play a key role, which led NUMO to announce to the public start of open solicitation of volunteer municipalities in December 2002.

Following the call for volunteers, the siting process is planned to proceed in a staged fashion. The first stage involves use of literature information to determine the basic suitability of each volunteered site in the light of established exclusion criteria, and to rank sites in the event that there are more volunteers than can go through to the second stage of field characterisation. The initial field characterisation of "Preliminary Investigation Areas" (PIAs) is restricted to work carried out from the surface. Following this stage, sites are again compared and a reduced number carried on as "Detailed Investigation Areas" (DIAs), in which an underground characterisation facility is constructed to allow the deep geological environment to be examined in more detail.

According to this plan, a site would be selected, the associated repository concept specified and the licensing process initiated in the late 2020s.

The reference time plan for the first repository is based on an assumed capacity of 40,000 waste packages, corresponding to reprocessing of all spent fuel expected to be produced until around 2020. The vitrified HLW will be stored for 30-50 years before disposal. According to the Final Disposal Plan, repository operation would start in late 2030s with an annual emplacement rate of 1,000 canisters of vitrified HLW. It is important to note that this plan was developed before any detailed studies of the practicality of implementation of the idealised H12 concept had been carried out.

Special challenges resulting from the volunteering process

From the point of view of practicality of implementation, the time plan illustrates some important features, which, particularly at early stages, are quite different from most other national programmes:

- Initiation of the process is dependent on qualified volunteers coming forward; such volunteers must not be excluded on the basis of published stability criteria and could come from any part of the Japanese archipelago.
- The literature study phase is relatively short and would run in parallel for all qualified volunteers.
- Field characterisation is initiated at the PIA stage; the decision to select a PIA based on the results of evaluation of literature therefore corresponds to a considerable commitment of resources.
- The PIA stage is also relatively short and forms the basis for selection of a smaller number of DIAs where underground characterisation facilities are constructed – involving a yet greater commitment to the site.

There are thus a number of clear decision points where sensitive choices must be made between alternative sites (and associated designs) at an early stage, based on limited data. NUMO is committed to making such decisions in an open and transparent manner, which will be aided by a formal programme development process. Nevertheless, it is clear that the entire programme is a non-starter without communities being prepared to volunteer and to continue to support the site selection process.

The time plan is more similar to those in other national programmes at the later stages of site characterisation and subsequent construction and operation phases. However, some particular characteristics of the Japanese case need special consideration - in particular, the relatively large inventory and high emplacement rate for the reference case (NB as the Japanese nuclear power programme is expected to continue and expand, it would be attractive if these values could be increased even further). Operational practicality and safety are thus key aspects of any design – further constrained by the probability of relatively high seismicity and geological complexity of any Japanese site.

It is thus clear that volunteering in Japan results in challenges for both the site characterisation and repository engineering teams. These challenges are very closely

inter-related and hence it is important that the implementation programme is well planned in advance. Nevertheless, implementation will extend over the best part of a century – and possibly even longer in the case of an extended institutional control phase. Based on the history of the last century, this future period can be expected to involve major developments in science and technology and evolving socio-political conditions at regional, national and global scales, all of which could influence the repository programme. Although inherently impossible to predict, it is important to explicitly allow for such changes to external project boundary conditions.

For this purpose, and to make work more systematic, the NUMO Structured Approach (NSA) has been developed. The NSA has been previously outlined (e.g. Kitayama et al., 2005a;b) and will be described in detail in a technical report which is presently being completed (NUMO, 2007); hence it is not discussed further here.

Structuring is based on the sequence of decisions which have to be made as the project advances. As every decision can be defined in terms of a response to specific requirements, a Requirements Management System (RMS) has been adopted to implement the NSA (also presented in detail in NUMO, 2006). This RMS will allow the justifications, supporting arguments and knowledge base used for every decision to be clearly recorded and will highlight when such decisions may need to be revisited due to changing boundary conditions or technical advances. It thus serves as a valuable tool to help maintain experience and, in particular, "institutional memory". Implementation of a formal RMS is inherently easier for a young organisation like NUMO, but it has a special role at present, when most members of NUMO's technical staff are on short attachment from other organisations.

Such a process is important to resolve the dichotomy of maximising the flexibility required to tailor the programme to the characteristics of volunteers while maintaining the focus needed to concentrate efforts to optimise use of limited resources. System understanding is limited at early stages and hence "provisional" decisions may have to be made on the basis of knowledge which is known to be incomplete; the assumptions behind such decisions can be continuously monitored until they are confirmed or disproved – requiring the decision to be revisited in the latter case. The explicit acknowledgement of such uncertainties is important, illustrating clearly to stakeholders that future changes are part of a structured evolution process. This contrasts with examples from other programmes, where early project decisions often tended to become "frozen-in" and hence hard to change without causing public concern.

Practical implementation of the site-selection process

As a starting point, with the emphasis on ensuring transparency, NUMO has openly published the "Siting Factors for the Selection of Preliminary Investigation Areas". These are effectively the criteria which will be used to determine the acceptability of a volunteer or to compare volunteers if there are too many of them to go through to the PIA stage. Some of these factors are, however, especially critical given the plate tectonic setting of Japan – associated with volcanism and active fault movement, for example. NUMO has

thus established groups of leading national and international experts in relevant fields to develop advanced models to support the predictability of geological stability on a location-specific basis. This work has been extensively reported elsewhere (e.g. M. Apted et al., 2004).

More recently, effort has concentrated on more practical preparation for carrying out the characterisation of volunteers. Early planning of the process of carrying out literature studies has been extended to development of manuals to guide the process of field work in a PIA. Although it is impossible to know in advance what exactly a volunteer site would look like, typical characteristics of relevant Japanese sites can be outlined and some of the goals of field work specified on the basis of key features (e.g. Fig. 1). This can be extended further by examining how field characterisation studies have been carried out in other national programmes where similar challenges (e.g. geological complexity, active tectonics, coastal locations) are met. The applicability of such manuals can now be tested by applying them in dry runs of key site investigation technology carried out at a test site in Japan.

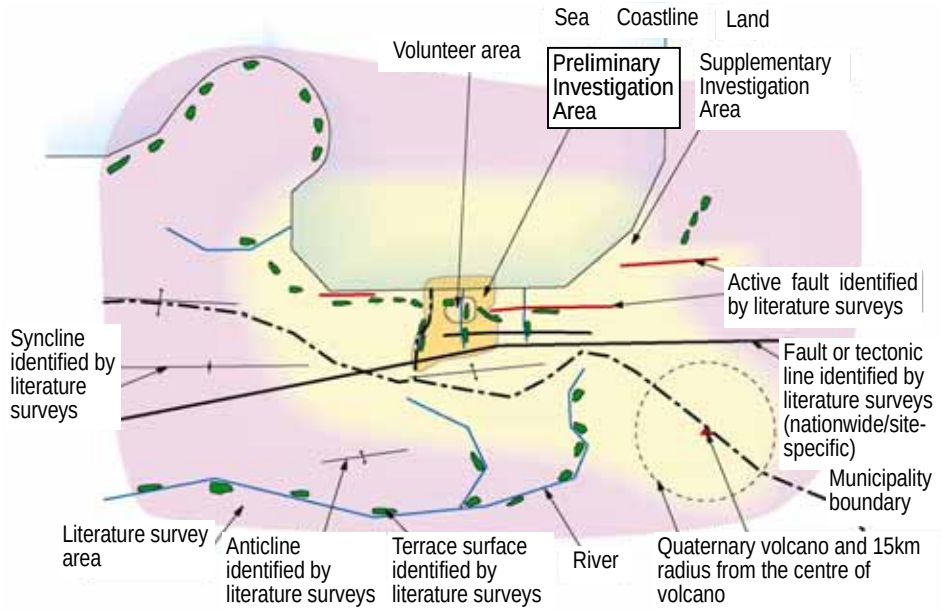

Figure 1 An example of a hypothetical Preliminary Investigation Area where a Quaternary volcano and active faults are identified by literature surveys near the volunteer area.

Generic repository design refinement in terms of practicality

Although NUMO is still waiting for volunteers, the challenging implementation time plan means that pre-emptive studies are valuable to provide support for the first phase of site evaluation. In particular, NUMO has recently refined generic repository designs in terms of practicality; including detailed planning of construction and waste emplacement, studies of operational safety and a design dry run associated with performance

assessment, using site environment data from Japanese civil engineering(e.g. Kitayama et al., 2006).

The planning study identified that the large reference inventory and emplacement rate of 5 waste packages per day is challenging to implement. In the study, a logistics simulator was used to evaluate different design options, indicating that prefabricated EBS modules – PEMs – could be advantageous from this point of view. The advantage of PEMs is also clear from general project management studies, which evaluate the influence of potential operational disturbances (Figure 2). Such designs allow more flexibility to recover from a wide range of perturbations.

To evaluate operational safety, one of the key constraints on practicality, a methodology has been developed that places particular emphasis on utilising experience from civil engineering and the nuclear industry, which may be directly relevant for potential accidents associated with the construction processes. For other types of accident, it may be possible to reason by analogy to similar processes elsewhere. Nevertheless, some activities associated with waste package emplacement and repository closure are unique and a special analytical approach is needed. The results of the safety study will provide feedback for design improvement, leading on to further iterations of operational safety assessment.

The design and associating performance assessment dry run allow unfavourable site environment data to be identified, leading to requirements for improvement of PA methodology and the site characterisation programme at future stages of investigation.

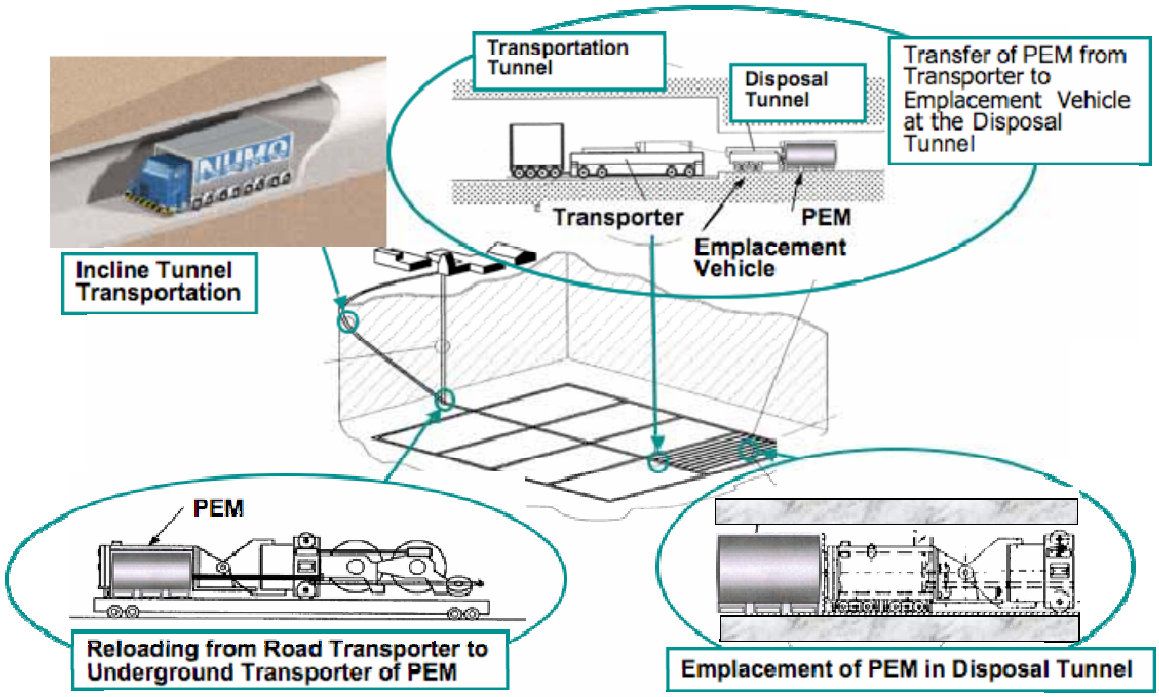

Figure 2 One example of a range of operational concepts examined within the NUMO logistics and project management studies – use of PEMs.

Increasingly detailed designs also lead to a requirement to develop associated performance assessment codes and databases which can simulate more realistically all components of the engineered barriers and their geometry and layout. Such improved realism is expected to demonstrate increased robustness of the technical barriers which may play a very important role in feeding back to determine the requirements on emplacement and, indeed, the minimum acceptable performance of the natural barrier.

Conclusions

The decision to adopt a volunteering approach to siting gives special requirements for:

- NUMO's overall development plan – the NSA provides a process which maintains focus while preserving flexibility
- Project management – to ensure that decision-making is open and transparent (both internally and externally)
- Preparing the site characterisation, repository design and PA toolkits to allow programmes to be tailored to the number and particular characteristics of volunteers

Emphasis in this presentation has been on technical aspects, but these have to be seen within the context of a general confidence-building programme focused on building dialogue with stakeholders (Kitayama, 2006).

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