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The NUMO International Technical Advisory Committee (ITAC):

Background, accomplishments and perspectives on the role of technical support groups

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Nuclear Waste Management Organization of Japan (NUMO)

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Preface

This report presents an overview of the roles and activities of the International Technical Advisory Committee (ITAC), which served NUMO through its formative years from 2001 to 2008. This group supported NUMO during the time when many of the basic, often innovative, concepts that characterise the Japanese deep geological disposal programme were developed. This overview thus provides a perspective on these activities that is not available in other material published in English.

ITAC Phase 1 has now been brought to a close, having served the role for which it was planned. It is intended that this document will provide an integrated record of the work of the committee, helping NUMO (and maybe also other similar organisations) to assess the relative merits of its structure, remit and modus operandi in order to aid in the planning of future review and advisory groups.

The report has been compiled from the records of the 12 ITAC meetings by the ITAC chairman and secretary, who have endeavoured to place the committee's work in context and to provide the background needed to explain its accomplishments to international readers.

1 Introduction

1.1 Establishment of ITAC

In 2000, Japan was relatively late amongst the leading nuclear power nations in establishing an organisation devoted specifically to managing the country's nuclear wastes intended for deep geological disposal. Many nations, including Belgium, Canada, Finland, France, Germany, Sweden, Switzerland, the UK and the USA, already had (or once had) national organisations charged with developing disposal solutions for such waste types. However, the Japanese Government and the nuclear utilities had engaged in extensive preparatory work, focused primarily on generic R&D to establish fundamental generic feasibility (run mainly by PNC/JNC), before establishing the Nuclear Waste Management Organization of Japan (NUMO) as the body responsible for implementing a repository for geological disposal of HLW (further background on http://www.numo.or.jp/en/index.html). A precursor organisation, SHP, operated for several years, gathering information and making contacts to national waste management agencies around the world. In addition, one of the utilities provided support and commissioned a series of position papers that then led to a special seminar and ultimately a reference book (Chapman and McCombie, 2003). Such preparatory discussions also addressed the topics of the form, structure, programme and advisory bodies that could be best suited to a new disposal organisation.

Shortly after its establishment, NUMO engaged in bilateral discussions with the Swiss waste management organisation, Nagra, on the topic of advisory bodies and this led to a “dry run” with a technical group, including four individuals who later became members of the International Technical Advisory Committee (ITAC) that NUMO decided to establish in 2001. The initial key objective was to ensure that NUMO could have access to the details of what had been successful – and, very importantly, what had **not** been successful – in major foreign programmes. The separation of roles into (a) advice on future plans and (b) review and technical support was discussed, but NUMO decided that, initially at least, advisory and review functions could be covered by a single group.

Accordingly, invitations were extended to individuals who had in-depth knowledge of other national programmes and could therefore help NUMO to benefit from lessons learned in these. In the original Terms of Reference of ITAC, it was stated that, to perform their role optimally, ITAC members should meet as many as possible of the following requirements:

- wide and long experience in one or more foreign waste disposal programmes
- scientific and technical expertise in some of the following key areas:
    - overall waste disposal strategies and concepts
    - siting procedures, engineered barriers, performance assessment and confidence-building
    - procedures for independent international review and programme support
- familiarity with the structure and the content of the Japanese HLW programme
- good network of external connections in the waste disposal field
- an internationally established personal reputation to help enhance the credibility of NUMO.

In this way, ITAC membership gradually expanded to include individuals with intimate knowledge of key national programmes, as illustrated below.

Canada	Keith Nuttall
Finland	Juhani Vira
France	Bernard Faucher
Germany	Klaus Kühn
Sweden	Johan Andersson
Switzerland	Ian McKinley (Secretary)
UK	Neil Chapman
USA (WIPP)	Erik Webb
USA (Yucca Mountain Project).	Mick Apted
International	Charles McCombie (Chairman)

However, the selection also covered a wider range of programmes in which these individuals had been actively involved, including:

- Further national programmes in Taiwan, Korea, China and South Africa
- International studies of the IAEA, NEA, EC, Pangea Project and Arius

The mechanisms employed to efficiently transfer experience in a variety of key areas are described below. A particularly important selection criterion was that ITAC members should ideally have prior knowledge of, and experience with, Japanese waste management work. This helped to lower hurdles that could have resulted from lack of familiarity within ITAC regarding the technical progress and cultural environment in relevant Japanese R&D areas.

However, the role of ITAC has not been confined to the transfer of past know-how and experience. The Committee's functions have evolved over seven years in a variety of advisory and review modes, designed to also ensure that state-of-the-art work is performed by NUMO and to provide forward-looking perspectives. In summary, the roles of ITAC have been:

- Transfer of past experience from established national waste management programmes, as described above.
- Providing direct input to technical documentation, in particular to the NUMO documents accompanying and supporting the solicitation process for volunteer siting communities.
- Review of technical strategy, work programme and individual projects.
- Advising on setting priorities and introducing new activities.
- Providing direct support to NUMO technical staff in selected areas.

This last bullet point is somewhat unusual for formal advisory committees, which do not normally become directly involved in the work of the programme on which they advise. It was nevertheless judged to be an effective approach, given that various ITAC members are recognised experts in relevant work areas and are well suited to providing such hands-on support. Naturally, when ITAC was engaged in review of work packages carried out with direct involvement of individual ITAC members, these members were then considered as part of the NUMO team and assisted in presenting projects rather than commenting on them.

A final key point concerning the basic structure of ITAC is that it was not designed to be the sole body providing advisory input to NUMO. At the same time as ITAC was established, NUMO set up a Domestic Technical Advisory Committee (DTAC) in order to allow in-depth

interactions with the Japanese scientific and technical communities. DTAC members also sometimes acted in direct support roles as well as top-level reviewers and advisors (Kitayama et al., 2005a).

1.2 Organisation of work

The frequency and the content of ITAC meetings were adapted over the years to reflect the changing needs of NUMO. Each of the twelve meetings that took place lasted three days. The first day was generally devoted to NUMO providing an overview of its programme status and – importantly – to NUMO providing responses to the ITAC recommendations from the previous meeting. Much of the remainder of days one and two was devoted to individual NUMO Project Leaders presenting the status of their projects, responding to comments from ITAC and discussing any recommendations made. While the primary focus of NUMO presentations was on technical topics, presentations were also made to ITAC by NUMO's public relations group, in order that ITAC might also advise on issues and factors related to NUMO's approach to seeking volunteer communities as possible candidate repository sites.

With time, an additional agenda item was introduced, in which ITAC members summarised national positions on selected key topical issues. The areas addressed are listed in the following section. On the third day, a closed session of ITAC was held. This lasted several hours, during which a formal presentation of principal conclusions and recommendations was prepared for delivery to NUMO senior management and technical staff. This presentation, which concluded each meeting, together with any clarifying questions from NUMO, were documented subsequently to provide a formal record of the meeting, which was then published on the NUMO website.

As mentioned above, direct collaboration between individual ITAC members and NUMO project staff was also part of the functioning of ITAC. This occurred in formal sub-groups or projects or by NUMO directly allocating technical tasks to individual members. Technical areas that have benefitted from such "hands-on" involvement include the tectonic studies performed in the ITM project, work on repository design concepts, development of site characterisation planning manuals, studies on requirements management systems (RMS) and on implementing Working Standards, use of multi-attribute analysis, etc. As several ITAC members were members or contractors of sister organisations that subsequently established bilateral collaboration agreements with NUMO, this provided yet another mode for interaction.

Further ITAC activities have involved interactions with DTAC. There have been only two formal combined meetings, but joint appearances at public meetings and in workshops also took place. The final ITAC meeting also included a trip to Rokkasho to view the relevant back-end activities at this site. Although requiring considerable effort from the NUMO side, this was very useful for ITAC – particularly in relation to NUMO's enhanced responsibility for TRU, as discussed in more detail in section 4.5.

1.3 Overview of topics considered

The topics covered during the 12 ITAC meetings have been strongly determined by the evolving needs of NUMO. At the outset, the major effort was on advising on input to the solicitation documentation prepared for NUMO's voluntary siting strategy and on reviewing the various drafts produced. This was an extremely important task, since these documents

were the first scientific/technical publications of the new waste management organisation and hence vital for helping to establish NUMO's credibility with the public and also with the international waste management community. The ITAC input was not only on the content, but also on the presentation of the material and its tailoring for particular audiences. Behind the discussion on the key documents lay intensive technical exchanges on the siting factors to be used and on the range of repository design concepts to be examined.

Further in-depth technical exchanges have taken place on the topics of regulatory frameworks, site characterisation, performance assessment and operational logistics. NUMO benefited not only by receiving direct access to current information from various national and international programmes, but also by hearing the open discussions and comparisons made by ITAC members when contrasting the varying approaches adopted in different countries on similar topics.

In addition to addressing such purely technical issues, ITAC also reviewed and advised on the various project management and decision-making structures and processes being developed in NUMO. The principal initiatives here involved development of the NUMO Structured Approach (NSA), which was designed to provide an overall framework for the flexible tailoring of its activities required by the volunteering approach to siting. Advice was given on the overarching structure of the NSA and also, at a more detailed level, on components such as the Requirements Management System (RMS), Working Standards and a Quality Management Programme. Finally, although not part of its principal Terms of Reference, ITAC has been informed throughout by NUMO on its public communication programmes and, in fact, communication and public confidence were a focus at one meeting. The figure below gives a concise overview of the timing of the ITAC meetings and of the focus in each period of its work. The different levels (1 to 3) of the solicitation documentation are explained later in section 2.2.

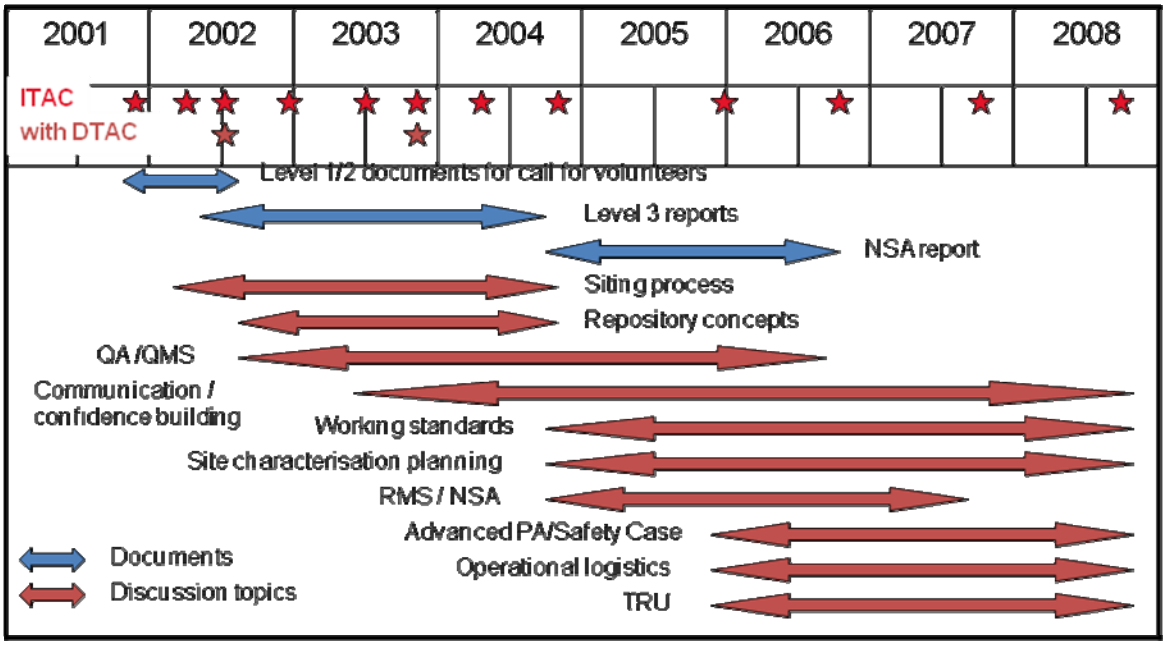

Figure 1-1: Overview of the timing of the ITAC meetings, main documents and topics of discussion.

As explained above, a common feature at ITAC meetings has also been a series of concise presentations by members summarising national positions on key topical disposal issues. A list of the titles of these special agenda items illustrates the range of subjects covered:

- International HLW Programme Reviews: status with respect to siting / siting factors; safety case; repository concepts and practicality of implementation (ITAC 3)
- Site Characterisation Programmes (ITAC 4)
- Quality Assurance in National Programmes (ITAC 5)
- Timescales for Compliance (ITAC 8)
- Public Communication (ITAC 9)
- TRU Disposal (ITAC 10)
- Repository Closure and Monitoring (ITAC 11)
- Use of Technical Review and Advisory Groups (ITAC 12)

1.4 Current status

Initially, the most important and urgent task was to ensure that the documentation for the solicitation process was sufficiently complete and of high quality. These were essential pre-requisites to helping establish the technical credibility of NUMO as a repository implementing organisation. For this reason, initial ITAC meetings were relatively frequent and concentrated on the solicitation documentation. Subsequently, NUMO's main task was to prepare for the siting work that will follow the emergence of volunteer communities and to initiate all of the activities that are necessary in an established, major repository organisation.

The current situation is that most of the essential programme elements have been put in place and that, in some technical areas, NUMO is now at the forefront along with other leading programmes. After several years of development, NUMO has now established its technical credibility in Japan (especially with academics and professional organisations). It has also become a well regarded organisation within the international waste management community. Its scientific basis equals that of other national programmes in virtually all areas, with superior expertise in some selected key areas, such as understanding of the impacts of tectonics and volcanism. It has recognised the crucial importance of quality management and continues to develop its structured approaches to implementation, supported by appropriate management tools. Unfortunately, volunteers have not yet come forward and this limits the technical activities that NUMO can undertake.

A further important boundary condition is a recommendation from a Government sub-committee that all main organisations in the radwaste field (implementers, regulators and supporting R&D institutions) should have independent advisory and review groups. As noted above, this was initially considered by NUMO; however, for the first phase of work described in this document, a more efficient structure was preferred, with ITAC members being involved in advisory work, review activities and even in directly assisting NUMO staff in specific project areas. The appropriate delineation of these roles in future advisory bodies that NUMO may appoint is discussed in chapter 6 of this report.

When site-specific investigations are started, NUMO's primary technical need will no longer be the transfer of experience from other national programmes. More emphasis will be placed on mastering current and future scientific and technical approaches to site characterisation, site selection, engineered barrier development, repository design, repository operational and long-term safety assessment, etc. For this future work, a new ITAC phase will be introduced,

with participants bringing expertise in key disciplines rather than experience from national programmes. Accordingly, it has been decided to conclude the activities of the current ITAC and reconstitute future technical advisory / review committees when the next phase of the Japanese national disposal programme has been better defined.

1.5 Objectives and structure of this report

The present ITAC has provided a valuable service during the initial years of a major new national programme. This report documents how the Committee operated and what has been achieved. The target audiences include:

- The Japanese Government and NUMO senior officials, who should be able to judge to what extent the resource-intensive advisory activities of ITAC have contributed to the national disposal programme.
- The Japanese scientific and technical community, which should be aware of the breadth and depth of NUMO's work to respond to the technical challenges associated with a deep geological disposal project under the boundary conditions in Japan.
- NUMO staff, who can review the ITAC Phase 1 contributions in order to optimise the structures and working procedures chosen for future advisory groups.
- The international waste management community – and especially the increasing numbers of new nuclear nations – to communicate lessons learned and help partner organisations judge the pros and cons of establishing such groups.

One important objective at the conclusion of this report is to provide a list of suggestions that might be of value to NUMO when managing its future project work and, in particular, when re-introducing technical advisory or review bodies for its repository implementation programme.

To enhance the utility of the report, the many topics addressed by ITAC during its 12 meetings are addressed not in a chronological fashion but rather grouped by theme.

2 Supporting the call for volunteers

2.1 The NUMO technical and societal siting process (voluntary; three stage)

The approach to be followed in Japan was laid down in the Law of 2000 (METI, 2000), which states that the Ministry of Economy, Trade and Industry (METI) is responsible for formulating and announcing a basic policy for the final disposal of specified radioactive waste which should include:

- *A fundamental endorsement of final (geological) disposal of specified radioactive waste*
- *Factors concerning the selection of preliminary investigation areas, detailed investigation areas and sites for repository construction*
- *Policy measures designed to promote the understanding of interested local citizens with respect to the selection of areas/sites*
- *Issues concerning the implementation of final disposal of specified radioactive waste*
- *Issues concerning the development of technologies for final disposal of specified radioactive waste*
- *Measures designed to promote the understanding of the general public regarding final disposal of specified radioactive waste*

NUMO was charged with tasks starting from selection of the preliminary investigation areas (PIAs), detailed investigation areas (DIAs) and sites for repository construction, through to operation and closure of disposal facilities for the initially "specified" high-level waste (HLW) from reprocessing of spent fuel. The Law also described PIAs and DIAs as follows:

- *"Preliminary investigation area" means any area where, based on literature surveys, data and other evidence, significant tectonic activity resulting in earthquakes, volcanic activity, uplift, erosion or other natural disruptive phenomena is unlikely to occur now and in the future.*
- *"Detailed investigation area" means any preliminary survey area where site investigations have indicated that the potential host geological formation is stable at present and is likely to remain so in the future and that tunnels and other underground structures can be excavated in the formation without difficulty.*

Based on this background, a stepwise siting strategy was developed for Japan, as illustrated in the NUMO schematic below.

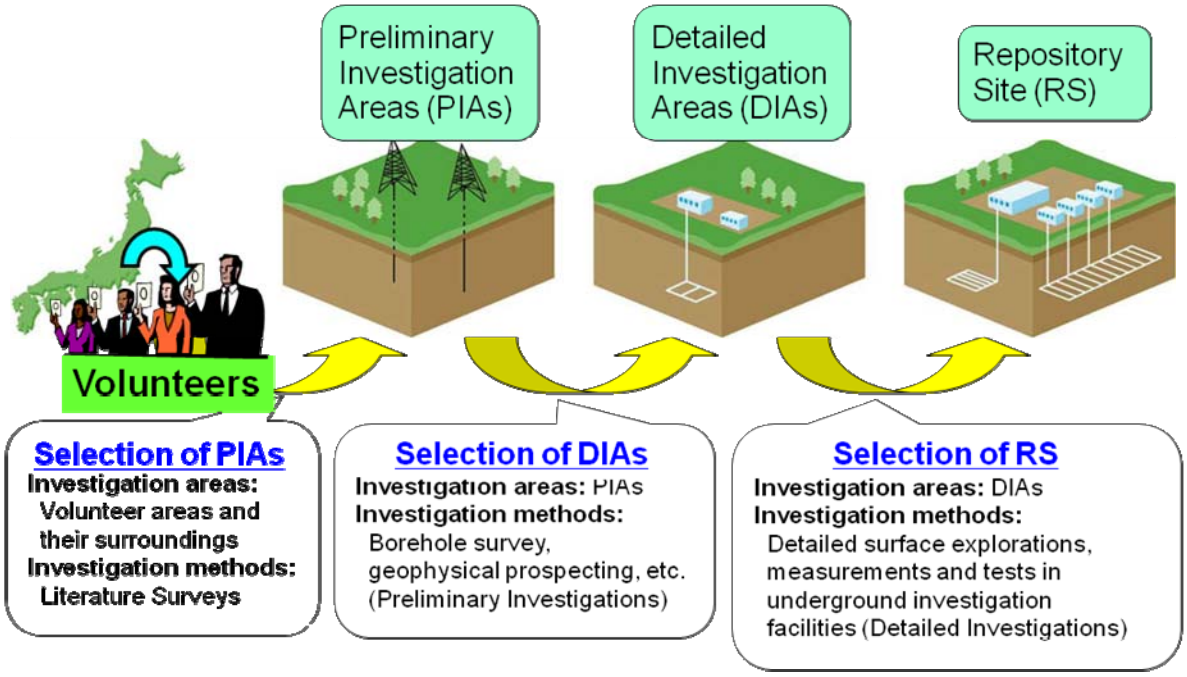

Figure 2-1: The three stages of the site selection process.

The Government policy did not specify what process NUMO should use in order to identify and then narrow down the potential siting regions. Comparisons with other national programmes and their progress over the two last decades of the 20th century indicated that selection methods had been evolving. In the early days of repository programmes, "top down" decisions were taken by experts (often behind closed doors) and then a siting decision announced to the public with some justification provided. This "Decide, Announce, Defend" approach had, however, run into problems in various countries and it was increasingly acknowledged that consent of the local siting community was a great advantage – or even a necessity. Accordingly, NUMO decided that the societal aspects were so important that a purely volunteering approach would be adopted.

ITAC members strongly supported the concept of such a volunteering approach. Even though it was novel, this was considered to be forward-looking and represented a sensible extrapolation from international trends towards increased involvement of host communities. It was also considered to be well anchored within NUMO's policy of openness and transparency in the siting process. Nevertheless, ITAC recognised that this approach would lead to many challenges for NUMO – both technical and institutional – and these have been a focus for much of ITAC's subsequent deliberations.

Despite the problems that have been experienced in soliciting volunteer communities over the last five years, it can be seen that NUMO's choice of a volunteering approach was a pioneering decision that has influenced later siting work in other major nuclear programmes, such as those in Canada (NWMO, 2008) and the UK (NDA, 2008a). These programmes may, in fact, have learned also from some of the difficulties that NUMO has faced in the Japanese siting effort. In both the UK and Canada, considerably more time was invested in seeking input from all parties including the public and building public consensus on the way forward before actually issuing a call for volunteers. Also, in both cases the commitment required of a volunteer community was reduced below that required in Japan and direct government support for the siting agency was more apparent than in Japan.

A commonality among all three national programmes was that their volunteering siting approaches were each launched by a newly established organisation. NUMO realised that it is essential in such an approach that communities trust that the waste management organisation will accept only volunteer communities that can be shown to fulfil the geological requirements for safe repository siting. Since NUMO was a new organisation, a primary goal then became the building of public trust in the technical competence, transparency and ethical principles of NUMO. A key role of ITAC in its initial years of operation was to advise NUMO on how this challenging task could be best addressed. The necessary elements were judged to be:

- a structured and clearly documented site selection process
- a competent, well structured staff team within NUMO
- a comprehensive waste management programme for HLW
- transparent documentation, making clear to the public that all of the above aspects are under control.

ITAC also emphasised that the quality of the technical support documentation had to be very high to give the necessary credibility to the disposal organisation, if the public were to be asked to accept that an objective, scientific evaluation would guarantee that only geologically suitable sites would enter into the selection process. The concept of publishing "exclusion factors" that would allow interested stakeholders to judge whether volunteer sites were potentially suitable or not and also "favourable factors" that would identify features of sites used to assess degree of suitability as a basis for site comparison was supported. The development of a range of repository design concepts was recognised to be a natural consequence of NUMO's willingness to look objectively at any of the wide variety of potentially suitable siting environments that could conceivably arise from the volunteering process. These important technical aspects are considered further in later sections.

In addition to such technical points, ITAC members also raised important institutional issues that could affect the siting process. Clear and active Government support should be offered throughout. This is needed to facilitate the informal contacts with community officials, which are often a necessary first step towards formal negotiations and which can help to surmount the threshold barrier to the voluntary siting process. Sensitive issues such as the right of withdrawal from negotiations should be addressed early in the process, as should scenarios in which volunteers do not emerge or else an impracticably high number of communities register interest. Another critical issue was the matter of compensation – with the risk that this can be considered as "buying off" a community to accept a hazardous project. The entire aspect of compensation and its presentation was the focus of an informal review of national procedures, which showed major differences between countries and illustrated how strongly this topic is associated to local culture. Nevertheless, it is clearly an important issue which can encourage volunteers, but has to be communicated by NUMO and governmental authorities with great care and in a manner appropriate within the Japanese national context.

A particular topic which was discussed on several occasions is the sensitive issue of what to do if no volunteers come forward. ITAC considered it prudent to plan for such an eventuality and examine how various options could facilitate soliciting of volunteers. Because of NUMO’s particular boundary constraints, no specific actions were recommended, but clearly this is a topic that might need to be revisited in the future.

2.2 The documents supporting the call for volunteers

The crucial documentation produced in support of the volunteering process was structured into a comprehensive "Information Package" to be made available to all municipalities in Japan (English translations available on the NUMO website – www.numo.or.jp). The structure of this Package, together with other supporting documents, is illustrated below.

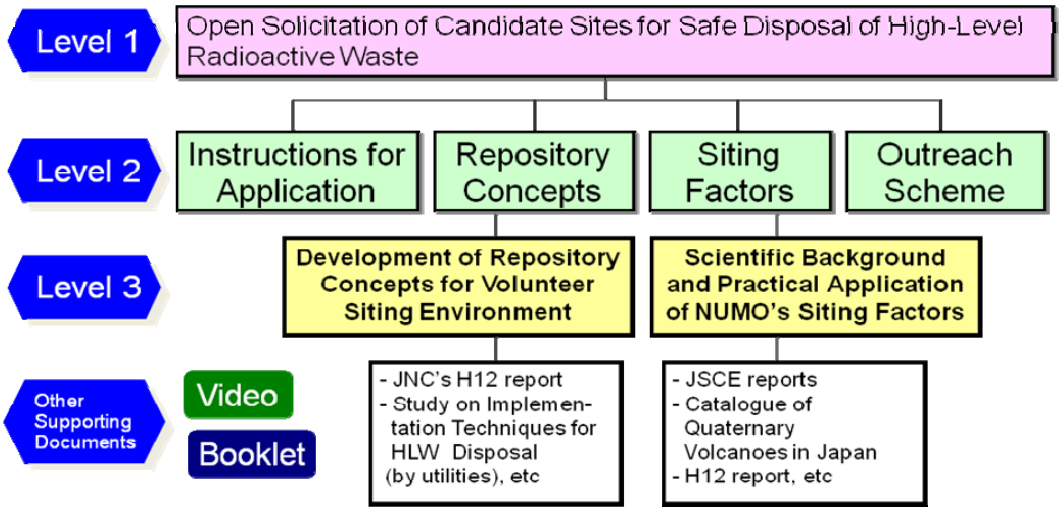

Figure 2-2: Structure of the Information Package and key supporting documents.

ITAC provided diverse recommendations that were largely taken on board by NUMO. These included detailed review and advice on the format and content for all of the original level 1 and 2 documentation distributed to communities in the solicitation process. In particular, the concept of the concise overarching document that was attached to the invitation of the NUMO President was proposed by ITAC. Direct assistance was also given with English translations of these reports.

The level 2 Repository Concepts and Siting Factors reports in the solicitation documentation contained sufficient technical information to ensure that communities could have a realistic picture of the impacts that volunteering as a PIA, or eventually hosting a repository, would have on their locality. Some of the relevant issues discussed by ITAC were:

- Practical details of the volunteering process, including clear specification of the degree of commitment of volunteers at various stages of the project: this is still an open question.
- Involvement of the Government in the process: this was initially very limited, but has become more active recently.
- Ability of local communities to independently assess technical siting factors and the support that could be provided to help them in this process.
- Representation of repository concepts at a simple level: providing focus while preserving flexibility to respond to both uncertain technical boundary conditions and socio-economic constraints or requirements.

For the scientific and technical community, however, greater depth was required in the NUMO documentation. Thus, ITAC strongly supported the concept of producing the two further level 3 reports on repository concepts and siting factors. In practice, individual ITAC members worked directly with NUMO staff to produce the important English language

versions of these documents, which served as an early demonstration to the national and international community of the quality of NUMO's scientific approach, as considered further in the following sections.

3 Advice on NUMO's technical siting process

For the siting work, ITAC input included intensive discussion of the overall process and of the siting factors (SF), including the important issue of the quantitative limits to be applied therein. The classification of the SF into groups reflects Japanese law. However, instead of numbering these, ITAC worked with NUMO to develop more useful nomenclature and classification. One category is defined as Evaluation Factors for Qualification (EFQ), which are sub-divided into Nationwide Evaluation Factors (NEF) and Site-specific Evaluation Factors (SSEF); these all relate to the basic acceptability of a site. A second major category, labelled as Favourable Factors (FF), will be used when sites are compared and ranked.

3.1 The Siting Factors report

As one of the first technical reports produced by NUMO and the first open discussion of the technical aspects of site selection, this document had very high importance for both the HLW programme and establishing NUMO's credibility as an organisation. ITAC strongly supported NUMO's decision to publish an English language version of this report and to produce this in parallel with the Japanese version. As with the Repository Concepts report discussed below, it was emphasised that the English version was not a simple translation of the Japanese report, but rather a modified version that took into account the different boundary conditions and background knowledge of national and international audiences. ITAC was involved in several iterations of developing the contents list, draft text and illustrations for this report – much of which was also reflected in the Japanese version.

ITAC emphasised from the start the challenges involved in the production of this report. The volunteering approach would present difficulties in any country, but particularly so in a land like Japan, with complicated geology in an active and complex tectonic setting. Particularly for an international audience, therefore, the English version of the Siting Factors report (NUMO, 2004a) thus included extensive background on the geology of Japan, to put the findings of the earlier H12 feasibility study (JNC, 2000) into perspective and support the development of the key "EFQ - NEF". These are effectively exclusion criteria to ensure that any sites that are unsuitable due to lack of required geological stability or the presence of natural resources are not taken further in the siting process. Such assurance that unsuitable sites will not be considered is clearly critical to the credibility of the volunteering process and ITAC invested considerable effort to support clear and defensible specification of these parameters.

ITAC considered that the main EFQ were technically defensible and well described. The only minor reservation – also found in other national programmes – involved definition of natural resources, where conflicts could limit site acceptance. After much discussion, ITAC considered the NUMO definition, which focused on currently utilised resources, to be a pragmatic solution, but noted that input from the Government / regulators was needed in order to ensure that the treatment of potential resources that were not presently utilised – in particular, aquifers and geothermal resources – is clearly defined.

ITAC noted that the definition of the SSEF and FF is less politically sensitive, but more technically challenging. This is due not only to the difficulties of assessing potentially

complex volunteer sites, but also to the decision to allow flexible tailoring of repository designs to specific site characteristics, which introduces unusually strong coupling between the site selection and repository concept development components of the programme. ITAC recognised that this was very sensible given the boundary conditions of the Japanese HLW programme, but noted that there was little international experience with such a process.

A further important ITAC discussion concerned the practical difficulties of carrying out site investigations that conformed to the legal requirements on what activities are allowed in PIAs, whilst at the same time allowing collection of crucial scientific data that must be gathered outside the PIA itself. The figure below, developed during ITAC brainstorming with the NUMO siting team, shows how the requirement for Supplementary Investigation Areas (SIAs), which contain geological features that could influence the repository behaviour, could be communicated.

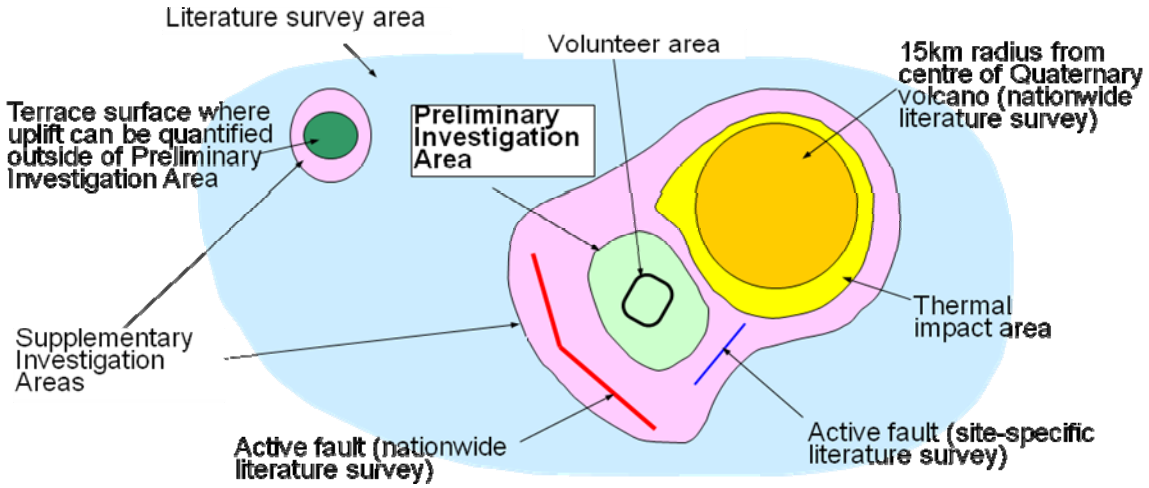

Figure 3-1: Schematic figure showing how the legal Evaluation Factors for Qualification affect the identification of the location and geometry of a Preliminary Investigation Area. (NUMO, 2004a)

Production of the Siting Factors report (NUMO, 2004a) was a focus for early ITAC efforts and N. Chapman provided direct assistance in producing the first draft and incorporating ITAC review comments into the final version. During the production of the report, several important issues emerged from the summary of the geological setting of Japan in relationship to arguments about geological stability. There were clearly some differences between ITAC and DTAC with regard to the timescale of predictability of geological evolution of the Japanese archipelago – even after a joint meeting. This aspect of predictability is critical to the treatment in safety assessments of future development of active faults or volcanoes or the reliability of long-term uplift / erosion data.

Based on such considerations, both the Siting Factors and Repository Concepts reports include a common introduction which emphasises the key timescale of concern for assessing safety of HLW disposal. Although this is not reflected as yet in regulatory guidelines, there are clearly arguments that the timescale for assurance of natural barrier performance should be in the order of 10,000 years. After this time, the toxicity of HLW has decayed to a level similar to that of the original naturally occurring uranium ore from which the reactor fuel was fabricated. Certainly, for such a timescale, there is consensus between DTAC and ITAC that

local tectonic evolution can be predicted based on extrapolation of the record of past developments.

Even though the toxicity is much less after 100,000 years, the hazard from a repository could still be significant for extreme scenarios (e.g. sustained uplift and erosion). Further clarification of the understanding of tectonic evolution was thus identified as a key area for R&D – which resulted in the extensive ITM project, discussed further below.

3.2 Site selection and characterisation

Following publication of the Siting Factors report, ITAC discussions focused more on practical aspects of site characterisation and the selection process. This was initiated by a review during ITAC-4 of the international state-of-the-art in siting, which illustrated the significant differences (and some similarities) between different national programmes. The review highlighted, in particular, the contrast between the earlier technologically driven programmes and more recent projects which place greater emphasis on public acceptance.

This was followed by an ITAC / NUMO brainstorming session to examine the consequences of various possible volunteer scenarios – ranging from no volunteers to large numbers of volunteers that would stretch NUMO's technical capacity at even the literature survey phase. For such extreme options – and also the case of a single volunteer – it was clear to all involved that technical aspects have to be set in the context of socio-political boundary conditions defined by the various levels of Japanese Government and any volunteer communities. Even in the favourable case of a "few" volunteers, NUMO's planning for field work and strategy for site selection would be considerably influenced by the extent of variations between sites.

Such strategic considerations were complemented by more technical evaluation of NUMO's plans for the initial literature survey and the process of selecting PIAs. ITAC recognised that NUMO was planning such work well and making use of modern GIS technology – having reservations only about NUMO's ability to recruit and retain the key staff required to integrate the diverse data that would be produced in the very short time allowed. This was a recurring theme, which is covered further in chapter 5.

Although the H12 report provides a good basis for synthesis of literature information, there is little experience in Japan in planning and implementing a characterisation programme for the deep geological environment. Thus, ITAC strongly supported NUMO initiatives to "mine" international experience in the form of a "roadmap" that illustrated how specific technology could be tailored to different sites. For such tailoring, a particular challenge for NUMO was the wide spectrum of sites that could pass the exclusion filter of the EFQs and the range of repository designs that might then need to be considered – each with its own special characterisation requirements. Here, it was recognised that NUMO's "structured approach" (NSA: NUMO, 2007) and requirements management system (RMS) seemed to be appropriate ways to respond to and manage these novel boundary conditions (discussed further in the next section).

NUMO's evolving plans for the PIA characterisation and the associated development of clear goals that would form the basis of DIA selection were regularly reviewed by ITAC. In the

absence of volunteers, the NUMO siting team initiated a number of useful projects, in particular:

- In a project carried out for NUMO by the ITC, Site Characterisation Planning Manuals were produced (with direct involvement of ITAC members Neil Chapman and Johan Andersson).
- Testing general manuals for site characterisation, developed based on Japanese and international experience, in "dry run" tests at geotechnical research sites.
- The "ITM" project to expand understanding and gain consensus in the critical area of tectonic stability.

These initiatives offered not only increases in the databases in important technical areas, but also opportunities for key NUMO staff and contractors to gain practical "hands-on" field experience and build up contact networks with some of the top Japanese and international experts in critical topics. In addition to ITAC review of planning and progress, individual ITAC members (N. Chapman and M. Apted) provided direct support for the ITM project, which played a particularly valuable role in establishing NUMO's credibility in the tectonic arena via high profile publications (Apted et al., 2004; Chapman et al., 2007; Goto et al., 2008; Tsuchi et al., 2008a; 2008b) and will result in a textbook that will effectively define the state-of-the-art in this area (Connor et al., 2009).

3.3 Impact of the siting process on repository concept development strategy

As noted above, at an early stage NUMO acknowledged the need to have a flexible range of repository concepts in order to make optimum use of any given site. This increases the technical complexity of deriving a site characterisation programme tailored to specific locations and is the driving force behind the NSA, as discussed below. At early stages of the siting work, however, ITAC agreed that it was sensible for focus to be placed on the "H12" reference designs (JNC, 2000). These have been shown to be particularly robust with respect to post-closure safety over a wide range of credible site characteristics. It was emphasised, however, that implementation of such basic, generic H12 designs may be problematic under expected geological conditions in Japan and, hence, factors that influence the safety and practicality of repository construction and operation were particular focuses for the early site characterisation phase.

In terms of direct feedback to modification of repository concepts to fit particular sites, general examination of the distribution of sizes of individual Japanese municipalities, with consideration of the requirement that potential siting areas should not contain active faults, led to identification of the size of the repository footprint as a special concern for the reference inventory of 40,000 waste packages. ITAC considered it prudent to investigate design variants with smaller footprints, but also recommended consideration of a more flexible treatment of inventories: considering whether smaller repositories would still be commercially practical and the possibility of emplacing larger quantities of waste at a suitable site. For either case, clear communication to all stakeholders well in advance of a decision would be necessary.

4 Repository concept development

In the repository concept work, a key point was the recommendation to start with a range of designs going beyond that proposed in the earlier H12 studies. In particular, ITAC continually stressed that practical engineering aspects and also operational safety considerations would play important roles in the final selection. A further important point was the emphasis on the need for flexibility to tailor a repository concept to a volunteer site.

4.1 The Repository Concepts report

Like the Siting Factors report, the "Repository Concepts Catalogue" (NUMO, 2004b) was seminal. It provided a novel approach towards documenting repository designs and forged a pragmatic link between the generic preparatory work carried out by JAEA and the range of design options that NUMO would need to consider for implementation at particular sites. ITAC reviewed the development of the general concept and the contents of the catalogue in some depth – strongly supporting both the fundamental philosophy and the decision to develop designs based on the well established H12 barrier components. Indeed, subsequently, this step has been validated by the way in which it has influenced concept development in other national programmes (e.g. Defra, 2008, NDA, 2008b). ITAC did, however, emphasise that, for particular sites or later as NUMO moves to actual implementation of a repository, design concepts outside the H12 envelope might usefully be considered.

The English language report was produced with direct support from I. McKinley and involved several iterations of intensive review by ITAC. In particular, transparent documentation of the design philosophy and design factors was considered to be an excellent way of improving understanding by stakeholders – and it was emphasised that this is an integral part of NUMO's policy of openness and transparency. Although flexible tailoring of repository designs is undoubtedly a sensible approach under Japanese boundary conditions, it contrasts with the emphasis in many national disposal programmes on defining reference concepts. This latter approach can certainly have particular advantages in terms of allowing R&D efforts to be tightly focused and a well specified design concept is eventually necessary for performing credible safety assessments to support licensing; however, there are also disadvantages in establishing reference designs too early in a programme. These include loss of an "optimisation" mentality and waste of effort on concepts that are not appropriate under the boundary conditions of an operational repository – effects that can be seen from international experience.

An important issue that couples the repository concept to the early stages of siting involves constraints on site acceptability set by the practicality of construction of a cost-effective facility, as indicated in the figure below. As emphasised by ITAC, although the EFQ "exclusion criteria" are well specified, the absolute limits on "practicality" are, to some extent, set by the capabilities of current technology. It cannot be precluded that major advances in future mining or materials technology could cause re-appraisal of such limits. For this reason, it may be prudent to categorise sites that are not taken further on the basis of practicality as "reserves" rather than "rejects". Nevertheless, to ensure NUMO's credibility, it is also important that the message is strongly presented that sites which are fundamentally unsuitable for safety or operational feasibility reasons (see next section) will be excluded from

consideration. Given this dichotomy, ITAC accepted the presentation of such issues in the Repository Concepts report, but recommended that the entire process of site comparison be carefully studied. This was implemented by NUMO in the form of a series of "dry run" exercises for model sites that were representative of the kind of locations that may result from the volunteering process.

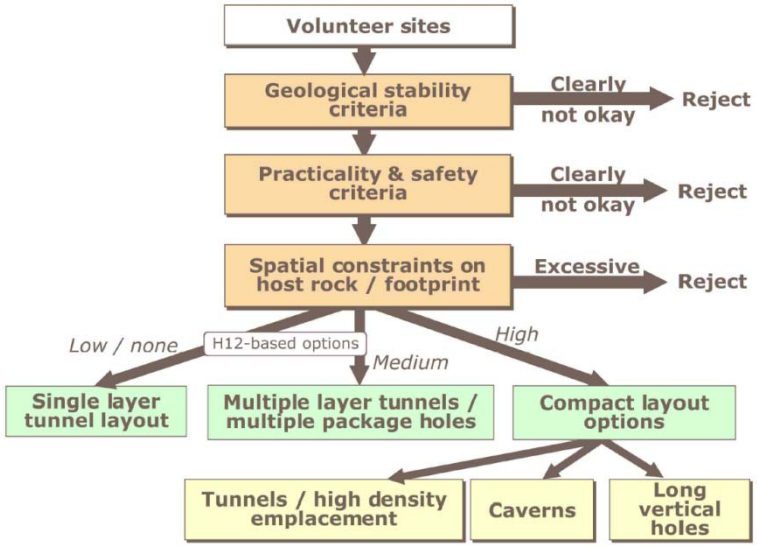

Figure 4-1: **Illustration of evaluation of constraints on a site and resulting design variants. (NUMO, 2004b)**

4.2 Operational safety, practicality and logistics

Given the issues raised during the production of the Repository Concepts report, ITAC considered the NUMO studies of operational safety, practicality and logistics as a very sensible use of resources prior to a volunteer coming forward. As expected by ITAC, the practicality of handling compacted bentonite under humid conditions emerged as a major concern. This was further complicated by the logistical problems caused by the high reference emplacement rate (five vitrified HLW waste packages per day), which is considerably higher than in most other national programmes. Indeed, the NUMO material flow analysis provided a valuable perspective on this area, which quickly showed the limitations of standard H12 designs but indicated that some of the modifications included in the Concept Catalogue (e.g. pre-fabricated emplacement modules (PEMs), multi-package overpacks) could provide major gains.

Studies of construction practicality and operational safety also highlighted the issue of using concrete in emplacement tunnels. As has been seen in other national programmes, this is an area where there is a conflict in the requirements for operational and post-closure safety. ITAC agreed with the high priority assigned to this issue in NUMO's R&D work and considered the workshop which was organised on this theme – co-hosted with Posiva – to be a significant contribution towards coordination of international efforts on this topic (NUMO, 2004c).

ITAC strongly supported studies of the practicality of implementation, as this is a clear responsibility of NUMO, and also considered that stronger links to assessment of operational

safety may be useful, given the problems that conventional accidents have caused in other national programmes. Even at the early stages of design work, it has to be borne in mind that the waste packages have to be emplaced with assured quality using remote handling techniques. In case of failure of a package to meet quality specifications – or in other kinds of operational phase disruption – waste packages may need to be retrieved, which may involve risks to the staff involved. Designs should thus minimise the risks of recovery being needed and, as this can never be completely precluded, make the reversal process as simple as possible. ITAC noted that one important component of such work is development of a description of operational perturbations that need to be considered during design.

Based on international experience, ITAC also emphasised the value of integrating design desk studies with full-scale tests in underground facilities. There is a wide programme of relevant work ongoing in European test sites and NUMO was recommended to maintain its watching brief on – and participation in – such work. It was also recommended that NUMO consider actively testing their own designs – if possible in Japanese URLs but, if that was not feasible, in facilities run by partner organisations.

4.3 Safety case and advanced performance assessment (PA) for comparison of options

Development of the concept of a broader "safety case" – as a more appropriate goal than earlier safety assessments based almost exclusively on modelling approaches – occurred internationally over the period that NUMO was establishing their own ideas on this topic. Terminology is, however, as yet not consistent across national programmes and ITAC emphasised that it was important for NUMO to clearly establish its own nomenclature – particularly in Japanese. ITAC considered that NUMO has adopted a sensible definition of a safety case and an appropriate stepwise development process (Kitayama et al., 2007). Nevertheless, safety case terminology is not well understood in Japan and should be explained further. This will be particularly important when NUMO documents its plans to develop safety cases to assist in site selection and later for licensing. A special course organised by the training organisation ITC (ITC, 2004) on this topic was attended by senior Japanese experts; this could be usefully extended in the future to include further technical staff.

In early reviews, ITAC emphasised that the H12 PA approach (JNC, 2000) was inappropriate for NUMO's requirements, as it is not capable of realistic comparison of sites and concepts. General plans for future "next generation" PA code development seem appropriate. Ensuring that well tested models and databases are available when they will be required is essential for NUMO and hence such work should be an R&D priority. Even if development is carried out by supporting organisations, NUMO should take a strong role in providing guidance and, in particular, ensuring that models are rigorously tested to the level appropriate for eventual support of a license application. As in the design development work discussed above, ITAC noted that such testing may require long-term, in-situ "performance confirmation" experiments: thus, even if the data are required only in the 2030s, establishing long-duration tests is a task that should be addressed as soon as possible.

4.4 Special design topics – monitoring, retrievability and closure

Although the emphasis that NUMO placed on such topics at the early stage of design was originally considered surprising, ITAC soon realised that it was justified when seen in the context of development of regulations in Japan (associated with the L1 interim depth repository for "high beta/gamma" LLW being investigated at Rokkasho). Given the regulators' desire to have homogeneous regulations for all disposal facilities, it is important that NUMO can provide well thought-out input to the associated debate. International overviews of the state-of-the-art in these areas were featured in ITAC-11, which also included detailed discussion on NUMO concepts.

On monitoring, it is clearly important for NUMO to establish plans for baseline monitoring, which needs to be implemented as soon as PIAs are selected. Indeed, compilation of existing data to support baseline measurements should be a goal of the literature survey. Construction and operational monitoring can be important components of Quality Management, in addition to providing opportunities to test site models. More specific performance confirmation monitoring, particularly for the EBS, is a trickier question. There is ongoing discussion about whether this is necessary or not – approaches seem to depend very much on national regulations and perceived needs for public acceptance. ITAC warned that, with existing technology, there are no safety-critical performance indicators that could be monitored without risking degradation of performance due to the presence of the monitoring system. Nevertheless, it was clear that, in case it is required to provide such a system, it is prudent for NUMO to investigate associated issues now.

The issue of performance monitoring is closely coupled to retrieval. International terminology is rather loose, but ITAC recommended distinguishing between "reversal" of emplacement – which must be a well established procedure to allow any quality problems to be rectified – and "retrieval" of emplaced waste after tunnels have been filled and sealed. Also, as a matter of both policy and terminology, ITAC emphasised that waste in NUMO's concepts was always retrievable in principle – the differences between design options are associated with the varying levels of effort and risk associated with recovery of waste at various times after emplacement. Again, there are considerable differences in positions taken by individual national programmes. Nevertheless, ITAC thought that NUMO's plan to examine options of retrieval up to the point of repository closure seemed a reasonable compromise.

This leads to the process of closure. It was evident that this has not been examined in any depth in most national programmes, but could be important in Japan due to the pressure to include an extended period (maybe 300 years) of institutional control – analogous to that specified for surface disposal sites. If such institutional control is required, there are obviously impacts on approaches to monitoring and retrievability. ITAC agreed that NUMO should make strong arguments that actions should not risk degrading safety barriers and hence emphasis should be on rapidly sealing all repository access and ensuring that site access is controlled to prevent perturbations such as drilling. If any performance confirmation is needed, long-term demonstration projects in a spatially separated URL seemed to be preferable to anything within the repository zone, although it would be hoped that either technology would have advanced or acceptance increased to the point that this was not required.

4.5 Technical implications of added TRU responsibilities

Recent expansion of the range of "specified" radioactive wastes managed by NUMO to include longer-lived wastes from reprocessing and MOX fabrication (termed "TRU") represents a significant increase in the strategic and technical challenges that the organisation faces (METI, 2007). The former aspects are discussed in section 5.6; here, emphasis is on technical issues. As was evident from an international review during ITAC-10, this type of waste varies between national programmes but, in all cases, requires very careful management. Although not inherently more hazardous than HLW, its heterogeneity and chemical complexity make development of a robust safety case more difficult. ITAC emphasised that it was important that NUMO fully recognised the challenges involved and assured availability of sufficient manpower and budget to overcome them.

As a starting-point, ITAC strongly recommended that NUMO re-assessed waste definition terminology – which is not standardised in any country, but is particularly arcane and confusing in Japan. For example, there is a huge potential for confusing both domestic and foreign observers by using the term "TRU", which is conventionally applied to waste containing 'transuranic' or actinide-bearing elements. In some cases in Japan, "TRU" is applied to those longer-lived wastes other than HLW that require deep geological disposal, even if such TRU wastes contain no significant actinide concentrations. In other cases, "TRU" is applied to any wastes containing significant level of transuranics (hence statements like "TRU that goes for near-surface disposal"). It was noticed that even NUMO staff do not use "TRU" consistently. It is absolutely essential that NUMO can communicate clearly and unambiguously to both Japanese and English audiences and ITAC feels that the importance of clear terminology cannot be overemphasised.

At a technical level, concepts developed in the past for TRU were examined by ITAC. It was noted that the 1st TRU Report (TRU Coordination Team, 2000) included an extensive internal review, so that this should be considered along with the more recent 2nd TRU report (JAEA and FEPC, 2007) to provide a starting-point for NUMO's work in this area. In any case, the generic concepts in these reports for a preliminary grouping of waste types need to be transformed into a catalogue of options in the way that NUMO did for HLW. ITAC strongly supports such work, but warned that international experience suggests that this will involve a lot of innovative thinking for this complex waste type – especially given the boundary conditions set by the volunteering approach to siting.

The production of a design catalogue for TRU also requires the parallel development of appropriate, realistic PA codes and databases. The extremely simple "mixing tank" approach to modelling the engineered barriers in the 2nd TRU report requires major improvement, supported by more complete specification of waste characteristics and assessment of the degree of flexibility with regard to conditioning and packaging. This will certainly involve many challenges. For such waste, complicating factors such as gas, organics, colloids and microbes cannot be regarded as minor perturbations, but may play a significant role in the assessment of safety. This would be a priority area for R&D.

The TRU project was put in context at the final ITAC meeting by a visit to the Rokkasho investigation site. The parallels between the L1 project and NUMO's TRU disposal are clearly close and NUMO was recommended to follow technical developments here. Evidence of links between the L1 project and NUMO teams were encouraging and ITAC recommends that all opportunities should be taken to extend these. Nevertheless, NUMO should proceed

with care when using the L1 project as an “analogue” of a TRU repository. In particular, any use for public communication purposes should be planned carefully as some near-surface characteristics of this site (water inflow, rapid corrosion, extensive biological activity) differ from those sought for a TRU repository.

5 Organisational development of NUMO

Although not a main goal for ITAC, the technical aspects of NUMO's projects could not be easily separated from organisational aspects and hence ITAC's input here is documented in this section.

5.1 Structure and staffing

NUMO is unusual from an international perspective as it was established initially on the basis of limited term attachment of technical staff from "stakeholders" – predominantly the utilities, R&D organisations and METI. This is not without precedent (e.g. early phase of Nirex in the UK), but the short period of attachment was a major concern for ITAC from the beginning. International experience shows clearly that radwaste disposal is a complex, multi-disciplinary field where experience over decades is required in order to integrate the scientific and technical basis of repository projects. ITAC has been impressed by the high level of ability of NUMO's technical staff and the rate at which they have been brought up to speed. Nevertheless, the loss of such staff when they have returned to their original employers has resulted in systematic critical loss of continuity and institutional knowledge, which is already a limiting factor in NUMO's R&D work. It was a recurring recommendation from ITAC that NUMO examine possible options and inducements to increase the numbers of experienced staff who are permanently retained.

As is the case worldwide, there are also shortages of experienced staff throughout the nuclear industry in Japan. ITAC has thus encouraged NUMO to consider how to recruit and train young staff who would be in a position to take leading roles in the key steps towards licensing in the 2030s. Certainly, if NUMO had such staff with long-term career prospects, it would make sense to invest more in training – especially building up "hands-on" experience via secondment to international partner organisations with ongoing site characterisation projects, participation in complex URL and natural analogue studies, etc.

5.2 Working Standards and communication with regulatory bodies

Due to lack of existing regulations, development of internal Working Standards that define provisional boundary conditions for repository projects is clearly a key issue for NUMO and has been discussed at several ITAC sessions. In addition, ITAC members (M. Apted, J. Andersson) also provided direct support on this topic.

An early recommendation from ITAC was that NUMO should build contacts with the regulators and participate actively in the process of development of regulatory guidelines. There are clear sensitivities due to the need for regulator independence. Nevertheless, it is in the interest of all involved parties to ensure that regulations are balanced, unambiguous and allow compliance to be clearly demonstrated with a reasonable investment of effort. ITAC was pleased to note a move towards joint participation in open meetings over the last five years or so.

As noted above, ongoing development of regulations led to focused ITAC technical discussions on closure and monitoring. Another topic that led to a special ITAC session was timescales for compliance (ITAC-8). This is certainly an area where there is little international consensus, as the issues involved are not only technical, but also include regulatory, societal and philosophical considerations. Nevertheless, the specified requirements for assessment of impacts in the distant future can have large impacts on the repository programme. This was seen in the case of Yucca Mountain, for example, when the earlier compliance timescale of 10,000 years was increased to one million years, based on advice on long-term geological stability from a US National Academy of Sciences review panel (background provided in Appendix 2 of Chapman and McCombie, 2003). Although discussion in Japan tended to focus on the timescale over which tectonic developments might be predictable based on extrapolation of current geological conditions (around 100,000 years), as an alternative approach ITAC recommended also considering the timescale over which the toxicity of high-level (or TRU) waste was greater than that of the original ore used to manufacture an equivalent quantity of fuel (around 3,000 years). In any case, there are good arguments for applying the exceedingly strict quantitative dose limits (10 μSv/a) only for a limited time period and, after that, relying more on alternative performance indicators.

In recent years, discussions on regulatory approaches in Japan have tended to focus exclusively on linking dose limits to scenario probability, although a rational approach also requires consideration of the timescales involved. ITAC has noted that this is an important issue for NUMO. For example, uplift and erosion at a repository site in Japan is a highly probable process and thus, even for relatively low uplift and erosion rates, having the repository at or near the surface will be a probable scenario if there is no limit on the future timescale that needs to be considered. Experience in other national programmes has illustrated that it will be extremely difficult to show compliance with a 10 μSv/a limit for such uplift and erosion scenarios. For example, this has been shown in analyses of scenarios in Switzerland for the case of repository erosion after several million years (Nagra, 2002) and was also indicated by conservative bounding analyses presented in the H12 report (JNC, 2000).

ITAC also recommended that the current terminology used in the classification of scenarios in Japan be reviewed. For example, it is very difficult to argue anything about the probability of human intrusion – it may be better to simply identify a group of “special treatment” scenarios.

5.3 QA / QMS

Introduction of a quality management system (QMS) was identified by NUMO as an important issue and was the special topic of ITAC-5. ITAC strongly recommended implementation of a QMS as soon as possible - but also advocated learning from the positive (and negative) experience in other programmes, for example:

- Formal ISO certification is worth considering, mainly due to probable expectations of regulators and the general public. Nevertheless, certification alone will not cover all of NUMO’s needs as this tends more to cover processes rather than content – and is thus inadequate on its own for a complex, multi-disciplinary project.
- NUMO will need to ensure that its QMS is also extended to any supporting organisations that are providing input for future safety cases. International experience has indicated that this can require a change of culture in some R&D organisations, which requires significant time and effort to implement.

Progress has been regularly reviewed, but a formal QMS has not yet been fully implemented, since the formal documentation has not been completed. ITAC has noted that the later this occurs, the more difficult it is to "back assure" existing data, so this should be a priority for NUMO before site characterisation commences.

5.4 RMS / NSA

The NUMO initiative to develop a requirements management system (RMS) arose after intensive ITAC discussion on transparent and documented decision-making for site selection and tailoring repository concepts to sites (discussed in the previous sections). This was extended into a rather novel formalised methodology for stepwise tailoring of the entire programme – referred to as the NUMO Structured Approach (NSA). ITAC was originally rather sceptical, but gradually recognised that this methodology had merit for NUMO's particular boundary conditions. The concepts were intensively discussed by ITAC, who also reviewed the resulting report documenting this work (NUMO, 2007: production supported by I. McKinley). Due to its novelty, ITAC recommended publishing information on the NSA in the technical literature, which resulted in a series of papers (Kitayama et al., 2005b; 2005c; 2006) broadening recognition for this methodology.

While ITAC support the NSA and RMS concepts, caution was expressed on the extent to which they would be adopted at a working level. It is clear that this requires communication of the benefits to both NUMO staff and key contractors and implementation of a user-friendly RMS. This must be assigned high priority if the NSA is to be rigorously applied from the point of initiation of the literature studies at volunteer sites.

5.5 Communication and confidence-building

Although the topic of communication is not within ITAC's main technical remit, this is clearly a key issue due to NUMO's volunteering approach and, hence, was a topic at several ITAC meetings. Specifically, at ITAC-9, ITAC learned about the communication efforts employed by NUMO, involving use of a wide range of media. However, although attempts have been made, it is difficult to measure the effectiveness of NUMO's extensive media campaigns. ITAC's impression was that one problem is the fact that NUMO communication is not fully integrated with community outreach programmes by the Government, utilities and other relevant organisations and this seems to limit its impact. Recently, the Government has committed to providing more support of NUMO's call for volunteers; however, even more positive and open communication by top-level Government representatives to encourage volunteers would be valuable. NUMO itself has also drawn some lessons from the negative experiences it has had with some communities. The need to react more quickly, to establish both local contacts and a local presence, is one of the most important points. There should be no time gap in which opposition to volunteering can be built up without NUMO being in a position to offer competent and rapid responses to public concerns.

Associated with general communication, the topic of building confidence in NUMO as an organisation has been repeatedly discussed by ITAC. The issue initially was that NUMO was a new organisation and not well known either nationally or internationally. ITAC has strongly

encouraged NUMO to be active in the technical conference circuit in both Japan and overseas and has been impressed at the way the organisation has rapidly established itself as a major player in the radwaste field. Unfortunately, international success at establishing its "brand name" appears to have been generally greater than that within Japan; also, in both cases, most recognition has been from technical stakeholder groups. While this acceptance by the technical community is necessary for NUMO to gain both national and local acceptance, it is not sufficient, and a wider profile is certainly needed in Japan. This is improving with increased links to media and NGOs, but there seem to be some gaps that could be future targets (e.g. communities that host existing nuclear facilities).

5.6 Organisational implications of expanded responsibility for TRU

The technical aspects of expanding NUMO's responsibility to include TRU waste were discussed in section 4.5, but, in both the general ITAC sessions and the special TRU topical session associated with ITAC-10, administrative and organisational aspects of this development were discussed. Although the rationale for NUMO taking responsibility for this specified waste is strongly supported, ITAC noted that this needs to be carefully explained to the public, especially as initial volunteering was intended only for HLW. The documents expanding the call for volunteers to include TRU must thus be prepared very carefully. For example, as noted in the previous section, “TRU” terminology must be rationalised. Also, on the topic of terminology, the term “co-disposal” should be used with care, as possible cost benefits of co-location of disposal facilities are not clearly established as yet. Indeed, this may be a topic that could be identified as an open issue that would be decided on the basis of consensus with potential host communities.

As also previously noted, the technical challenges associated with TRU are significantly greater than with HLW – which has implications for both communication and manpower planning. For communication, it is important not to overstate the hazard of TRU, but it must be recognised that a site which would be suitable for HLW may not necessarily be acceptable for TRU. This is a result of the general "over-design" of the HLW EBS, as well as differences between the characteristics and attributes (including volume) of high-level and TRU wastes. Care must be taken not to be pressured into assuring “equivalent” EBS performance for TRU. In any case, close interaction between technical and communication groups is needed to avoid risks of confusing stakeholders or provoking unreasonable safety comparisons between HLW and TRU.

On the manpower side, all the arguments above on staffing assume an even greater emphasis when a parallel TRU programme is taken into account. It is clear that, although there are differences between HLW and TRU, there are also some fundamental similarities. From an organisational viewpoint, therefore, there are both advantages and drawbacks associated with the options of either setting up separate HLW and TRU groups or integrating responsibility in a single group. The ITAC review showed that there are international precedents for both options – separation is more common in larger programmes and integration is found in the smaller ones. In any case, this is a secondary concern compared to assuring that resources of qualified manpower – which seemed strained even for HLW – are sufficient to adequately establish a credible TRU programme.

6 Conclusions

6.1 Summary of the mission of ITAC Phase 1

The key objective of ITAC during the early years of NUMO's work was to help establish NUMO as a technically competent and transparent organisation that could successfully develop a national geological disposal programme for HLW. The issue of winning sufficient trust of the public and of the technical community was especially important in Japan because of the purely voluntary siting process that was adopted by NUMO. Within this mission, the most urgent and important tasks facing ITAC were to advise on, and provide input for, the solicitation documentation and key supporting technical reports. Subsequent to this first series of activities, ITAC has been involved with helping NUMO prepare for the siting and repository development work that lies ahead. Much input has been given on organisational issues and on more detailed technical tasks such as site characterisation, engineered barrier design, etc.

6.2 Current status of NUMO

After several years of development, NUMO has now established its technical credibility in Japan (especially with academics and professional organisations). It has also become a well regarded organisation within the international waste management community. Its scientific basis equals that of other national programmes in virtually all areas, with superior expertise in selected key areas, such as understanding the impacts of tectonics and volcanism. It has recognised the crucial importance of quality management and continues to develop its structured approaches to implementation, supported by appropriate management tools. Also important is the acknowledged need to recruit, train and retain staff who will serve in the NUMO team for much longer periods of time than the typically three-year attachments that were common in the early days.

The critical objective that has not yet been reached is finding communities that are willing to volunteer to be considered as potential preliminary investigation areas (PIAs). The lack of success to date is not a consequence of any weakness or failing in NUMO's technical programme: there has been little or no criticism of NUMO's scientific or engineering design work, either in Japan or internationally. One reason for this situation may be that the formality of the solicitation process has made the act of volunteering, even at the first level, appear to be a very committing step for a local community. Further measures may be possible to lower the threshold to volunteering. The UK and Canada, for example, have introduced an interim smaller step into their volunteering processes – a step in which communities are asked only to engage in dialogue with the repository implementer. The UK has also directly addressed the sensitive issue of when and under what conditions communities might withdraw from the process. Insights may also be gained by NUMO from studying the long community relations programmes that have led in Finland and Sweden to local communities democratically agreeing to host a geological repository. Addressing the public/political challenges of finding volunteers in Japan must obviously be the top priority for NUMO at present.

Even after communities come forward, NUMO will be confronted with a range of complex programmatic and technical challenges. To successfully master these, NUMO will have to continue to develop its technical, scientific and management capabilities. For this, it may once

again be useful to make use of technical advisors. Accordingly, the current ITAC, to end its work in Phase 1 of the NUMO programme, has made some comments below on the roles of advisory bodies. Rather than making specific recommendations at this time, it has indicated the key points that NUMO should consider when it eventually constitutes one or more technical advisory or review bodies for the coming phases of its work. This is first put in context by an assessment of NUMO's future challenges.

6.3 Future challenges for NUMO

Although ITAC has helped NUMO to achieve proficiency and credibility in many technical areas, there are some important aspects of the Japanese programme that have not yet been addressed in the work of the Committee. One example is the production of an overall R&D plan. The obstacles to preparation and documentation of such a plan have partly been the pressure of the top priority work on the solicitation documentation and partly because there seems to be a lack of established procedures to ensure overall guidance to, and coordination of, Japanese R&D in the waste disposal area. In the future, it will be important for NUMO not only to have its own structured R&D programme, but also to have sufficient influence over supporting R&D work on radioactive waste disposal that is carried out by other Japanese organisations. Another obvious topic that could usefully have been addressed by ITAC concerns the development of a Japanese concept for Safety Case development. The extensive expertise of many ITAC members in this area make it regrettable that little time could be devoted to this important topic in the first phase of ITAC. Further topics to which ITAC members could obviously contribute include priority work areas in Japan, such as the implementation concept for TRU and the formulation of new regulations. Concerning the latter topic, it is noted that NUMO is active in developing open contacts with regulators; nevertheless, ITAC may have been able to provide further input here, based on the evolution of, and the lessons learned from, foreign regulatory programmes.

6.3.1 Programmatic challenges facing NUMO

Programmatic challenges facing NUMO include:

- **Reinforcing its siting process** (together with the Government) to enhance the probability of local communities volunteering. As indicated above, there is relatively little that can be achieved through the technical programme of NUMO, other than ensuring that high quality science and engineering continues to be carried out and presented in a form that is accessible to all stakeholders.
- **Detailed design of site characterisation programmes**. Although the broad approach has been studied, any local community that expresses interest will wish to know very soon exactly what activities will be carried out and to learn of their potential impacts.
- **TRU disposal**. Due to the recently allocated additional responsibility for TRU disposal, NUMO faces further challenges for its staffing, structures and overall programme.
- **Regulatory developments**. The regulations covering waste disposal in Japan are still not completely defined. It is crucial that NUMO remains involved with the work being done by Government officials in order to provide input on the practicability of

proposed regulations and to assess the impact on NUMO work of any standards that are established.

- **Internal standards and QMS**. A promising start has been made in these areas, but fully operational methods should be in place, at the latest, before site-specific activities are begun.
- **Staffing.** The recent initiatives to develop a more stable staff structure and to strengthen training efforts are very welcome. Continuing pressure must be applied here, however, especially if the current rising interest in nuclear power leads to expanding reactor programmes that will compete with NUMO for good staff.
- **Building credibility with all stakeholders**. This is an ongoing task that requires personal engagement of all NUMO staff, maintenance of high professional standards, transparency in all areas of work and implementation of advanced communication methods to make all stakeholders aware of NUMO's work.

6.3.2 Technical challenges facing NUMO

Technical challenges facing NUMO include:

- **Repository design concepts**. Concepts for TRU repositories or combined HLW/TRU repositories must be developed, as has been done for the HLW facilities. The concepts for these facilities must be reviewed and refined to ensure that they are not only fundamentally feasible, but safe and practical to implement under the boundary conditions of the Japanese programme.
- **Safety assessment**. As well as developing, documenting and testing NUMO's approach to preparing a repository Safety Case, it is also necessary to provide focused support for development of next-generation PA toolkits and databases.
- **Site characterisation methodology**. In addition to the programmatic aspects of siting mentioned above, specific methodological developments are required – including in-situ testing of data gathering and analysis tools and methodology.
- **Waste Acceptance Criteria (WAC).** NUMO should work towards defining WAC based on preliminary safety assessment of specific waste types in a model deep repository (particularly important for TRU).
- **Tectonics/long-term stability**. In the Japanese environment, these will continue to be areas of earth science in which NUMO must keep abreast of, or indeed push the leading edge of, the scientific state-of–the-art.
- **Development of concepts for monitoring, sealing and repository closure**. Although these activities lie far in the future, NUMO should have an agreed policy and technical position that can be discussed from the earliest stages in the siting process, since these topics have been seen to be raised in numerous national disposal programmes and are under discussion for the regulation of the Rokkasho L1 project.

6.3.3 Why a pause and a re-structuring?

Given that the sections above describe outstanding challenges and identify areas where the current ITAC believes that it has contributed less than it might have done, an obvious question is why it has been decided to close down the current Phase 1 of ITAC.

The principal reason is that the original function of ITAC, namely the transfer of useful experience and knowledge from established waste management programmes, has been largely accomplished. The size and the membership of ITAC for its first phase were determined by this main goal. Having built on this past technical global experience, NUMO is now one of the leading disposal organisations and has a range of bilateral collaboration agreements with partner organisations worldwide. Today, volunteer siting is the key hurdle for NUMO, rather than establishing its technical credibility. If NUMO continues to seek advice from other programmes, the emphases will be on strategic and communication issues. When potential siting areas have been identified, so that active site characterisation and repository design work can move ahead, a different approach to utilising international and national advice from technical experts may be more appropriate than the large, relatively infrequent meetings that have been a feature of recent ITAC work. It is also questionable whether separation of ITAC from the domestic committee (DTAC) is an effective way to provide the best support for NUMO.

Recognising these points, the present ITAC devoted some of its final meeting to pooling ideas on how NUMO might best organise its external expert group structures when a second phase is initiated. The assembled suggestions are documented below.

6.4 How might the value of future advisory or review committees be enhanced?

6.4.1 Factors influencing the choice of structures

There are diverse factors which can affect the implementer's freedom and choices in defining its own advisory or review bodies. These can be broadly grouped into those relating to the national framework and culture and those determined primarily by the stage to which the disposal programme has developed.

National boundary conditions:
The national legal or regulatory framework may impose external review requirements on the implementer. For example, the CNE in France and the NWTRB in the USA were created by political bodies to overview the waste management agencies. Pre-existence of suitable expert bodies may also lead to natural choices for advice or review of national programmes (e.g. Academies of Science or professional and scientific societies). When the implementer sets out to create its own advisory bodies, a key factor will be its own size and in-house competence. A small, newly created implementing body, such as NUMO was in 2001, will obviously have more need for external advice. A large organisation such as the USDOE, which also has access to an extensive national research laboratory infrastructure, may need fewer external advisory groups. The strength and operational methods of the regulatory body can also influence the implementer's choice of advisors. If there is a strong regulator carrying out open, comprehensive review work, then the implementer itself may need to organise less independent review – or alternatively it may need more external support in order to prepare its eventual license application and respond competently to the regulatory review.

Other overarching features of the national programme may also influence the implementer's choice of expert group structures. One example is the extent and usefulness of agreements with its foreign sister organisations. Today, most major national waste management

programmes have bilateral and/or multilateral formal agreements with their counterparts in other countries. This arrangement provides a useful vehicle for exchange of information and experience. Maximum benefit will be gained from this, however, only if the partners are fully open in their exchanges and also if they are prepared to both give and accept critical comment on their programmes. Finally, obvious national attributes that influence approaches to exchange of expertise are the cultural and language differences between nations. As described early in this report, one of the criteria for selection of the original ITAC members was an interest in, and prior knowledge of, the Japanese programme. This greatly eased the technical work and also the personal relationships between members and NUMO staff. Nevertheless, the language barrier remains a particular problem and, as is the case in countries such as Sweden and Finland that have similar difficulties, production of key documentation in English may be required in order to ensure that it can be subject to wide enough peer review.

Stage of programme development:
The maturity level of a national waste management programme clearly strongly affects its requirements for external expert advice. The start-up (or restart, in the various cases where programmes have been suspended) of disposal organisations is a time at which broad advice is most important. This was clearly recognised at NUMO when it was created and at NWMO and NDA in, respectively, Canada and the UK when these programmes were re-launched. Major programme milestones, such as site selection, may also be decision points at which overarching external advice and review can be useful. When a programme is in a fully operational mode, then the most useful type of advisory or review input may be from small groups or individuals (national and international) who are acknowledged experts in specific technical areas.

6.4.2 Future NUMO external expert groups

ITAC has compiled a "check-list" of issues for NUMO to consider when deciding on its future external expert support. This list is provided below:

NUMO-specific issues:

- **Current technical competence level of its own staff**: Are there gaps in NUMO's technical capabilities? Are there junior staff members who could benefit from being "mentored" by experienced external advisors?
- **Current technical and public credibility of its own organisation**: Does NUMO have sufficient staff with the stature to represent its programme on the national and international stages? Could it benefit from association with well known experts in specific technical or societal areas?
- **Current NUMO priorities**: The urgent challenges are related to the siting process and to the impacts of expanded TRU responsibilities. Does NUMO require external advice on how best to tackle these issues?
- **Continuing need for knowledge transfer from foreign work**: Are the existing NUMO bilateral agreements together with interactions in international bodies (e.g. IAEA, NEA, EDRAM) now a sufficient means for ensuring knowledge transfer? If not, what specific gaps can be identified?

Structural and organisational issues:

- **Splitting expert groups according to support functions**: Would it be more efficient to separate regular "hands-on" support from independent review and strategic advice? What should be the extent of segregation between review, advice and assistance roles? What are the pros and cons of panels of experts in ad-hoc advisory groups compared to stable, long-term groups?
- **Scope of terms of reference of advisory groups**: Should strategic, programmatic, technical, and societal issues be separated or is it more effective to have integrated groups?
- **Choice of advisors**: One should first agree the definition of the expertise sought in any group, then consider any other requirements of members and only then begin selection of members.
- **How to use advisors/reviewers to assess quality** of (or give the 'stamp of approval' to) essential supporting work done by other Japanese organisations.
- **Integration of advisory and review groups into the overall Japanese waste management system**: Advice and review should be integrated into the overarching NUMO QMS, which applies also to work carried out by supporting R&D organisations. The appropriate level of contact between international advisors and DTAC and/or the Japanese scientific community must be decided upon. The same applies to the level of contact between advisors and other Japanese stakeholder groups – especially regulators.

Modus operandi of expert groups:

There are numerous basic organisational questions to be considered, for example frequency of meetings, terms of office, coping with the strain on internal resources, use of translators to overcome language barriers, use of video-conferencing, etc. However, there are also very important points of principle concerning the functioning of an expert group. These include:

- How to identify potential bias or conflicts of interest of advisors in order to avoid or manage such conflicts (this was not a problem for ITAC, but is clearly more sensitive for a group with an independent review role)
- Whether review monitors should be used to ensure transparency and completeness in handling review comments (commonly a requirement if such review is a component of a QMS)
- Whether the input provided by external experts is to be kept internal or to be published in some form (varies according to role: review input may require open publication whereas technical support may involve other issues, such as intellectual property rights).

6.4.3 ITAC views on future expert groups

ITAC has been valuable for NUMO in various ways. The Committee has provided review, advice and also direct assistance. As described above, it is understandable that ITAC Phase 1 is being closed down now that past knowledge has been transferred from foreign programmes and NUMO's external contact network has become established. ITAC believes, however, that NUMO would benefit from future use of advice and support from international experts in order to respond to the major project challenges that lie ahead (see section 6.3). Such experts may also form a more intimate link to national programmes that are developing rapidly,

providing efficient access to new knowledge and experience in key areas (e.g. repository engineering, site characterisation, licensing). As NUMO moves closer to key programme milestones (selection of PIAs, DIAs and a final site) and eventual licensing, the need for independent review becomes more critical and, from experience in other national programmes, this may require accessing resources of international manpower. A further, not insignificant, by-product of the existence of a formal review body is that it provides a point of focus for NUMO's project staff and encourages periodic, structured summaries of programme status.

Based on its experience in several years of working with NUMO, ITAC has made some suggestions that may help structure future advisory bodies.

A key issue concerns the links between internal review, independent "external" review, advice and direct assistance. Although these can be separated, review is clearly a valuable precursor to advising and gives advisors a good overview. NUMO needs both review (as part of its QM system) and advice. It is not necessary for NUMO to separate review and advisory roles – but, if NUMO claims a review is fully independent, it may be necessary to go outside their advisory groups (e.g. NEA, IAEA, ad hoc committees). It is also not necessary to separate advice from direct assistance, although potential conflicts of interest need to be carefully managed. In short, ITAC experience has shown that members of the same group can fill a range of review, advice and assistance roles, if carefully managed. To make best use of resources, NUMO should ensure that requests for expert support are specific, well defined and focused on addressing identified NUMO problems. A well integrated group could, however, also work closely with NUMO to identify specific problems; this would be valuable for NUMO and also satisfying for the advisors.

A further important consideration is the strength of the connections of NUMO expert groups to other groups. NUMO's own groups should have some level of inter-connection. Although it is difficult to fully integrate international and national groups completely, owing to language barriers, ITAC experience with DTAC has shown that interchange is valuable whenever it is practical. Indeed, the support role of individual ITAC members has clearly shown that mixed Japanese / foreign teams can function effectively and, although needing to be carefully managed, there is no fundamental barrier to closer integration of expert groups. It could also be productive if NUMO and its advisory groups were to have discussions with regulatory and other organisations, e.g. in the framework of joint workshops to consider boundary conditions for regulations.

Several possible structures are conceivable for future NUMO expert bodies. Review groups and their roles should be specified within NUMO's quality management plan. In terms of providing advice, one option is a single strategic overview group and several topical specialist groups. The specialist groups may have more specialised sub-groups or individual technical experts for particular areas. In any case, at the current NUMO programme stage, the focus should be on relevant scientific disciplines (or interdisciplinary expertise) rather than wide coverage of foreign programmes. Nevertheless, experience from individual national programmes may be targeted, chosen in terms of their direct relevance to NUMO's current priorities.

For overview groups, an important question is whether they cover programme strategy and integration in both technical and non-technical areas, or – like ITAC – are formally confined to technical issues. For specialist groups, there are numerous potential areas of application in the NUMO programme, e.g.

- repository designs and EBS behaviour
- site characterisation methodology and techniques
- safety case development and presentation
- societal interaction and communication.

NUMO has, in its first years of activity, made very intelligent use of input from international advisory experts. As a mature waste management programme, its requirements for external advice are now different – at present strongly determined by its siting programme. When the pace and direction of the NUMO programme become clearer, then it would, in the view of the present ITAC, be beneficial for the Japanese programme if NUMO were to establish further, re-structured advisory bodies to help it address the challenging tasks ahead.

7 Acknowledgements

The members of ITAC would like, above all, to thank NUMO staff for providing them with the opportunity to help establish NUMO as one of the world's foremost waste disposal organisations. All members gained an increased knowledge of the Japanese programme and also close and enduring technical contacts to NUMO colleagues. Equally valued by ITAC are the close and enduring personal relationships with NUMO colleagues and with their fellow ITAC members. Not least, we are grateful that we have, over the years, gained some additional appreciation of the Japanese culture and way of life.

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Acronyms and abbreviations:

Arius: Association for Regional and International Underground Storage
CNE: National Review Board, independent evaluation body for the R&D programme concerning waste management in France
DI: Detailed Investigation
DIA: Detailed Investigation Area
DTAC: Domestic Technical Advisory Group (of NUMO)
EBS: Engineered Barrier System
EDRAM: The International Association for Environmentally Safe Disposal of Radioactive Materials
EFQ: Evaluation Factors for Qualification
FF: Favourable Factors
GIS: Geographical Information System
H12: JNC project to establish the scientific and technical basis for HLW disposal in Japan (documented in JNC 2000)
HLW: High-level waste; in the Japanese context this is vitrified waste from reprocessing of spent fuel
IAEA: International Atomic Energy Agency
ITAC: International Technical Advisory Committee (of NUMO)
ITM: International Tectonics Meeting; a NUMO project to develop an advanced understanding of volcanism and tectonics
JAEA: Japan Atomic Energy Agency
JNC: Japan Nuclear Cycle Development Institute (integrated into JAEA together with JAERI (Japan Atomic Energy Research Institute) in December 2001)
JNFL: Japan Nuclear Fuel Limited
L1: JNFL project for intermediate depth disposal (50-100 m) of “high beta/gamma" radioactive waste
LLW: Low-level waste; in the Japanese context, this includes all waste with significant radioactivity that is not classified as HLW. It is operationally sub-classified depending on source and concentration of radioactivity in the waste and thus, formally, also includes TRU
METI: Ministry of Economy, Trade and Industry
MOX: Mixed oxide fuel (U-Pu reactor fuel using recycled material from reprocessing)
NDA: Nuclear Decommissioning Authority (UK)
NEA: Nuclear Energy Agency of the OECD (Organisation for Economic Cooperation and Development)
NEF: Nationwide Evaluation Factors; included in EFQ
NGO: Non-Governmental Organisation
NWTRB: Nuclear Waste Technical Review Board (USA)
NWMO: Nuclear Waste Management Organization (Canada)
NSA: NUMO Structured Approach
NUMO: Nuclear Waste Management Organization of Japan
PA: Performance Assessment
PEM: Prefabricated EBS Module
PI: Preliminary Investigation
PIA: Preliminary Investigation Area
PNC: Power Reactor and Nuclear Fuel Development Corporation, precursor to JNC
QA: Quality Assurance
QMS: Quality Management System
RMS: Requirements Management System
RC: Repository concept
RS: Repository Site
SF: Siting Factors
SIA: Supplementary Investigation Area
SSEF: Site-specific Evaluation Factors; included in EFQ
SHP: Steering Committee on High-level Radioactive Waste Project
TRU: The Japanese term for non-HLW with sufficiently high toxicity that it requires deep geological disposal, arising predominantly from reprocessing and mixed oxide fuel fabrication

URL: Underground Research Laboratory
USDOE: United States Department of Energy
WAC: Waste Acceptance Criteria
WIPP: Waste Isolation Pilot Plant (USA)