Meeting Summary: NUMO-NTI Tokyo Workshop on Developing Spent Fuel Strategies

May 29 – June 1, 2017
Tokyo, Japan

Day 1: May 29

The topic of cooperation at, and potential internationalization of, URLs was introduced at the DSFS workshop in Hawaii (August 2016). The first day and a half of the Tokyo workshop was dedicated to perspectives on URL activities and identifying specific topics for possible cooperative activities at those URLs. The technical and social dimensions of radioactive waste management were also addressed.

Dr. Hiroyoshi Ueda from NUMO presented on the radioactive waste management program and the role of URLs in Japan. As stipulated in the Strategic Energy Plan revised in 2014, the policy of Japan is to pursue a closed nuclear fuel cycle, with HLW from reprocessing going to a deep geological repository. Japan has several nuclear fuel cycle facilities: the Rokkasho Uranium Enrichment Plant, Reprocessing Plant, the MOX Fuel Fabrication Plant, the LLW Disposal Center and the Mutsu Recycled Fuel Storage Center. The reprocessing plant is currently waiting for the Nuclear Regulation Authority (NRA) to complete the process of establishing new regulatory requirements then final commissioning will occur. It is expected that the plant will begin operation in 2018 and MOX fabrication will commence in 2019.
As of May 27th 2017, 5 NPP units are operating, 12 units have been allowed by NRA to restart, and restart applications for another 14 units are under review. Applications for 18 units are under consideration and 6 units are in the decommissioning phase.

R&D on disposal of HLW from spent fuel reprocessing was initiated in 1976. Following the Final Disposal Act in 2000, the Nuclear Waste Management Organization of Japan (NUMO) was established, with the responsibility for the implementation of the geological disposal program, under the jurisdiction of the Ministry of Economy, Trade and Industry (METI). A Final Disposal Fund was also created based on an electricity charge collected from consumers to cover all costs of NUMO's activities.

The Fukushima Daiichi accident and concerns about the impact of radiation on human health have raised questions about the safety of a geological disposal facility, particularly the consequences of an earthquake.

In 2014, a new Strategic Energy Plan was adopted which defines nuclear energy as an important base-load power source and maintains that a closed fuel cycle is the way to reduce dependency on foreign energy supply to the greatest possible extent. It also explains that geological disposal should not be delayed by extended interim storage and that the repository development should ensure reversibility and retrievability. The government is required to promote the site selection process by identifying “scientifically preferable areas” in advance of a consent-based, three-stage process conducted by NUMO as specified in the Final Disposal Act in 2000. This will be followed by the new siting approach which was defined by the Basic Policy amended in 2015 as explained in the presentation by Dr. Ueda on the second day. An Underground Investigation Facility (UIF) will be constructed in the candidate host rock during the detailed investigation stage. Activities related to broadly applicable underground characterization techniques and development of methodologies that are not specific to the host rock or the potential site are carried out in generic URLs. Once the rock is known and the UIF has been established, the focus should be on the activities related to the host rock and its specific environment.

NUMO is currently preparing a Generic Safety Case Report to reconfirm the feasibility and safety of the deep geological disposal, reflecting the latest R&D achievements and providing flexibility in adapting the design of DGR to potential host rock in Japan.

The Japanese generic URLs are critical pieces of R&D infrastructure that address key technical issues, develop human resources, accumulate technical knowledge/experience and thus steadily build public trust. JAEA operates: the Horonobe Underground Research Center that conducts R&D in sedimentary rock; the Tono Geoscience Center which includes the Mizunami Underground Research Laboratory that conducts R&D in crystalline rock; and the Nuclear Fuel Cycle Engineering Laboratories at Tokai that includes the ENTRY (Engineering Scale Test and Research Facility) and QUALITY (Quantitative Assessment Radionuclide Migration Experimental Facility) facilities.

Mr. Hideaki Osawa introduced R&D activities at the Horonobe Underground Research Laboratory. Horonobe and Mizunami are generic URLs and were established following a recommendation by the Japan Atomic Energy Commission in 1994. The Mizunami URL started in 1996 while Horonobe started in 2001 and both are designed to confirm the applicability of geological disposal techniques, understand the deep geological environment, provide technical training for staff from Japanese and international waste management programs, and promote public understanding of deep geological disposal.

Activities conducted at Horonobe include development of techniques for understanding and monitoring the geological environment, designing construction technologies and enhancing the safety assessment methodologies.

In the current phase, a full-scale EBS test is being conducted to observe the near-field coupled THMC phenomena in situ, increase confidence in modelling, and demonstrate disposal pit excavation technology, emplacement technology and tunnel sealing technology. The mass transport test (combining in-situ and laboratory tests) is developing the evaluation technique for radionuclide migration in fractured argillaceous rock.

The Horonobe URL collaborates on information exchange with KAERI and ANDRA, technical training with IAEA URF Network and has also been involved in international projects like the Mont Terri Rock Lab in Switzerland and the DECOVALEX (DEvelopment of COupled models and their VALidation against EXperiments) research and model comparison collaboration.

Regarding interaction with the public, a Public Information House and an International Communication House were opened in 2007 & 2009 respectively. A scientific festival for the young people is also organized to increase awareness. Further, JAEA promised the Hokkaido Prefecture and the town of Horonobe that it would never bring in or use radioactive wastes in the area during the project phase or after the project has finished.

An overview of the R&D activities at the Mizunami Underground Laboratory was provided by Mr. Eiji Sasao. The Mizunami project is currently in its third phase, developing technologies for reducing groundwater flow and drift backfilling as well as developing modeling technologies for radionuclide mass transport. By developing the drift backfilling technologies, it is targeted to understand the groundwater recovery process and mechanism of geological environment during facility closure, to verify the simulation methods for recovery process in fractured granite and to develop monitoring techniques for facility closure phase and appropriate closure method taking recovery process into account. A grouting technology is also being developed. Like Horonobe, the agreements between JAEA and the local governments stipulate that no radioactive material or engineered barriers will be brought in or used at Mizunami, the site will not be turn into a storage facility or repository, and the environment around the facility will be protected. The Mizunami URL is open to international research and education.

Professor Gu discussed HLW disposal in China. The spent fuel and HLW arising from reprocessing will be disposed of in a multi-barrier geological repository placed between 500 and 1000m deep in the host rock. It is estimated that the amount of spent fuel to be reprocessed by 2050 will exceed 30,000 tHM. China started R&D work on HLW disposal from 1985, but so far the studies have been limited to simulations with a focus on disposal geology and chemistry.
Regarding disposal geology, 5 possible sites have been compared – the Beishan area in West China (Gansu Province), where drilling work has been carried out since 1980s and analyses of the rock and groundwater have been done, has been selected as the candidate granite site. Investigations in clay have also been performed. Regarding disposal chemistry, work has been done to simulate the geologic environment, to establish experimental methods and analytical techniques plus behavior of the key nuclides in the groundwater from the Beishan drillings have been studied. The disposal roadmap is as follows: 1. until 2020, perform laboratory R&D on repository siting, including feasibility studies and a safety assessment with the construction of the URL by about 2020; 2. from 2020 to 2040, underground testing including feasibility studies

and safety assessment for a prototype repository; and 3. from 2040 to 2050, demonstration of a prototype repository and the construction of the full repository.

URL planning in South Korea was explained by Mr. Park from KORAD. ROK will soon face saturation of its on-site storage capacity with the Wolsong site expected to reach capacity in 2019. A siting process is currently being developed for integrating a site-specific URL with interim storage and a final repository. A scientific feasibility study for site investigation is needed together with a process of two-way communication with the local stakeholders to build trust and confidence. A legal system also has to be established for a transparent siting and decision-making process.

The siting process for an interim storage facility and a final repository will involve several stages, starting with exclusion of unsuitable sites, a search for volunteers, preliminary site investigations, local public opinion surveys and then in-depth site investigations.

A retrievable deep geological repository will first require the construction of two URLs: a generic URL by 2018 to conduct R&D on a disposal system; and a site-specific URL by 2028 that would be expanded into the disposal facility. The timeframe is estimated at:

- 12 years to site the interim storage facility and final repository
- 24 years to construct a repository, including –
    - 7 years to construct a consolidated interim storage facility
    - 14 years to construct a URL and conduct RD&D activities at the site-specific URL

Alternative options such as the deep borehole disposal are being researched with international partners.

Mr. Jeong from KAERI discussed the safety case aspects of the conceptual disposal system (AKRS-16) for pyro-processed HLW at the KAERI Underground Research Tunnel (KURT) site in Daejeon. KURT is a generic URL and R&D site in crystalline rock designed to improve understanding the deep geological environment, contribute to the performance validation of the multi-barrier system and to test the technical feasibility of disposal construction and operation techniques. No radioactive material is used at the facility and it will not be used for disposal.

According to the IAEA and OECD/NEA, the *safety case* is an integration of arguments and evidence in support of the long-term safety of, and the associated level of confidence in, an activity or facility – in this case a geological disposal facility. For confidence building, regulatory compliance should be supported by reasoning based on probabilistic analysis of the exposure dose and risk, uncertainty analysis, natural analogue studies, complementary safety indicators (such as radionuclide concentration and release rates) and defense in depth.

The study presented by Mr. Jeong compiles and analyses the research results carried out in the KURT for HLW disposal, as well as provides a methodology for the safety case preparation for HLW radioactive disposal. The safety case report includes the following: design base and disposal facility, site description, waste type and characteristics, engineered barrier system, the features, events and processes & scenarios, description of the model and data, the post-closure safety assessment, complementary considerations and a synthesis of the safety case. For the safety case report, a wide variety of tests and experiments were carried out including deep borehole investigation, hydrological and geochemical monitoring, single hole heater tests, EDZ characterization, solute migration experiments, in-situ demonstrations of EBS performance and long-term corrosion experiments. An international project with Sandia National Lab in the US was carried out to support the activities needed for the safety case development. AKRS-16 can be used for providing necessary information for the development of regulations, for transferring methodologies and basic data for a repository development to the implementer and for confidence-building and communication between stakeholders regarding HLW disposal.

Mr. Li from TPC discussed the technical feasibility assessment report on spent fuel final disposal in Taiwan. Over the past 20 years of R&D, granite, mudstone and Mesozoic basement rock were studied and granite rock was selected as the preferred host rock for a geological repository. This year, TPC is required to submit a technical feasibility report (SNFD2017) on spent fuel disposal to the AEC to confirm if the granite is suitable and if TPC has adequate engineering capabilities for constructing a geological repository and assessing its long term safety. AEC required that TPC should strengthen technical exchanges and cooperation with foreign institutes and conduct an international peer review in preparation for the SNFD2017.

The final disposal site should be decided by 2038 with operation expected after 2055. A reference case was constructed and the disposal concept is the Swedish KBS-3 system.

Evaluation of the technical feasibility of a safety assessment has been completed. The next stage is to propose candidate potential sites and develop assessment models for each, as well as communicating with the general public based on the concept of open information and transparency.

Mr. McMahon from the Nuclear Waste Disposal Research and Analysis Department of the Sandia National Lab presented the deep borehole disposal concept. The deep groundwater in the crystalline basement can have very long residence times and is isolated from shallow groundwater and can be highly saline and geochemically reducing, which enhances the sorption and limits of solubility of many radionuclides. The concept involves a 2km disposal zone with 1 km basement seal down to depths of 5km. Single boreholes or a grid of boreholes may be used. The Department of Energy proposed conducting a demonstration (2017-2021) deep borehole field test (DBFT) – drilling two boreholes to 5km. A proposed site in North Dakota and an alternative site in South Dakota were nominated by one team in 2016 but the host communities refused. Following a second request for proposals, sites in Texas, New Mexico and South Dakota were nominated by four teams. However, the Trump Administration's FY2018 budget request does not include any money for a DBFT. According to a May 23, 2017 DOE press release, the contractor teams will continue to communicate with the communities they had sought to partner with in order to answer questions as the project winds down, but all other work will cease immediately. Mr. McMahon also discussed the performance assessment modeling activities related to the DBFT test.

Mr. Lee from KAERI presented on the deep borehole disposal (DBD) study in South Korea. The DBD study, as an alternative method to deep geological disposal (DGD), is included in the National Basic Plan for HLW management launched in 2016. The concept: drilling a borehole in crystalline rock (mainly granite) to a depth of 5km and disposal of HLW in the lower part of the borehole (3-5km). It is considered safer and more cost-effective than the DGR and there are also several other advantages including isolation from shallow groundwater, low permeability of the disposal environment which prevents the groundwater flow, weakly connected transport pathways, the simple 'features, events and processes' scenario and the safety case. Disadvantages include the need to prove performance, the need to develop investigative and site characterization technologies, as well as difficult retrievability. KAERI started work in 2013 with a preliminary evaluation of the geo-environmental characteristics of the deep geological formations. A preliminary feasibility study on the application of the DBD was performed then KAERI conducted preliminary studies on the performance and safety assessment, including thermal analysis, manufacture of the inner vessel of the disposal container, the canister handling system and a sealing experiment. KAERI is now looking to conduct international technical information exchange on its DBD technology.

Mr Jung discussed the IAEA's Underground Research Facilities Network for Geological Disposal (URF Network). The URF Network was established in 2001 as an IAEA Network of Centers of Excellence on training in, and demonstration of, waste disposal technologies in underground research facilities. The purpose of this network is to encourage the development of geological disposal programs around the world through demonstrations of technology, improved training, enhanced communication, sharing of knowledge and exchange of best practice between participating organizations. Japan, ROK, China and the US are all members of the network. At present, 17 URFs are operating or under construction in 11 different Member States. However, 17 URFs have been closed and some of the information at those facilities has been lost. IAEA TECDOC-1755 on the Planning and Design Considerations for Geological Repository Programmes of Radioactive Waste describes the role of URFs. A new IAEA report, a compendium of URF RD&D findings, is being developed under the umbrella of the URF Network that will update a 2001 document. OECD/NEA also produces reports on URLs that cover the need for, and role of, the facilities, planning of a URL program and international cooperation.

Day 2: May 30

The first part of the day was dedicated to potential internationalization of R&D at URLs. Dr. Osawa from the Horonobe Underground Research Center began by defining what issues we would need to consider for making the next generation of URLs useful. He then listed some potential URL programs, including demonstration of realistic concept implementation practicality with full QA, multi-disciplinary integration of support of associated safety case (operational and post-closure), illustration of robustness to operational perturbations, and special consideration of dynamic evolution of the geosphere. Finally he showed some of the benefits of internationalizing URLs for potential partners, including established underground infrastructures and regional characterization databases which have already been paid for, relevant site conditions for many national repository concepts, well-defined boundary conditions for the specially-constructed facility, ease of access and infrastructure for management of large-scale demonstration projects, sharing of knowledge and experience, promoting better quality research and peer review. Existing purpose-built URLs, like the JAEA URLs, could serve as regional collaboration platforms, providing cost-effective support to other advanced programs.

Dr. Saegusa discussed potential collaboration in integrated model development for performance assessment with URL experiments. Validation and verification processes with quality assurance are required to demonstrate confidence in the evaluation by numerical simulations. Projects dedicated to verification and validation, like INTRACOIN, HYDROCOIN and INTRAVAL, have been performed since the 1980s. Also IAEA standards require that any calculation methods and computer codes used in the safety analysis undergo verification and validation. In a heterogeneous rock, understanding the hydrogeological properties for validating the computational model has not been fully explored. Close cooperation in investigation, data analysis, numerical modeling and definition of evaluation target is important. One possible area of cooperation involving URLs is developing an effective process for investigation, modeling and validation for groundwater flow and solute transport evaluation in heterogeneous rock. Comparison exercises (between simulated and measured values, and among several simulated results by various alternative models) can be carried out.

Dr. Wakasugi discussed potential collaboration based on on-going experiments and R&D activities at Horonobe URL. Horonobe was involved in the DECOVALEX in-situ full scale engineered barrier system experiment. Thermal-hydraulic-mechanical-chemical (THMC) behavior in and around the EBS was studied. A tracer experiment for the rock matrix and for fracture was also conducted at Horonobe. Based on activities performed so far, some potential collaboration tasks were identified such as extended benchmarks based on the EBS experiment with simulation of transient processes of coupled THMC behavior until full saturation in the EBS, dismantling method of the EBS experiment and performing of a tracer experiment with development of upscaling method from small size experiments to PA scale model for safety case, validation of system performance and benchmark numerical simulations.

Dr. Sasao discussed URLs as tools for training and communication with the general public on geological disposal. Due to Japanese policy, training for the implementer (i.e. NUMO) cannot be undertaken at the URLs. The local governments don't welcome NUMO in the area before a disposal site is determined. Training for the next generation is also difficult as there is not much awareness or interest in the subject of radioactive waste disposal in universities so funding such education needs to come from external sources. URL communication with local residents is achieved by a monthly newspaper, a weekly report, leaflets and some materials dedicated to children like a money box with a printed photograph of granite. The website of the URL includes information dedicated to the public. Site tour for students are provided at the URL and dedicated symposiums are also part of the URL outreach activities, as well as press releases describing research being undertaken. Unless more work/funding is found, Mizunami will operate until 2019 when it will closed then backfilled (by 2022). Dr. Sasao reiterated that there are insufficient human resources at the URL for training activities and site tours.

The session on siting and public trust was opened by Mr. Isaacs describing the Canadian siting experience. In 1998 the Seaborn Panel (appointed by the federal Minister of the Environment to conduct an independent environmental assessment of AECL's deep geological disposal concept) concluded that while from a technical perspective the safety of the disposal concept had been demonstrated, from a social perspective it had not. Since then, the Nuclear Waste Management Organization has placed a great deal of emphasis on stakeholder engagement and public communication. A key aspect of the Canadian approach is intense, transparent, widespread and continuous dialogue with citizens, affected parties and decision makers. Mr Isaacs underlined the many non-technical dimensions of siting that have to be considered in the process like ethics, sociology, risk communication, socio-economics, cultural understanding, sustainability, political science and psychology. Adaptive phased management of the siting process was adopted in the *Choosing a Way Forward* document, which recommended long-term monitoring with potential for retrievability, implementation of a program for continuous learning and R&D, sequential decision making and seeking a community willing to host the repository. Some of the lessons learned from the Canadian experience include: assigning importance to societal as well as technical considerations, engage the public and key stakeholders, plan carefully and involve the right experts, respond in real time to unexpected events and "promise, then and deliver, then do it again and again" to build trust.

Dr. Ueda presented the new siting approach for geological disposal in Japan. In 2002, NUMO initiated the siting process an open solicitation for volunteer host municipalities. More than 10 local municipalities expressed interest but most did not enter into further discussion. Toyo town in Kochi prefecture did request a literature survey in 2007. After submission of the application, there was an escalation in opposition activities. The mayor resigned and the newly elected mayor withdrew the application in 2007. An analysis report provided by the University of Tokyo determined the causes of the failure: opposition activities successfully altered the perception of inhabitants using arguments based on emotion (including characterizing the financial incentives as disreputable), the mayor lacked an action plan and effective policy advisors, NUMO did not effectively communicate with affected stakeholders and the municipal government was able to exercise a very limited influence on the dispute. Following the Toyo town withdrawal, the Government started to explore less controversial ways for municipalities to apply for literature surveys. However, no concrete steps were taken before the Fukushima accident. Based on discussions with advisory working groups, the Government developed a new approach to geological disposal. In May 2015, the Basic Policy on the Final Disposal of the Specified Radioactive Waste was amended to focus on encouraging the public to understand the issues. Also, the government would take the lead in identifying the geologically most suitable areas of the country for disposal. A nationwide dialogue with the general public and regular meetings with potential host communities will be undertaken by NUMO, in cooperation with power companies, to explain HLW issues and the siting process. NUMO will also prepare informational material and provide financial support to communities interested in geological disposal. Tours for families, students and educators to research facilities including URLs have been organized.

Dr. Hwang discussed the current status of spent fuel management and the national framework for HLW disposal in South Korea. Before 2024, a national database of spent fuel characteristics should be completed. Behavior of spent fuel in storage is being studied taking into consideration creep behavior, SCC and the long-term impact of irradiation. Securing ISFSI and URL sites is projected by 2028. Risk perception as well as two way communication should be integrated into the process. Korea has different fuel types which pose challenges for the disposal program.

Dr. Newman discussed lessons learned from the ‘nuclear corridor’ in West Texas and South Eastern New Mexico. He stressed that before trying to find a host community for a repository, public trust should be built. This can be achieved by demonstrating the ability to manage lower levels of radioactive waste and store spent fuel while cultivating a reputation for competent and safe operations and developing a transparent, fair, consent-based and adaptive siting strategy. In Texas, Waste Control Specialists had been: disposing industrial solid waste (1994); treating/temporarily storing DOE by-product material + LLRW and disposing of NORM (1997); disposing of DOE by-product material (2008); disposing of LLRW (2009); and temporarily storing LANL TRU waste destined for WIPP (2014). In 2016, WCS & AREVA submitted a CISF license application to the NRC. In New Mexico, Eddy & Lea Counties plus cities of Carlsbad & Hobbs created the Eddy-Lea Energy Alliance (ELEA) in 2006. In 2015, ELEA signed an MOU with Holtec to design, license, build and operate an underground facility near WIPP. In 2017, Holtec submitted a CISF license application to the NRC. Situated in the so-called ‘nuclear corridor’ – which includes URENCO USA, WIPP, Pantex, Sandia National Lab and Los Alamos National Lab – the communities are exposed to and comfortable with industrial hazard and this changes risk perception which helps explain local support for both applications. For WCS, a demonstrated a track record of safe operations and engaging the local workforce help to build trust. Starting with LLRW disposal can be an important first step in a holistic waste management strategy, even if the LLRW site does not expand its mission.

Day 3: May 31

Dr. Umeki discussed the need for knowledge management at the back-end of the fuel cycle. He explained that a holistic management approach should assess future inventories and characterize potential waste from various fuel cycle scenarios. By combining measurements with models, the data can form an integrated inventory database that can be used to efficiently assess consequences of changes in the fuel cycle or requirements of regulators. This approach should also contain analysis of existing conceptual ideas, examining their advantages and disadvantages for a variety of repository system development boundary conditions. In this way, a particular design can be better justified as it should represent an optimum choice for a given siting environment represented in the form of SDM (site descriptive model). Design engineers should collaborate closely with other specialized teams – site investigation and performance assessment – to ensure that the concepts are safe, practical, acceptable and cost-effective. Performance assessment models therefore need to be as realistic as possible. The activities of three teams should be integrated in a safety case with all available knowledge. A project to develop a state-of-the-art knowledge management system has been initiated using advanced information management technology. It includes a safety case structure that can facilitate the use of core knowledge by both the implementer and regulator.

Mr. de la Codre discussed the OECD/NEA approach to knowledge transfer. Radioactive waste management is a complex and multi-disciplinary field with many stakeholders. The importance of knowledge transfer in radioactive waste management has some particularities imposed by the specific risks and very long timelines involved. Challenges for both national and international programs include political and institutional stability, regulatory complexity and technological advances. NEA knowledge transfer projects include: EGIRM (Expert Group on Inventorying Reporting Methodology); IRM (Information and Requirements Management in Geological Disposal Programs), RepMet (Radioactive Waste Repository Metadata Management) and RK&M (Preservation of Records, Knowledge and Memory across Generations). NEA also maintains valuable databases on the features, events and processes associated with geological disposal and on thermochemistry for selected chemical elements that assists in specialized data modeling for safety assessments.

Dr. Constantin discussed education and training with an emphasis on international cooperation. The 2012 NEA report *Nuclear Education and Training: From Concern to Capability* acknowledged a number of challenges. While progress is being made in addressing certain issues, concerns remain that sustainable processes are not in place in all areas or in all countries. Some key questions for E&T are:

- how can competencies and qualifications be identified?
- what are the knowledge and skill gaps?
- what changes and optimizations are required in E&T schemes?
- how to train and maintain a highly qualified staff?

One of the clearest ways to overcome these challenges is for countries to work more closely together. International organizations like the IAEA and OECD/NEA are ideal venues for collaboration and harmonization while the education networks like ENEN, ANENT, LANENT and AFRA-NEST offer coordinate regionally. Another powerful educational network is the World Nuclear University. Specialized international educational networks like INSEN, the NSSC Network and the IAEA E&T program as well as dedicated E&T events and projects play an important role. URLs should also be considered an E&T resource.

Conclusion

Key nuclear waste specialists from Japan, South Korea, China, Taiwan, and the United States participated in the May 29 –June 1, 2017 Developing Spent Fuel Strategies (DSFS) regional workshop in Tokyo, the fourth in this continuing series of workshops. The workshop was organized by the Nuclear Threat Initiative, under a grant from the MacArthur Foundation, in cooperation with the Nuclear Waste Management Organization of Japan. This was the first workshop to be co-hosted by an organization from a participating country, making an important statement about the potential and growing value of this initiative and setting a precedent for the future.

The intent of the DSFS initiative is to bring together Pacific Rim nations facing back end of the nuclear fuel cycle challenges to share relevant information, identify issues of common interest and work toward cooperation on those topics that can provide meaningful benefits to the participants' waste management programs.

Participants provided detailed presentations on underground research laboratories, deep borehole studies, internationalization of spent fuel management R&D, approaches to siting waste management facilities that build public trust and continuity of knowledge/knowledge management. Each presentation was followed by enlightening group discussion. A visit to the Mizunami URL was also part of the agenda. For each topic, it was reconfirmed that they are critical subjects to continue discussing and next steps and potential research projects have been identified that could lead to future collaborative work. Beyond the particular topics covered in this workshop, a number of additional areas of mutual interest have also been identified for future workshops.

Very importantly, the relationship between safe operation of nuclear fuel cycles, comprehensive management (including ultimate disposal) of spent fuel/HLW and global security remains a high priority element of the discussion. It reinforces a major objective of the DSFS project; that it is in everyone's best interests for each nation to have programs in place to safely and securely manage the front and back end of the fuel cycle. Failure to meet these obligations threatens the future of nuclear power and international security.

We appreciate that senior waste management experts from all five countries have come together several times now and have made real progress toward a building a multinational research agenda. The personal and organizational relationships that have been forged and/or deepened will pay off in ways both anticipated and unanticipated.