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West Cumbria MRWS Partnership

Dear Partnership Member

Geological Information Seminar, 15 November 2010

NDA Briefing Note

A draft of this note was produced in response to a request to brief the West Cumbria MRWS Partnership's Geological Information Seminar on the 15 November 2010. This briefing provided the basis for discussion on geological developments that have taken place since the mid-1990s in the five broad areas requested by the Partnership:

a) Improved understanding of the role of geology in containing radionuclides (i.e. radioactive elements)

b) Improved 3-D seismic surveying

c) Advances in 3-D computer modelling

d) Information relevant to the MRWS site selection process in West Cumbria

e) How geological information will be taken into account under the current site selection process.

The intent of the note is to set out what has changed since the 1990s in terms of the science and to give some explanation as to why it is appropriate to consider hosting a geological disposal facility in West Cumbria. The note is not intended to provide a balanced assessment of all the geological issues that will need to be considered during the MRWS site selection process.

The note was originally presented as a draft at the Partnership seminar in November 2010 so that the NDA could learn from the seminar if there was further information that the local community would like to receive. This, updated, final version of the note includes some additional information.

a) Improved understanding of the role of geology in containing radionuclides

Geological disposal involves the use of what is termed a multiple barrier approach where engineered barriers and the natural barrier provided by the geology work together to contain the radionuclides associated with radioactive wastes. The main objective of this containment is to prevent or minimise the movement of radionuclides through the groundwater system back towards the surface environment. If radionuclides in the groundwater eventually move out of the engineered system, a number of physical and chemical processes could occur in the deep rock-water system to contain them.

In most of the types of rocks found at depth in West Cumbria radionuclides that escaped the engineered barriers would tend to move with the flow of groundwater in naturally-occurring fractures and joints in the rocks. Given the very long times taken for water to flow from depth back to the surface many radionuclides would completely decay to stable, that is non-radioactive, nuclides before reaching the surface environment even if they travelled at the same rate as the groundwater. However, this would not be true for very long-lived radionuclides and a number of processes that prevent or retard their movement in relation to groundwater flow are therefore important.

Work in this area over the last 15 years, in Sweden in particular, has given a great deal more confidence that two relevant processes can be characterised and applied in assessing the "transport resistance" of the geology.

- One important process involves the diffusion of radionuclides out of the water in the fracture carrying flow and into stagnant water in closed-ended pores in the rock adjoining the fracture, where the radionuclides essentially become trapped. Work in Sweden and elsewhere now allows scientists to combine experiments on rock samples taken from boreholes with measurements taken on the rock walls of boreholes to determine the extent to which this process will operate.
- A second important process is termed sorption and involves the transfer of radionuclides out of solution in groundwater onto the solid surface of minerals on the rock wall of a fracture or pore. There has been a major international effort over the past 15 years to improve the understanding of sorption such that many of the uncertainties about its effectiveness, that had to be taken into account previously, have been removed.

In addition, other processes such as the possible transport of radionuclides in the form of colloidal particles or as gas that are relevant to the safe disposal of radioactive wastes are better understood (and subject to ongoing research).

b) Improved 3-D seismic surveying

Seismic surveys involve studies of the velocity and deflection of man-made shock waves to investigate the deeper structure of the Earth. 3-D seismic surveying can give a detailed picture of the structure of rocks at depth, including the "discontinuities" in the rocks that could control groundwater movement. Since the former Nirex carried out a trial survey in the 1990s, other waste management organisations, notably Nagra in Switzerland, have successfully built on that,

and oil-industry experience, to use the technique to characterise the detailed structure of large volumes of rock having the potential to host a disposal facility.

c) Advances in 3-D computer modelling

3-D modelling of groundwater flow through the large volumes of rock relevant to geological disposal has been possible for some time, but until recently was unable to represent the detailed structure of the rock that would control the precise pathway taken by the water. Partly driven by radioactive waste management programmes in other countries such as Sweden, Finland and Canada, computer modelling techniques have now been developed that can calculate the tracks of particles of water flowing from depth to the surface environment through a volume of rock that has been adequately characterised. These computer models have been tested in international co-operative programmes such as the Äspö Hard Rock Laboratory (Sweden) Groundwater Modelling Task Force. Their use in safety assessments in Sweden continues to be scrutinised by their independent regulator and its scientific advisors. There are other areas (eg 3-D visualisation models) where there have been significant advances since the 1990s.

Why these developments are helpful

These developments, outlined under points a, b and c, allow a more reliable understanding of the potential for transport of any radionuclides released from the engineered barriers of any disposal facility. Coupled with 3-D information about a site, modern 3-D groundwater flow models can be used to analyse both the present day flow system and the effects of possible future changes in driving forces on important aspects of that system, such as flow rates and the locations of discharges at the surface.

Without such improved techniques there would be greater uncertainty about the performance of the geological barrier at the conclusion of surface-based site investigations. The resulting, possibly small chance that the geological barrier might have unfavourable characteristics could dominate the developing safety case, even if the site was in reality suitable. These scientific and technical developments would also be helpful in the case of a site that was unsuitable since they would allow this to be identified more readily than was possible previously, thereby saving time, trouble and pointless expenditure of public money.

d) Information relevant to the MRWS site selection process in West Cumbria

It is clearly important to take account of what was learned about the geology and hydrogeology of West Cumbria from the investigations carried out by and for the former Nirex. Most of the detailed work was focused on the Longlands Farm site. Roughly speaking, the information that Nirex presented to the Rock Characterisation Facility (RCF) Local Planning Inquiry in 1995 was based on less than 25% (in cost terms) of the geological information that it had acquired by the time investigations were halted. The information available in 1995 did not enable an adequate understanding of the controls on groundwater flow or of some of the field observations, as was acknowledged in Nirex's reports on its modelling work and reflected in the RCF Planning Appeal inspector's report..

When the full suite of information was available later, groundwater flow models were developed on behalf of Nirex by many of the UK's recognised hydrogeology experts and, following independent peer review, were published in December 1997 in "Nirex 97" as a means of documenting the outcome of the work programme. These models took account of all the features and processes that could control the flow of groundwater, including:

- the topography and rainfall of West Cumbria,
- the various types of water found at depth,
- the fracture zones in the deep rocks, and
- the hydrogeological properties of the rocks and their fractures, joints and pores.

The models, which were tested against field observations not used in their development ("independent test data"), showed groundwater flows and flow paths which Nirex concluded did not exclude the possibility of safe disposal of long-lived radioactive wastes (the UK intermediate-level waste inventory) at the Longlands Farm Site, as described in "Nirex 97" The British Geological Survey integrated information from the Nirex studies into its Memoir "Geology of the West Cumbria District", also published in 1997.

The current MRWS process is a completely new process and therefore the area covered by expressions of interest in West Cumbria is being considered in the same way as any other area in the UK which made an expression of interest. However, if local communities choose to participate in the site selection process and historical information gathered by Nirex were relevant to the evaluation of potential candidate sites there would clearly have to be a due process of review and scrutiny in the light of current understanding and all relevant information as outlined in the next section.

e) How geological information will be taken into account under the current site selection process

The MRWS site selection process recognises international experience that to be successful it should be based on an approach of voluntarism and partnership. Candidate sites that are identified by a local community engaged in the process and agreed by Government will be subject to evaluation for suitability against key criteria including the site's geological and hydrogeological characteristics as well as other relevant site assessment criteria.

At various stages of the site selection process, the independent environmental regulator requires that safety assessments will be presented to show, amongst other things, how the site's geological and hydrogeological characteristics are consistent with meeting safety requirements. Before a GDF can be developed a full safety case must be presented for scrutiny and agreement by the regulators.

The potential for earthquakes to affect the safety of a disposal facility provides a specific example of one area where geological information would be assessed in increasing detail at successive stages of the site selection process. In deep rocks the effects would be relatively localised so earthquakes and faults were not included in the sub-surface screening criteria to be used in relation to areas in Stage 2 of the MRWS site selection process. However, as noted in the MRWS

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White Paper, account should be taken of earthquakes and faults once the stage of assessing candidate sites has been reached.

Initially this is likely to involve assessing whether there is evidence of seismically active geological faults or fractures that might obviously rule out a siting option. If a site were carried forward to the surface-based investigation stage, more detailed information would become available to assess the potential size and consequences of movements that might occur in the deep rocks in the future. SKB (Sweden) has published details both of the type of site information that is required and of the methods they used to carry out the necessary assessments of potential effects of earthquakes.

I have attached a list of technical reports that I hope will provide useful more detailed information on the various topics touched on in this note. Most of the UK reports are available via the NDA/RWMD web based bibliography and the SKB reports from their website. If you need any assistance with obtaining copies please let me know.

I hope that this note addresses the main questions, comments and observations raised before and at the seminar.

Yours faithfully

Alun Ellis

Repository Project Director
2 February 2011

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Further reading list

Radionuclide transport properties

Knight, L., Black, J. and Watson, S., *NDA-RWMD Geosphere Characterisation Project: Data Acquisition Report: Measurement of rock properties relevant to radionuclide migration.* Report QRS-1421A-R3, Version 2, prepared by Quintessa Limited, April 2008.

3-D seismic surveying

Nirex, *Sellafield Geological and Hydrogeological Investigations: Spatial heterogeneity of the rock mass within the potential repository zone.* Nirex Science Report No. S/97/005, August 1997.

Emsley, S., *Geosphere Characterisation Project: Data Acquisition Report: Surface-based Geophysical Techniques.* Report No. 07154270359.501/A.0 prepared by Golder Associates (UK) Limited. August 2008.

3-D computer modelling of groundwater flow

Follin S, Hartley L, Jackson P, Roberts D, Marsic N, *Conceptual model development and numerical modelling using CONNECTFLOW, Forsmark modelling stage 2.3.* SKB Report R-08-23, 2008.

Scientific outcome of Nirex investigations

Nirex, *Nirex 97: An assessment of the post-closure performance of a deep waste repository at Sellafield.* Nirex Science Report S/97/012 (4 volumes), 1997.

Norris S, *Nirex 97: An assessment of the post-closure performance of a deep waste repository at Sellafield .Summary Report.* Nirex Science Report S/98/015. 1998.

Norris S, Chapman N, Maul P, *Nirex 97: An assessment of the post-closure performance of a deep waste repository at Sellafield.* Report on peer review by QuantiSci Ltd. Nirex Science Report S/98/014, 1998.

Earthquakes and faults

Fälth B, Hökmark H, *Seismically induced slip on rock fractures. Results from dynamic discrete fracture modelling.* SKB Report R-06-48, 2006.

Fälth B, Hökmark H, Munier R, *Effects of large earthquakes on a KBS-3 repository. Evaluation of modelling results and their implications for layout and design.* SKB Report TR-08-11, 2010.

Nirex, *Report on the Seismological Database (in 4 volumes),* Nirex Report SA/95/003, 1995.