Nuclear Waste Advisory Associates

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Submission to the House of Commons Energy and Climate Change Committee Inquiry into the Energy National Policy Statements.

Memorandum from Nuclear Waste Advisory Associates

Effective Arrangements for Waste from New Reactors Do Not Exist

January 2010

ACRONYMS

AoS	Appraisal of Sustainability
C-14	Carbon-14
CoRWM (i)	Committee on Radioactive Waste Management (i) 2003-2007
CoRWM2	Committee on Radioactive Waste Management (ii) 2007-present
DECC	Department of Energy and Climate Change
DEFRA	Department of the Environment, Farming and Rural Affairs
DoT	Dept of Transport
DSS	Disposal System Specification
DTI	Dept of Trade and Industry (now part of DBIS – Department of Business, Innovation and Skills)
EA	Environment Agency
EBS	Engineered Barrier Systems
EDZ	Excavation Damage Zone
EPR	Reactor type
EU	European Union
GDF	Geological Disposal Facility
GRA	Guidance on Requirements for Authorisation
HLW	High Level Wastes
HPA	Health Protection Agency
IAEA	International Atomic Energy Agency
ILW	Intermediate Level Waste
IPC	Independent/Infrastructure Planning Commission
ISA	Isosaccharinic acid
JRC	Joint Research Centre
Kd	Sorption
MKG	Swedish NGO Office for Nuclear Waste Review
MOX	Mixed Oxide fuel
MRWS	Managing Radioactive Waste Safely
NAPLs	Non-Aqueous Phase Liquids (section 9.2)
NDA	Nuclear Decommissioning Authority
NEA	Nuclear Energy Agency
NWAA	Nuclear Waste Advisory Alliance
NPS	National Policy Statement
OECD	Organisation of Economic Cooperation and Development
PAMINA	Performance Assessment Methodologies in Application to Guide the Development of the Safety Case
PI	Public Inquiry
Pu	Plutonium
R&D	Research and Development
RCF	Rock Characterisation Facility
RWMD	Radioactive Waste Management Directorate (NDA)
SEPA	Scottish Environment Protection Agency
STUK	Finnish Radiation and Nuclear Safety Authority

1.0 Executive Summary

1.1 This memorandum examines the evidence for the Government's assertion that effective arrangements will exist for waste produced by new reactors.

1.2 We note that four former members of the Committee on Radioactive Waste Management (CoRWM (i)) have written to the the Secretary of State to express concern that the Committee's recommendations have been seriously misrepresented in the Draft National Policy Statement for Nuclear Power Generation, and state that: *"It is unknowable whether or not effective arrangements will exist …"*

1.3 Nirex's application to begin excavation work at their proposed disposal site near Sellafield in the 1990s - the so-called 'Rock Characterisation Facility' (or 'RCF' proposal) was rejected on generic scientific grounds (as well as for site specific reasons). The implications of this rejection have still not been fully examined or resolved.

1.4 Technical problems and uncertainties described by the Environment Agency (EA), and the European Union Joint Research Centre (EU JRC), as well as the uncertainties regarding radionuclide properties detailed in this memorandum, such as their solubility and sorption – or even their presence as a gas - could mean estimted contamination levels calculated for a deep geological disposal facility are in error by a factor of 10,000 to 1,000,000 which clearly has implications for the risk estimates.

1.5 Resolution of the problems raised at the Nirex RCF Inquiry, and more recently by the EA and EU JRC, is not a simple matter of providing sufficient funding for researchers over the next few decades. It may, in fact, not be possible to resolve all of the issues. Further research may not produce the required answers or it may identify further serious problems that simply had not previously been realised. Therefore it may not be possible to make a safety case for deep geological disposal. So, **the Government's confidence that effective arrangements to dispose of waste from new reactors will exist is premature.**

1.6 The task at hand for a waste disposal applicant is to demonstrate that the resultant dose would be less than 20 micro sieverts[1] per year. This memorandum addresses the current status of the nuclear industry's ability to utilise reliable and meaningful data in order to forecast the likely health impact of placing nuclear waste in a deep underground disposal facility – in order that such a project would not 'recklessly endanger people in the future.

1.7 We conclude that achieving such a dose target is simply not scientifically demonstrable or achievable in practice. It is in the nature of chemical elements and geological and biological systems to behave in a variable and hence unpredictable manner such that they make reliable risk/time calculations into the far future not only difficult but virtually impossible.

1.8 The Government's evidence (produced as part of the Nuclear National Policy Statement consultation) refers very specifically to the Finnish disposal project. It claims that the Finnish Regulator ('STUK') "*did not identify any reason why the project couldn't move forward*".[2] But this does not provide an accurate representation of the STUK evidence base.

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[1] micro = one millionth. A Sievert is a measure of radiation dose. It's units are energy - per unit weight - of exposure ; and it can be thought of in terms of the overall '*punch*' associated with the bombardment.

2 The arrangements for the management and disposal of waste from new nuclear power stations:a summary of evidence, DECC November 2009 para 121
https://www.energynpsconsultation.decc.gov.uk/nuclear/managementdisposalwaste/summaryevidencepaper/

1.9 New reactor fuel would be 'high burn up' fuel which is hotter and more radioactive than spent fuel from existing reactors and unlike anything generated in the UK before. Such waste fuel would require longer storage at the reactor site and would be more fiercely radiotoxic. The Government is relying on disposability assessments of this new type of fuel carried out by the Nuclear Decommissioning Authority (NDA) to reach its conclusions. But these assessments have still to be reviewed by the Environment Agency (EA). However, the EA review is not due until Spring 2010 and therefore the results of this project will not be available to be fed into the Government's Public Consultation on this matter, thereby denying consultees access to crucial information.

1.10 The Nuclear industry has failed to present independent information to either the Nuclear NPS or the Justification process on conditions for workers and the public in the countries that mine and process uranium for new reactors. Two previous public inquiries into new reactor construction in the United Kingdom (UK) have recommended that an evaluation of these impacts should be carried out. Without a full evaluation of these impacts, including a Sustainability Appraisal, the Nuclear NPS is not fit for purpose

1.11 In short, the Government's conclusion "*…that effective arrangements will exist to manage and dispose of the waste that will be produced from new nuclear power stations"* is not supported by the evidence. The Nuclear NPS is, therefore, not "fit for purpose".

2.0 Introduction

2.1 Nuclear Waste Advisory Associates (NWAA) is an independent group of experts with a collective experience of nuclear issues of well over 200 years. We aim to provide information and advice on the risks posed by radioactive waste, and support to decision makers, stakeholders and communities involved in its management. Our membership includes former members of the Committee on Radioactive Waste Management (CoRWM(i)) and several members who worked for environmental organisations during the Public Inquiry into Nirex's application to build a Rock Characterisation Facility (RCF) in Cumbria.[3]

2.2 Part Three of the Draft National Policy Statement (NPS) for Nuclear Power Generation (EN-6) concludes that:

"*…the Government is satisfied that effective arrangements will exist to manage and dispose of the waste that will be produced from new nuclear power stations. As a result the* [Independent Infrastructure Planning Commission] *IPC need not consider this question*." [4]

2.3 Paragraphs 5.40 and 5.41 of the Consultation Document [5] are also relevant. These refer consultees to Annex G of the consultation document [6] for a description of how the preliminary conclusions on waste have been reached, and also to a document called "*The arrangements for the management and disposal of waste from new nuclear power stations: a summary of evidence*",[7] which gives further background on the evidence. Not referred to in the Consultation Document, but also relevant, is the Appraisal of Sustainability (AoS):

3 See http://www.nuclearwasteadvisory.co.uk/default.asp
4 Draft National Policy Statement for Nuclear Power Generation (EN-6), DECC, November 2009 Paragraph 3.8.20
http://data.energynpsconsultation.decc.gov.uk/documents/npss/EN-6.pdf
5 Consultation on Draft National Policy Statements for Energy Infrastructure, DECC November 2009.
http://data.energynpsconsultation.decc.gov.uk/documents/condoc.pdf
6 Also available here:
https://www.energynpsconsultation.decc.gov.uk/nuclear/managementdisposalwaste/annex/
7 The arrangements for the management and disposal of waste from new nuclear power stations: a summary of evidence, DECC November 2009
http://data.energynpsconsultation.decc.gov.uk/documents/wasteassessment.pdf

Radioactive and Hazardous Waste report, which is also called Annex K of the AoS Main Report.[8]

2.4 In this memorandum, NWAA examines the evidence for the Government's assertion that effective arrangements will exist for waste produced by new reactors, and concludes that the issue of dealing with nuclear waste already created (legacy waste) is far from resolved. Furthermore, this document reports the Environment Agency's view that further research cannot be relied upon to resolve the outstanding issues. This means that Government cannot assume that waste produced by new reactors can be safely disposed of in a deep geological disposal facility. Therefore the assumption that adequate arrangements for the long term management of radioactive waste from new reactors will exist when required is unfounded and therefore renders the NPS invalid at this point in time. Co-disposal of legacy and new build wastes was neither examined by CoRWM(i) nor considered within the extensive public consultation held in conjunction with CoRWM(i).

2.5 Given that there are acknowledged significant scientific, technical and ethical hurdles to the problem of disposing of nuclear waste, then the Draft NPS for Nuclear Power Generation (EN-6) is not fit for purpose. The Government should, therefore, return to the position espoused in the February 2003 Energy White Paper that there are "*important issues of nuclear waste to be resolved*" before new reactors can be built.[9]

2.6 We also examine whether the contention that "*no new issues arise that challenge the fundamental disposability of the waste and spent fuel expected to arise from operation of the EPR and AP1000 reactors*" [10] is correct, and conclude that there are in fact new issues associated with the waste fuel that would be produced by waste fuel from these reactors designs and that much further examination of the evidence for the Government's contention is required, as is an associated programme of relevant and appropriate research.

3.0 CoRWM(i)

3.1 Four former members of CoRWM(i) have written to the Secretary of State to express concern that the Committee's recommendations have been seriously misrepresented in the Draft National Policy Statement for Nuclear Power Generation.[11] The letter states:

"It is unknowable whether or not effective arrangements will exist …"

3.2 The CoRWM (i) recommendations called for

"…*an intensified programme of research and development into the long-term safety of geological disposal aimed at reducing uncertainties at generic and site-specific levels, as well as into improved means for storing wastes in the longer-term*".

The former CoRWM members say that because the scientific and technical requirements have not yet been met, it is not possible to conclude that effective arrangements for the long term disposal of waste 'exist or will exist'.

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8 Appraisal of Sustainability: Radioactive and Hazardous Waste, DECC, November 2009. http://data.energynpsconsultation.decc.gov.uk/documents/aos/wastematrices.pdf
9 Our Energy Future – Creating a low carbon economy, Energy White Paper, DTI, DoT, DEFRA. February 2003, paragraph 1.24
http://www.decc.gov.uk/media/viewfile.ashx?filepath=publications/white_paper_03/file10719.pdf&filetype=4
10 Draft Nuclear NPS para 3.8.10
11 A copy of the letter, signed by former chairman Professor Gordon MacKerron, Professor Andrew Blowers OBE, Mary Allan and Pete Wilkinson, dated 20th November 2009 can be found at http://www.nuclearwasteadvisory.co.uk/uploads/5647CoRWM1_Letter_201109.pdf

3.3 In addition CoRWM (i) was quite clear that its recommendations do not apply to waste arising from new reactors. This is because, in addition to the far more burdensome physical attributes of the much higher heat output and fission product content, the political and ethical issues raised by the creation of an unknown inventory of new build waste, with an indefinite time-scale for management, are quite different from those arising due to the waste burden we currently face following decisions and actions of our predecessors.[12] What is currently being put forward by Government is the proposal that we should create more wastes – knowing as we do that we have no credible strategy for its long term handling. The Secretary of State has ignored the recommendation by CoRWM(i) that the management of radioactive waste from new reactors should be subject to a separate process of examination. Therefore the social requirements for new build wastes have not been met, and thus again, it is not possible to conclude that effective arrangements 'exist or will exist'

4.0 Nirex Inquiry

4.1 In addition to concerns raised by CoRWM (i), there are far more fundamental concerns that were originally raised at the 1990s Public Inquiry into Nirex's application to begin excavation works at their proposed disposal site. The project was known as a 'Rock Characterisation Facility' (or 'RCF'). This proposal was rejected on generic scientific grounds (as well as for site specific reasons). The implications of this rejection have still not been fully examined or resolved nor has the necessary programme of research to address the inadequate scientific justification been implemented.

4.2 On 17th March 1997, the then Secretary of State for the Environment, John Gummer, rejected Nirex's planning application. He based his rejection on the evidence reported to him by the Inquiry Inspector, Mr. C S McDonald, and the Technical Assessor, Mr. Colin Knipe. Although much of the evidence dealt with site-specific issues, a very large amount of information pertaining to generic issues was also reported. Overall, the Inspector concluded that the Nuclear Industry should not be given the go-ahead to begin their planned programme:

"…*in* [their] *current state of inadequate knowledge.*" [13,]

4.3 Mr McDonald reported, for example, that the chemical containment system the industry proposed was:

"…*new and untried with more experimentation and modelling development indubitably required*" [14]

4.4 Similarly Colin Knipe, stated that:

"*The evidence suggests that considerably more experimentation and model development is needed on radionuclide solubility, sorption* [15] *and general thermodynamic relationships over the range of temperatures and chemical conditions"*[16]

He continued:-

"*There is a general need for the Nirex science programme to be advanced on all fronts."* [17]

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12 Managing our Radioactive Waste Safely, CoRWM, November 2006, para 25 page 15
13 C S McDonald (1997) Inspector's Report following 'Nirex RCF' Inquiry, Cumbria County Council, File (APP/H0900/A/94/247019) p277 para 8.56
14 McDonald (1997) pp 241-242 - para 6E.70
15 The nuclear industry use the term 'sorption' to refer to the 'take-up' of radioncuclides by rock surfaces.
16 Para C.142 Chapter C Science and Technical Programmes.
http://www.jpb.co.uk/nirexinquiry/Chapter%20C.rtf
17 Para C144 Chapter C Science and Technical Programmes.
http://www.jpb.co.uk/nirexinquiry/Chapter%20C.rtf

4.5 This generic concern was even confirmed in the September 2001"*Managing Radioactive Waste Safely*" (MRWS) consultation document which initiated the 'MRWS' programme. This document stated that

"*In March 1997 the then Secretary of State for the Environment decided not to give Nirex planning permission for the RCF. This decision called into question* ***whether at that time an underground repository for the disposal of radioactive wastes could be scientifically justified*** *or publicly acceptable. This led to a completely new look at radioactive waste management policy in the UK.*" [18] [Emphasis Added]

5.0 Further Research can Identify New Problems

5.1 The Inspector at the 1990s 'RCF' Inquiry concluded:

"The expansion in scope of the work over the last 5 years or so has also been very impressive, but does indicate amongst other things that the practical difficulties of the deep disposal option were originally underestimated by the international consensus."[19]

5.2 In November 2009 Professor Francis Livens, Professor of Radiochemistry at the University of Manchester, and also a member of the current CoRWM (ii) committee stated:

"*In recent years we have recognised where we do not have relevant expertise,* [concerning radioactive waste management] *and that is a first step towards dealing with these pressing problems.* ***We are starting at a very low base along what will be a long and complex journey.***" [20] [Emphasis added]

This indicates that very little further work has been done in the intervening period.

6.0 The Environment Agency (EA)

6.1 In November 2005, UK Nirex Ltd produced a paper for CoRWM (i) on the 'viability' of a planned deep disposal facility.[21] Any such future project would need a licence from the Environment Agency (EA) (in England and Wales and the Scottish Environment Protection Agency (SEPA) in Scotland). Thus, the EA produced a commentary response to Nirex' 'Viability' documents – which was also published in November 2005. [22] In this report the EA said Nirex:

"*…has not provided a good technical overview of many remaining key technical challenges and how they will be resolved … we consider that Nirex present an overly optimistic view".*

6.2 Whilst the EA review recognised that Nirex's report identifies a number of 'viability threatening issues', it expressed particular concern about Carbon-14 – a radioactive isotope of

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18 Managing Radioactive Waste Safely: Proposals for developing a policy for managing solid radioactive waste in the UK, DEFRA, September 2001. Page 9, para 1.3, http://www.ni-environment.gov.uk/ra_waste.pdf
19 McDonald (1997) Paragraph 6C.145
20 "*Nuclear waste research resurfaces*" Chemistry World, 20th November 2009 http://www.rsc.org/chemistryworld/News/2009/November/20110901.asp
21 The Viability of a Phased Geological Repository Concept for the Long Term Management of the UK's Radioactive Waste. Nirex Report N/122, November 2005. http://www.nda.gov.uk/documents/upload/The-viability-of-a-phased-geological-repository-concept-for-the-long-term-management-of-the-UK-s-radioactive-waste-Nirex-Report-N-122-November-2005.pdf
22 Review of Nirex Report: 'The Viability of a Phased Geological Repository Concept for the Long term Management of the UK's Radioactive Waste' Version 3.1 NWAT/Nirex/05/003 November 2005

carbon.[23] Nirex was assuming that the Carbon-14 would be held underground for a very long time into the future – as they had predicted that this carbon (in the form of 'carbon dioxide') would react with the cement in the disposal facility. However the EA stated:

"*In our view, more confidence is needed that complete reaction of carbon dioxide will occur in cracked backfill or that the gas pathway would not lead to unacceptable consequences were this not to be the case*". (Part 6, page 10).

Carbon-14 is discussed further at paragraphs 10.1 and 10.2

6.3 The Agency goes on to list ten key technical challenges "*...where further work is needed before an acceptable repository safety case could be generated*." [24] These are listed in Annex A. Note the sub-headings have been added by NWAA in order to ease comprehension of the points made.

6.4 In August 2009 the EA followed this up by producing a list of nine "*major knowledge limitations on the technical issues*". [25] These nine issues are listed in Annex B.

6.5 More recently, a report of a joint regulatory review carried out by the EA, Health and Safety Executive (HSE) and Department of Transport (DoT) states that:-

"*Although RWMD* [Radioactive Waste Management Division within the NDA] *has a considerable database of knowledge and research, it does not appear to have a clear picture of: (a) 'what we know enough about' (b) 'what else we really need to know' for development of a GDF* [Geological Disposal Facility] *and safety case, and hence (c) what the business priorities for research are. Work in hand led by the Head of Research may remedy this and should be encouraged*".[26]

7.0 EU Joint Research Centre

7.1 The EU JRC issued a report on geological disposal on 1st October 2009 with a press release which claimed the report identified no major conceptual or research gaps that would be a hurdle to deep disposal and conncluded that such an approach to radioactive waste management is 'technically ripe for implementation.' However this conclusion was not backed up by the evidence contained in the report.[27]

7.2 Chapter Two of the Report (pp 10 – 21) entitled "*The Technical Concept of Geological Disposal*" shows that in fact there are a very large number of conceptual and research gaps associated with deep geological disposal. Annex C lists nearly 40 technical issues, extracted from the report by NWAA, which indicate nuclear waste disposal is far from a proven technology.[28]

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23 See http://en.wikipedia.org/wiki/Carbon-14
24 Review of Nirex Report "The Viability of a Phased Geological Repository Concept for the long-term management of the UK's radioactive waste." Environment Agency, Nov 2005. Part 6 Page 11.
25 Technical Issues Associated with Deep Repositories for Radioactive Waste in different geological environments. EA August 2009
http://publications.environment-agency.gov.uk/pdf/SCHO0809BQVU-e-e.pdf See especially table 6.5 (pp 141 - 143) "*Summary of Major Knowledge Limitations on the Technical Issues*"
Summary document: http://publications.environment-agency.gov.uk/pdf/SCHO0809BQVV-e-e.pdf
26 Development of a Prospective Site Licence Company to Implement Geological Disposal, HSE, EA, DoT December 2009
http://www.environment-agency.gov.uk/static/documents/Business/RWMD_review_report_final.pdf
27 Geological disposal: technically ripe for implementation. EU JRC Press Release 1st October 2009.
http://ec.europa.eu/dgs/jrc/index.cfm?id=1410&obj_id=8820&dt_code=NWS&lang=en
28 W.E. Falck and K.-F. Nilsson "*Geological Disposal of Radioactive Waste: Moving Towards Implementation*", European Union – Joint Research Centre – Reference Report
http://ec.europa.eu/dgs/jrc/downloads/jrc_reference_report_2009_10_geol_disposal.pdf

8.0 The importance of chemistry

8.1 The next three sections deal with some of the major technical issues which need to be resolved before an acceptable safety case could be made for disposal. These include issues around solubility and sorption, and specific problems associated with the presence of plutonium in combination with cellulose and also the problem of gas generation.

8.2 A key factor in the calculation of risk is the level of hazard associated with the water that seeps out of a nuclear waste burial site. This would depend on:

- How much radioactivity would dissolve in the underground water supply system – its solubility - and,
- How much of this radioactivity would be taken up by the rock surfaces during the journey towards the surface.

8.3 To ascribe the appropriate chemical parameters to the solubility of each radionuclide, in order to ascertain the predicted contamination levels of ground-water that has washed through a radioactive waste burial site in advance, demands a huge amount of chemical data. At the RCF Public Inquiry (PI) it was established that the nuclear industry simply did not have the data to justify their claim that the risks arising from the burial of nuclear waste would be insignificant. (See para 3.4 above) Although this specifically refers to "*chemical conditions relevant to a Sellafield repository*", there would be similar difficulties in ascribing these chemical parameters *wherever the proposed location*.

8.4 In October 2007 the International Atomic Energy Agency (IAEA) published a document on recent findings concerning the solubility of radioactive wastes in a burial facility environment.[29] The report states:

"*The capacity to model*[30] *all the effects involved in the dissolution*[31] *of the waste form, in conditions similar to the disposal site, is the final goal of all the research undertaken by many research groups over many years. As we will see in this report,* ***this kind of investigation is far from being finished***" [32] (Emphasis added)

What was the case two years ago remains so today. The fact that the research is "far from being finished" indicates that the nuclear industry is not in a position to provide the necessary underlying data required to demonstrate that it could meet the risk targets set by the EA. (See paras 12.3 and 12.4).

8.5 In order to assess the reliability of predictions of contamination levels, an experiment was carried out in 1991 at the 'Pocos de Caldas' Uranium Mine in Brazil. The experiment tested whether chemical information fed into a computer model would enable an accurate forecast to be made of uranium contamination levels in underground water found at the site. In fact the computer model under-estimated the uranium levels of the underground water at the mine by a factor of 200 million.[33] Four possible explanations were advanced for this enormous error,

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29 "Spent Fuel and High Level Waste: Chemical Durability and Performance under Simulated Repository Conditions Results of a Coordinated Research Project 1998–2004" IAEA-TECDOC-1563 (October 2007) http://www-pub.iaea.org/MTCD/publications/PDF/te_1563_web.pdf
30 'Model' refers here to an approach to making predictions using equations.
31 'Dissolution' refers here to the process in which solids dissolve in liquids
32 "Spent Fuel and High Level Waste: Chemical Durability and Performance under Simulated Repository Conditions Results of a Coordinated Research Project 1998–2004" IAEA-TECDOC-1563 (October 2007) http://www-pub.iaea.org/MTCD/publications/PDF/te_1563_web.pdf Para 1.1 top of page 3
33 J.E. Cross, D.S. Gabriel, A. Haworth, I Neretnicks, S.M. Sharland and C.J. Tweed

though no definitive conclusion was reached. [34] This, in itself, indicates the extreme variability of the parameters in question and thus puts into question the whole basis for risk estimates advanced. Over fifteen years later (in 2007), the nuclear industry are still quoting data ranges for uranium contamination levels that can vary by up to 100,000,000 units.[35]

8.6 While the large error range may seem extraordinary, a comparison, for example, of the solubility of carbon in a diamond with the solubility of carbon in sugar illustrates just how easily wildly inaccurate predictions can be made. Sugar is a compound, made up of three different elements, carbon, hydrogen and oxygen. Although commonly found as solid crystals, sugar is readily soluble. On the other hand, diamonds, which consist of pure carbon, are essentially insoluble. Thus, it is safe to wear a diamond ring in the shower or when washing your hands as it will not dissolve. Similarly the other types of radioactive atoms in radioactive waste can exhibit very different types of behaviour in different chemical situations. It is the radionuclide that causes the harm, but generally speaking [36] radionuclides do not 'travel solo': they exist in combination with other chemical elements to form chemical compounds. Different chemical compounds can result in extraordinary degrees of variation in behaviour with respect to the specific radionuclide in question. It is therefore a mistake to attribute solubility to elements or isotopes of elements (as the nuclear industry and EA tend to do when making their estimates) when it should rightly be attributed to the compounds in which they are found.

8.7 In May 2008 the NDA's RWMD launched a consultation on its proposed research and development strategy.[37] On page 43 of the document, the NDA cites three reports concerning radionuclide solubility to indicate its current knowledge base. However each of these three reports was prepared prior to the 1995 / 96 RCF Inquiry and as such represent the same level of scientific and technical acumen which was a significant contributor to the Inspector's decision to refuse Nirex permission progress the proposed project. It can therefore be seen that little has advanced in terms of real evidence and research between the RCF PI in the late 1990s and the NDA Research Consultation just over a decade later.

8.8 In its consultation response, the NDA RWMD says "*a response to these* [technical] *comments will not appear in our updated strategy document*".[38]

8.9 An important factor in the forecast of the extent to which radionuclides will reach the surface is process of 'sorption'. Basically, in the context of the prediction of the risk associated with disposal, 'sorption' refers to the extent to which radionuclides would be taken up by solid surfaces (such as cement or rock). The difficulties involved in measuring sorption emerged at a Nuclear Energy Agency (NEA)[39] workshop held in Oxford in May 1997,[40] when Mr. Hans Wanner, of the Swiss Federal Nuclear Safety Inspectorate (HSK), stated:

"Modelling of Redox Front and Uranium Movement in a Uranium Mine at Pocos de Caldas Brazil" NSS/R252 Nirex, 1991 (pp 9,10,19)

34 These were as follows : (i) the uranium may not have been fully crystalline (i.e. it may have had an irregular structure) (ii) the uranium compound present may have been "*non-stoichiometric*" – (ie – the relative amount of the components in the relevant compound wasn't a simple ratio) (iii) colloids – ie large unwieldy compounds, and (iv) the presence of uranium (V) – a type of uranium compound in which five of the uraniums electrons are involved in it's bonding relationship with other chemicals.

35 D Swan and C P Jackson (SERCO) 'Formal Structured Data Elicitation of Uranium Solubility in the Near Field - Report to Nirex' (SA/ENV/0920 Issue 3 - March 2007 – page 6

36 The exception would be radio nuclides that are part of the inert (or 'noble') gas series. One such example is 'radon'.

37 Proposed Research and Development Strategy, NDA RWMD, May 2008 http://www.nda.gov.uk/documents/loader.cfm?url=/commonspot/security/getfile.cfm&pageid=20962

38 Response to comments on NDA RWMD's proposed research and development strategy, NDA March 2009. Report No. 10019689 http://www.nda.gov.uk/documents/upload/Research-and-Development-Strategy-for-Geological-Disposal-Facility-NDA-Response-to-Consultation-Results-March-2009.pdf

39 The 'Nuclear Energy Agency' is part of the 'Organisation of Co-operation and Development' (OECD)

"*The term "uncertainty" is commonly connected with "error" in a statistical sense, but a statistical basis rarely exists for* ***Kd*** **[sorption]** ***values*** *because they* ***depend on too many unknown parameters.*** *Hence the assignment of an uncertainty to a Kd value is usually a priori unscientific and unjustifiable*" (Emphasis added).

8.10 The EU JRC report (of October 2009) outlines this problem at some length. It says the Kd value is recognised as ***not*** reflecting in situ conditions and therefore does not "*have any prediction capabilities*". Nevertheless, it says, Kd values are still widely used in performance assessment calculations. "*In practice*", continues the report, "*it is impossible to parameterise all these variables over the whole domain to be investigated*".[41]

8.11 In other words, whilst sorption is regarded by the nuclear industry as a simple parameter that indicates the extent to which radioactive atoms escaping from a disposal facility will be taken up by the solid surfaces it would meet on its journey, in fact the complexity of the natural world and the sheer volume of data and computations required to quantify this parameter appropriately are beyond the capacity of current computers.

9.0 Cellulose and Plutonium

9.1 In 1989, the International Atomic Energy Agency (IAEA) identified a specific problem relating to the increase in the solubility of radionuclides caused by organic breakdown products that were sufficient to increase the radiological impact of a repository above the regulatory target dose.[42] A likely source was thought to be decomposition products of 'cellulose' – the woody compound used to make paper. Cellulose break-down products have been observed to increase radionuclide solubility by up to 10,000 fold[43,44] with plutonium being a particular problem.[45]

9.2 In July 2003, isosaccharinic acid (ISA) was reported as the most important breakdown product of cellulose. A plutonium / 'ISA' chemical species was identified as amongst the most stable of the 'complexes' studied.[46] However, the research did not appear to offer any answers but instead to merely express the same problem in more elaborate language. So, although the plutonium / paper mix has important implications for radioactive doses in the long term, the nuclear industry appears to have focussed its effort on describing the problem rather than resolving it.

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40 "Using Thermodynamic Sorption Models for Guiding Radioelement Distribution Coeffient (Kd) Investigations – A Status Report".
http://www.oecdbookshop.org/oecd/display.asp?sf1=identifiers&st1=662001061P1
41 W.E. Falck and K.-F. Nilsson "*Geological Disposal of Radioactive Waste: Moving Towards Implementation*", European Union – Joint Research Centre – Reference Report pp17-18
http://ec.europa.eu/dgs/jrc/downloads/jrc_reference_report_2009_10_geol_disposal.pdf
42 IAEA in – D. George (1989) NSS/R199 "*The Response to an IAEA Review of Deep Repository Post-Closure Safety R&D and Site Assessment Programmes of UK Nirex Limited*". (p 3)
43 Cross (1989) NSS/R151
J E Cross et al "*Modelling the Behaviour of Organic Degradation Products*" p(ii)
44 Ewart (1988) NSS/G103
F T Ewart et al, "*Chemical and Microbiological Effects in the Near Field: Current Status*" p19
45 Cross (1989) NSS/R151p3
46 Nicholas D.M. Evans - "*Studies on Metal Alpha-Isosaccharinic Acid Complexes A Doctoral Thesis submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy*" - Loughborough University, July 2003 (pp 24, 42, 272) [NB $Pu(OH)_4$ is 'tetravalent' – it is this 'valency' which is discussed on both 24 and page 272]

10.0 The Gas Problem

10.1 In February 2006[47] (and also in the earlier November 2005 'Viability' Report[48]), Nirex identified the need to carry out more research on the potential for large doses due the production and release of methane gas from decaying radioactive waste emplaced in a backfilled repository. The possibility was examined that Carbon-14, instead of being lodged in the cement backfill, would be able to escape from the facility as methane gas (CH_4) by travelling quickly upwards through fractures and pores in the overlying rocks until finally reaching the surface environment and entering the food chain. If this were to happen, then the impact on risk according to Nirex[49] could reach a figure as high as *one in a thousand* (i.e. one person in a thousand contracting a fatal cancer, a non-fatal cancer or inherited genetic defect as a result of such exposure as opposed to the target of one in a million). Furthermore, this particularly high risk could occur just *40 years* after the burial facility had been backfilled and closed as opposed to the thousands of years currently predicted to allow decay of the waste products to lower and 'tolerable' levels. It was concluded that if calculations confirmed that methane could indeed act in this manner over such a short period of time, then there may be a need to adjust the site selection criteria.

10.2 Clearly, if methane were to be a problem in this way, site selection criteria would need to be adjusted to make sure that gas would not be allowed to escape. But a contradictory site selection criterion arises in relation to the hydrogen gas issue. When the iron present in steel corrodes under '*anaerobic conditions*' (conditions in which oxygen is not present), hydrogen gas is released. Because of the need to avoid a build up of underground pressures from gas generation, the requirement for a route to release hydrogen gas has been central to calculations carried out by Nirex on the 'viability' of disposal.[50] The requirement to contain methane gas, yet to ensure that hydrogen is allowed to escape, are contradictory criteria which seriously undermine the radioactive waste disposal concept.

10.3 When Nirex carried out an initial review of their research programme in 1985/86, the significance of the 'gas issue' was identified. [51] Twenty year later, in a March 2008 report[52] for the European Commission's project on the 'Performance Assessment Methodologies in Application' to Guide the Development of the Safety Case (PAMINA), Simon Norris from the NDA called for more research on the gas issue. Similarly, the October 2009 'EU JRC' [53] report referred to: "*gas generation and migration … as an important study subject*." Both reports indicate the underlying concerns of 20 years ago are far from resolved. The implications of this contradiction in criteria are not dealt with in the Government's (June 2008) 'Implementation' White Paper. [54]

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47 "*C-14: How we are addressing the issues*" Nirex Technical Note Number: 498808, February 2006.
48 Nirex 'Viability Report' November 2005 – Nirex Report N-122 (page 14)
49 Nirex, 'C-14: How we are addressing the issues February 2006', (February 2006)Technical Note No: Number: 498808 [See p12 (Fig 1)]
50 Cooper MJ, Hodgkinson (ed) (1987). The Nirex Safety Assessment Research Programme: Annual Report for 1986/87. NSS/R101 Nirex. (page 113)
51 Cooper MJ, Hodgkinson (ed) (1987). "The Nirex Safety Assessment Research Programme: Annual Report for 1986/87". (page113) NSS/R101 Nirex.
52 Norris, S (NDA) Uncertainties Associated with Modelling the Consequences of Gas. EC Pamina Project, March 2008. http://www.ip-pamina.eu/downloads/pamina2.2.b.2.pdf
53 "*Geological Disposal of Radioactive Waste: Moving Towards Implementation*" W.E. Falck and K. F. Nilsson, European Union – Joint Research Centre – Reference Report 1st October 2009 http://ec.europa.eu/dgs/jrc/downloads/jrc_reference_report_2009_10_geol_disposal.pdf
54 See the Government White Paper "*Managing Radioactive Waste Safely: A Framework for Implementing Geological Disposal*" (DEFRA, June 2008) [54], the decision making steps are set out on pages 50 and 51; and the geological screening criteria are set out on pages 74 –75. http://www.defra.gov.uk/environment/radioactivity/mrws/index.htm

11.0 Techniques used in calculation of risk

11.1 When the nuclear industry refers to the 'parameters and equations' used in their risk predictions, one imagines a calculation which is similar to a straight-forward piece of algebra. In fact the methodology actually adopted is generally based on the use of '*probability density functions*' (pdfs) and the so-called 'Monte-Carlo' approach. A 'probability density function' is used to set out a statistical description of the range of possible data points for one given radioactive element and also the likelihood that a given parameter (for example radionuclide solubility or sorption) will possess this value.

11.2 The true range of data points is, quite routinely, extremely large (of the order of 'one to10,000' units – or even 'one to 100,000,000' units).[55] Furthermore, the distribution of the parameter value within this range is, generally speaking, not set out as 'normal distribution' commonly found in statistics. The selection of data from this large range is fed into the computer used to calculate the predicted risk using the 'Monte Carlo' method, i.e. almost randomly [56] from between the two points.

11.3 Much of the data used is not actually measured, but is obtained through '*data elicitation by expert judgement*'. 'Expert elicitation' refers to a method of 'synthesising data' [57] based on the judgement of experts – in other words 'educated guessing.' The Dutch research organisation 'RIVM' in a report specifically on data elicitation, concluded:

> "*With respect to the evidence base, it seems obvious that, at some point, the scientific evidence base would be so thin as to render quantitative expert judgement useless.*"[58]

Thus, if the data isn't there – it simply isn't there.

11.4 The fact that such methodologies are quite routinely used by the nuclear industry in order to produce predictions is alarming and demands an examination of whether the previous and existing work that has been carried out to predict repository safety actually has any sort of reliable basis under which a disposal license could be applied for.

12.0 Problems may never be resolved

12.1 Resolution of the problems raised at the Nirex RCF Inquiry, and more recently by the EA and EU JRC, is not a simple matter of providing sufficient funding for researchers over the next few decades. It may, in fact, not be possible to resolve all of the issues. Further research may not produce the answers or it may identify further serious problems that had not been previously identified. As implied by the Nirex Inquiry Inspector, it may be a case of 'the more you know, the more you realise what you don't know'.

12.2 A consequence of the fact that there are still major technical issues to be resolved is that, as Clive Williams of the EA specifically stated in November 2009:

"…work may or may not indicate that an acceptable safety case can be made" [59]

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55 D Swan and C P Jackson (SERCO) 'Formal Structured Data Elicitation of Uranium Solubility in the Near Field - Report to Nirex' (SA/ENV/0920 Issue 3 - March 2007 – page 6

56 With the caveat that more likelihood is given to the 'mid-range' points

57 "*Expert Elicitation: Methodological suggestions for its use in environmental health impact assessments* " (page 7) Slottje, P., Sluijs, J.P. van der and Knol, A.B. (RIVM Letter report 630004001/2008) 2008 ['RIVM' – 'The National Institute for Public Health and the Environment' (RIVM) is a centre of expertise in the fields of health, nutrition and environmental protection. It mainly carries out work for the Dutch government.] http://www.rivm.nl/bibliotheek/rapporten/630004001.pdf

58 ibid page 22

59 E-mail to Adam Scott CORWM (ii) Secretariat & Dr Rachel Western 16th Nov 2009

12.3 In other words, it may not be possible to make a safety case for deep geological disposal. So **the Government's confidence that effective arrangements to dispose of waste from new reactors will exist is premature.** The fact that money and effort invested in future research may not indicate that safe disposal is possible was referred to extensively in the EA's response[60] to an NDA RWMD consultation on its research strategy launched in May 2008.[61] Annex D lists some of the EA's comments.

13.0 Health Risks

13.1 What is critically important to realise is that the technical problems and uncertainties described by the EA, the EU JRC and in particular the uncertainties regarding radionuclide properties detailed above, such as their solubility and sorption – or even their presence as a gas - could mean estimted contamination levels calculated for a deep geological disposal facility are in error by a factor of 10,000 to 1,000,000 which clearly has implications for the risk estimates.

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13.2 In March 2008 the Health Protection Agency (HPA) held a consultation on Radiological Protection Objectives for the Land-based Disposal of Solid Radioactive Waste.[62] In response to the consultation one NWAA member said:

"[I]*t is imperative that the HPA takes full cognizance of the difficulties to be expected in actually reaching the targets that they set out. If the HPA do not do this, it would be very easy for the Nuclear Industry, or the Government, to imply that these standards had been met although it was very clear that it was not the case.*"

HPA's response to this point was that it is the responsibility of the developer of the disposal facility to make a sufficiently robust safety case.[63] It does not offer any advice on how to deal with the technical problems and uncertainties described above.

13.3 Under present legislation, the nuclear industry would require authorization from the EA in order to be able to go ahead with the burial of nuclear waste. The Agency published its Guidance on Requirements for Authorisation (GRA) in February 2009.[64] This sets a limit on the risk that may be caused by the burial of radioactive wastes of 10^{-6} (i.e. one in a million).[65] This means a risk of one in a million per year, for the person at greatest risk, of either non-fatal cancer, fatal cancer or inherited defects.[66]

13.4 The EA calculates the radiation dose which it believes will result in this level of risk. If the probability of receiving the dose of radioactivity is one, then the amount of radioactivity that would lead to a risk of '*one in a million*' (per year) would be approximately 20 micro

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60 "*Environment Agency, Response to Nuclear Decommissioning Authority Consultation on – Radioactive Waste Management Directorate Proposed Research and Development Strategy*" November 2008.
http://www.environment-agency.gov.uk/static/documents/Research/1976__RWMD_Proposed_RD_strategy.pdf
61 Proposed Research and Development Strategy, NDA RWMD, May 2008
http://www.nda.gov.uk/documents/loader.cfm?url=/commonspot/security/getfile.cfm&pageid=20962
62 Consultation on HPA Advice on Radiological Protection Objectives for the Land-based Disposal of Solid Radioactive Waste, HPA March 2008
http://www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1205741917946
63 Response to Comments received during the consultation on proposed HPA Advice on Radiological Protection Objectives for the Land-based Disposal of Solid Radioactive Waste. HPA April 2009.
http://www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1239868000504
64 Geological Disposal Facilities on Land for Solid Radioactive Wastes: Guidance on Requirements for Authorisation, Environment Agency, February 2009. http://publications.environment-agency.gov.uk/pdf/GEHO0209BPJM-e-e.pdf
65 ibid page 46 para 6.3.10
66 ibid page 47 para 6.3.15

sieverts [67] per year (20µSv/yr).[68] But risk is related to the chance of something happening, so if the EA can be persuaded that the probability of receiving a particular radiation dose from the waste facility would be less than one, then the EA would be prepared to authorise a dose greater than 20µSv/yr.[69]

13.5 The EA's GRA goes beyond radiological protection issues, for example, by explaining the regulatory process and describing what is expected in an environmental safety case from the developer and operator of a disposal facility. Central to the GRA is the notion that it is feasible to generate a reliable calculation of the risk that would arise from the disposal of radioactive waste, and, therefore, that it is possible to ensure that the risks that would arise from the burial of radioactive wastes would be at or below 'one in a million'

13.6 However it can be seen that the forecast of disposal risk is subject to errors of many orders of magnitude, and that demonstrating that the EA target would be met is simply not scientifically demonstrable or achievable in theory or practice. It is in the nature of chemical elements and also geological and biological systems to behave in a variable and hence unpredictable manner such that they make reliable risk/time calculations into the far future not only difficult but virtually impossible. Thus is hard to see what information could be used as a basis for the claim that the radiological impact from a repository would not exceed the target.

14.0 Finland

14.1 The Government states that:

"*The reference design currently being used by NDA for the purposes of estimating the costs of a GDF* [Geological Disposal Facility] *envisages spent fuel being packaged in copper canisters prior to disposal*"[70]

14.2 The Government's evidence (produced as part of the Nuclear NPS consultation) refers very specifically to the Finnish disposal project which is heavily based on the use of copper.[71] For example, paragraph 121 of the Government's summary of evidence states that STUK, the Finnish Radiation and Nuclear Safety Authority, presented their preliminary safety assessment for the expansion of the Finnish disposal facility to accept spent fuel in June 2009. Posiva is the Finnish nuclear waste company, jointly owned by the two Finnish nuclear utilities. It is responsible for implementation of the final disposal of spent nuclear fuel and the related research, technical design and development activities.

14.3 Dr Johan Swahn, the Director of MKG[72] in Sweden wrote (in December 2009): [73]

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67 micro = one millionth
A Sievert is a measure of radiation dose. It's units are energy - per unit weight - of exposure ; and it can be thought of in terms of the overall '*punch*' associated with the bombardment.
68 Ref 62 page 47 – para 6.3.17
69 Ref 62 page 47 – para 6.3.17
70 The arrangements for the management and disposal of waste from new nuclear power stations:a summary of evidence, DECC November 2009 (see footnote 14)
https://www.energynpsconsultation.decc.gov.uk/nuclear/managementdisposalwaste/summaryevidencepaper/
71 See para 121, page 26 – [and also footnote [116] which refers to:
Application for the Decision-in-Principle on the Final Disposal of the Spent Nuclear Fuel from Olkiluoto 4. Posiva Oy. (June 2009.)
http://www.posiva.fi/en/nuclear_waste_management/required_permissions_and_procedures/decision-in-principle/application_for_the_decision-in-principle_on_the_final_disposal_of_the_spent_nuclear_fuel_from_olkiluoto_4
72 'Miljöorganisationernas kärnavfallsgranskning'- the Swedish NGO Office for Nuclear Waste Review
73 E-mail to Dr Rachel Western of Nuclear Waste Advisory Associates, 18th December 2009

"*There is no way that anyone can honestly claim that Posiva has a completed robust safety case. The Posiva safety case has not been developed independently, but* ***relies entirely on the Swedish safety case work.*** *The final test of the Swedish safety case will not be done until the Swedish Radiation Safety Authority gives an approval of the safety analysis…****This will not be the case before 2013-2014****.*" (Emphasis added)

"*Already now there is concern from the authority about the barrier systems of copper and clay. It is not clear if all relevant copper corrosion processes are known and the risk for clay erosion is still not understood. So* ***an approval is not at all certain.*** *And nothing can today be claimed to be robust.*" (Emphasis added)

14.4 Annex E includes a summary of key points to emerge from the latest review of the Posiva Safety Case on behalf of the Finnish Radiation and Nuclear Safety Authority (STUK). The STUK consultants conclude that Posiva seem to have no sense of the utility of the data that they have gathered within a reliable prediction of disposal risk. Clearly when the Government claims that: "*STUK did not identify any reason why the project couldn't move forward*"[74] it does not provide an accurate representation of the STUK evidence base.

14.5 It is particularly worth noting that recent research suggests corrosion of the copper canisters may prove to be more of a problem than previously expected.

"*According to a current concept, copper canisters of thickness 0.05 m will be safe for nuclear waste containment for 100,000 years. We show that* ***more than 1m copper thickness might be required for 100,000 years durability****.*" [75]

Clearly, if such thicknesses of copper were required to ensure safe long term isolation of canisters, the cost and availability issues alone would render the entire disposal concept unviable.

15.0 Spent Fuel from New Reactors

15.1 Spent or waste nuclear fuel generated by new reactors currently looks unlikely to be reprocessed (i.e. subjected to a plutonium separation process). The nuclear industry plans to operate the proposed 'New Build' reactors in such a way that more electricity is generated from a given tonnage of uranium. As a result, the waste fuel produced (known as 'high burn up fuel') would be physically hotter, and also far more radiotoxic. As a result, such fuel would have to be stored for around 100 years to cool down after removal from a reactor. Consequently, as the new reactors are planned to have a life of 60 years, the sites designated for new reactors would probably also be required to act as nuclear waste sites for up to 160 years.[76]

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74 The arrangements for the management and disposal of waste from new nuclear power stations:a summary of evidence, DECC November 2009 para 121
https://www.energynpsconsultation.decc.gov.uk/nuclear/managementdisposalwaste/summaryevidencepaper/

75 "*Water Corrodes Copper*" G. Hultquist et al [July 2009 – (online)]
Catal Lett (2009) 132:311–316
Received: 29 June 2009 - Accepted: 19 July 2009 (Published online: 28 July 2009)
Springer Science+Business Media, LLC 2009
http://www.mkg.se/uploads/Water_Corrodes_Copper_-_Catalysis_Letters_Oct_2009_-_Hultquist_Szakalos_et_al.pdf

76 The arrangements for the management and disposal of waste from new nuclear power stations:a summary of evidence, DECC November 2009 para 53.
https://www.energynpsconsultation.decc.gov.uk/nuclear/managementdisposalwaste/summaryevidencepaper/

15.2 Little information has been given about how spent fuel would be stored and managed at the reactor sites over this length of time. For example, it is not clear whether a spent fuel packaging plant would need to be built on site at some point in the future. On-site spent fuel management arrangements may not be acceptable to the local communities, and may also be unsafe due to weather effects that may arise due to climate change.[77] The nuclear industry has not necessarily agreed with the Government's base case of on-site storage, and therefore spent fuel could start to be moved off-site to a central interim facility sooner than in 100 year's time with storage or processing imposed on some other unsuspecting community.

15.3 The Government is relying mainly on the NDA's so-called "disposability assessments" to reach its conclusion that it is "*satisfied that effective arrangements will exist to manage and dispose of the waste that will be produced from new nuclear power stations. As a result the IPC need not consider this question*." [78] These disposability assessments will be submitted to the Generic Design Assessment process for review by the EA. The EA review will not be available for public comment until the Agency carries out its Part 3 consultation exercise which is expected in Spring 2010, long after the National Policy Statement and Justification Consultations have closed on 22nd February.

15.4 There will, as current planning arrangements stand, be no opportunity for communities selected for new nuclear power stations to consider whether they wish to volunteer to host a long term radioactive waste facility for up to 160 years: it would simply be imposed upon them. Therefore the social conditions (the principle of volunteerism) recommended by CoRWM (i) would not have been met.[79] This is a further reason why it is not possible to conclude that effective arrangements will exist.

16.0 Radioactive wastes from uranium mining and processing

16.1 The above discussion has focused on radioactive wastes arisings from the so-called back end of the nuclear fuel chain, i.e. radionuclides created following the irradiation of nuclear fuel in reactors. In so doing it follows the course set out in the Nuclear NPS. But the largest amounts of radioactive wastes also arise in the mining, milling and processing of uranium, as well as in its enrichment and fabrication into fresh nuclear fuel. The Nuclear NPS, specifically Section 3, makes no mention whatever of this front-end waste management burden.

16.2 Given that all the uranium used in non-military nuclear fuel is imported into the UK, it is important – on equity and sustainability grounds - to assess the environmental, radiological and other health impacts of the source of this uranium. Inexplicably, the 200 page Appraisal of Sustainability: Radioactive and Hazardous Waste[80] makes no mention of the dangers and management challenges of uranium procurement and processing.

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77 At the time of writing, Cumbria has just been hit by extremely severe flooding.
78 Draft Nuclear NPS para 3.8.20
79 In its Implementation Report CoRWM indicated that its recommendations must also be applied at least to central and regional long terms stores (and, by implication, to on-site stores) if they are to inspire public confidence (See 'Moving Forward' para. 25 p.10 CoRWM 1703 Feb. 2007 http://www.corwm.org.uk/Pages/Archived%20Publications/Tier%202%20(7)%20-%20Implementation/Tier%203%20-%20Implementation%20advice/1703%20-%20Moving%20Forward%20-%20Report%20on%20implementation.doc)
80 Appraisal of Sustainability: Radioactive and Hazardous Waste, DECC, November 2009. http://data.energynpsconsultation.decc.gov.uk/documents/aos/wastematrices.pdf

16.3 In comparison in another report,[81] which has been presented as technical support to the Justification decision documents, this issue is addressed. Thus, although the Government themselves did not see fit to consider the Uranium issue, their Consultants did think that it was relevant.[82] The authors report an analysis performed for Sizewell and include a table showing the potential dose impact from the whole of the nuclear fuel chain. The figure quoted as the contribution from uranium mining and milling is almost 92% of the total health detriment from the nuclear fuel chain (expressed in terms of years of life lost).[83]

16.4 The UK has not examined fully within any major forum the issues arising from uranium mining. Calls were made by the Planning Inspectors at both of the last two Public Inquiries into proposed nuclear reactors (Sizewell B 1983-85[84] and Hinkley Point C 1988-89[85]) that such an analysis should be carried out, given that:

(a) uranium mining carries the highest average occupational radioactive exposure in the nuclear energy industry;
(b) uranium mining and processing is a major source of radioactive wastes;
(c) uranium mining causes very significant impacts on human health and the environment, and;
(d) the mining and processing of uranium not only affects this generation but will affect many future generations.

16.5 Michael Barnes QC (the Inspector at the Hinkley Inquiry) recommended that if future proposals were put forward:

"…*the applicants should use their best endeavours to present information to any future inquiry on conditions for workers and the public in the countries concerned who might be affected by the mining and processing of uranium for the project*."[86]

Moreover he noted that he was echoing the conclusion by Sir Frank Layfield in the Sizewell B Inquiry report, and said he shared Layfield's tentative disquiet on uranium mining. Layfield had also recommended that applicants present information in respect of the conditions for workers and the public who might be affected by mining and processing of uranium

16.6 As the Government has changed the planning process with the introduction of the Planning Act, we believe the Nuclear NPS itself, as well as the proponent companies in their Justification documentation, should have included such material (importantly based on independent sources), as recommended by the two inquiry inspectors. Indeed, one of our associates made a 74,000 word submission[87] to both the Strategic Siting Assessment and

81 Technical Advice to inform proposed Regulatory Justification decisions on new nuclear power stations, IDM68-2009.11, November 2009, Authors: Gregg Butler, Grace McGlynn (IDM), Andy Worrall, Kevin Hesketh (NNL) http://www.decc.gov.uk/Media/viewfile.ashx?FilePath=Consultations\proposedregulatoryjustificationdecisionsnewnuclearpowerstations\1_20091109121208_e_@@_technicaladviceregulatoryadvice.pdf&filetype=4
82 ibid section 2.5 page 13
83 ibid table 2 page 14
84 O'Riordan T, Kemp R, Purdue M (1988) *Sizewell B: an Anatomy of the Inquiry*, MacMillan ISBN 0333389441
85 Barnes, Michael QC (1990), *The Hinkley Point Public Inquiries*, HMSO Conclusions and Recommendations (see Chapter 31).
86 Barnes, Michael QC (1990), *The Hinkley Point Public Inquiries*, HMSO Conclusions and Recommendations Paragraph 31.145
87 Uranium Exploitation and Environmental Racism: why environmental despoliation and the ignorance of radiological risks of uranium mining cannot be justified by nuclear fuel production Response to the Justification Consultation, by Dr David Lowry, 25th March 2009. http://www.nuclearwasteadvisory.co.uk/page.asp?Id=51

Justification consultations, both making this point, and filling in the information gap. It remains a major omission of the Nuclear NPS and its associated documentation.

16.7 The price that would be paid for uranium is not only financial. Many additional costs such as people's health and environmental degradation have been externalised and are not taken into account. These need to be included in a full evaluation of the use of uranium as a fuel. Without a full evaluation of the impact of uranium mining, including an Appraisal of its Sustainability, the Nuclear NPS is not fit for purpose.

17.0 Conclusions

17.1 Neither the scientific nor the social requirements included in CoRWM's recommendations have been met. Therefore it is not possible to conclude that effective arrangements 'exist or will exist' to manage and dispose of nuclear waste from new reactors.

17.2 The Nirex application to begin excavation work at the site of their proposed nuclear waste disposal site was rejected following intense scrutiny at a Public Inquiry held in 1995/96. The proposal was rejected in large part on generic scientific grounds. These scientific and technical problems have yet to be resolved.

17.3 A very limited amount of progress appears to have been made since the work that was carried out for the 1990s project.

17.4 Both the EA and the EU JRC have listed a series of major knowledge deficiencies with regard to a series of technical issues. These issues include problems identifying the correct parameters for radionuclide solubility and sorption; specific problems related to cellulose increasing the solubility of plutonium; problems with gas generation and conflicting aims of, on the one hand limiting the escape of radioactive gases, and on the other allowing gases to escape to avoid a build-up of pressure.

17.5 Some of the methodologies used in risk calculations are highly questionable.

17.6 Further research may not serve to produce the required answer, in fact it may identify further serious problems that simply had not previously been thought of. It is also possible that further work may indicate that an acceptable safety case cannot be made.

17.7 Approval of the Finnish nuclear waste repository is by no means certain and cannot be used to support the Government's case.

17.8 The EA's review of the 'disposability' of the new type of waste fuel likely to be produced by new reactors will not be available for public comment until May 2010. Therefore, there will be no opportunity for communities selected for new nuclear power stations to consider whether they wish to volunteer to host a long term radioactive waste facility. Under Government proposals nuclear stations would act as radioactive waste sites for over 160 years into the future thus bolstering the conclusion that the social requirements of CoRWM (i)'s recommendations have not been met.

17.9 A full Appraisal of Sustainability of uranium mining and processing has not been carried out.

17.10 In short, the Government's conclusion "*…that effective arrangements will exist to manage and dispose of the waste that will be produced from new nuclear power stations"* is not supported by the evidence. The Nuclear National Policy Statement is, therefore, not "fit for purpose".

Prepared for NWAA by Dr Rachel Western & Peter Roche, with additional material provided by Dr David Lowry January 2010

Annex A: Environment Agency Comments on Nirex 'Viability' Report, November 2005

Carbon-14

"In the case of Carbon-14 (C-14), two issues are not mentioned in Section 9.2, although they are covered briefly earlier in the report. These include the need to build confidence in estimates of the release rates of C-14 labelled gases, particularly where these estimates depend on models of microbiological processes. Further, a key assumption is that all C-14 labelled carbon dioxide does not escape from the repository, but ***reacts with backfill via a carbonation reaction.*** *In our view, more confidence is needed that complete reaction of carbon dioxide will occur in cracked backfill or that the gas pathway would not lead to unacceptable consequences were this not to be the case. For example, if gases flow along partially sealed cracks, it might be difficult for the gas to access unreacted backfill.* ***These issues are all important to developing a better understanding of the radiological consequences that might arise from the gas pathway.*** *We agree with Nirex that there may be scope for managing any residual issues by appropriate measures."* (pp 10-11) [Emphasis Added]

Additional Issues

The Environment Agency Nuclear Waste Advisory Team says the following are some of the other key technical challenges that remain (Headings added by NWAA).

1) Longevity and Degradation

"*The need to better understand package longevity and corresponding degradation mechanisms over a long period of storage and hence any requirement to produce improved packages for certain waste streams or to make provision for reworking."*

2) Groundwater Flow

"*Developing a good understanding of groundwater flow and radionuclide transport at a specific site, including the representation of flow and transport in fractured rocks."*

3) Soluble Compounds that Weren't Originally Anticipated

"*A fuller understanding of the impact of organic complexants and colloids as well as Non-Aqueous Phase Liquids (NAPLs – which are addressed in Section 9.2)*."

4) Gas/Groundwater Flow

"Understanding the potential coupling between gas and groundwater flow."

5) How Much Can the Facility itself be Relied on to Hold the Radioactivity

"Developing a better understanding of the evolution of the 'near field' and its role in limiting radionuclide release, which should be closely linked to the consideration of possible design optimization."

6) The Need for Long Term Experiments

"The need for long-term experiments to demonstrate the behaviour of near-field components;"

7) Possible Impact of Presence of Nuclear Weapons Materials

"*Building more confidence in the safety case for criticality.*"

8) Whether Sealant Will Be Adequate in the Long Term

"Developing a clear strategy for repository sealing that is demonstrated to function adequately in the long term."

9) Allowing for Processes to Change over Time

"Building an understanding of time dependent effects and their consideration in a justifiable way in assessment models."

10) Getting the Data Right

"Demonstrating an adequate understanding of the values of key parameters."

Annex B: The Environment Agency's list of nine "*major knowledge limitations on the technical issues*", August 2009

From:
Technical issues associated with deep repositories for radioactive waste in different geological environments Science summary SC060054/SR1, Environment Agency, August 2009
http://publications.environment-agency.gov.uk/pdf/SCHO0809BQVV-e-e.pdf

See also Table 6.5, Pages 141 – 143
Technical issues associated with deep repositories for radioactive waste in different geological environments. Science report: SC060054/SR1
http://publications.environment-agency.gov.uk/pdf/SCHO0809BQVU-e-e.pdf

The Technical issues were identified:

• influence of different wasteform types on the design of the Engineered Barrier System (EBS);

• interactions between engineered components;

• interactions between the EBS and the host rock;

• impact of groundwater/porewater on EBS materials (including the impact of saline water);

• duration for which EBS materials maintain their function (durability);

• interactions between gas and groundwater (or porewater);

• characterising the site adequately;

• demonstrating long-term stability;

• impact of resaturation of the repository.

Annex C: Geological Disposal of Radioactive Waste: Moving Towards Implementation, by W.E Falck and K.F. Nilsson, European Commission Joint Research Centre, Insutute for Energy, October 2009.

http://ec.europa.eu/dgs/jrc/downloads/jrc_reference_report_2009_10_geol_disposal.pdf

The following is a list of the technical problems identified

1. Barriers

Geological disposal relies on a sequence of complimentary and/or redundant barriers … namely the waste form, the container, the buffer/backfill and the host rock. Assumptions have to be made about how each natural and engineered component will perform its function. [88]

2. Fractures

In granites discrete migration pathways will exist, but the frequency and length is difficult to assess quantitatively. [89] Therefore in fractured systems – more reliance has to be placed on the materials that make up the disposal facility – waste packages, buffer/backfill and other engineered elements of the repository itself. [90]

3. Radionuclide Inventory

Radioactive wastes have been building up for up to sixty years. [91] Radionuclide content of these wastes is either not known – or not known precisely. [92] To obtain this info on the radionuclide contents of the wastes is often regarded as too dangerous or too expensive. [93] Estimation techniques are being developed. [94]

Recently different radio-nuclides have been recognised as important in the risk calculation (eg. selenium.) A better understanding of the chemistry of these 'new' radio-nuclides is needed. [95]

4. Steel and Clay

The Vitrified High Level Waste (HLW) containers are assumed to be steel – however there are now concerns about the chemicals that would form when this steel corrodes. It is now being realised that these chemicals could interfere with the surrounding clay. The clay had been meant to provide a barrier – but the reactions between the clay and the corrosion chemicals corrosion might prevent this. [96] The behaviour of steel corrosion products in contact with clay needs more research.[97] Corrosion of ferrous components will change the geochemical environment and may be a possible source of gases producing significant amounts of hydrogen.[98]

Although the report states that 'experts seem to agree' that the underlying function is not at risk as a result of this corrosion, the paper cited as evidence of this to remains unpublished. [99]

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88 Page 10 Col one – mid page
89 Page 10 Col one – bottom of page
90 Page 10 – Col two – third way down page
91 Page 10 – Col two -bottom of page
92 Page 10 – Col two - bottom of page
93 Page 11 – Col one – top of page
94 Page 11 - Col one – top of page
95 Page 17 – Col two top of page
96 Page 11 – Col one – bottom half page
97 Page 12 – Col two – top of page
98 Page 20 – Col one, middle of page
99 Page 11 – Col one – bottom of page – [Ref : Hodgkinson , 2007 – see p 41 of EU JRC report]

5. Waste and Surroundings

The Interaction of spent fuel with other components of the near field needs to be investigated.[100]

6. New Fuel

New reactor types and changes in fuel design will necessitate research. [101] Higher Burn-Up and Mixed Oxide (MOX) fuel require new container design and more research on how such containers would behave on disposal. [102] (Considerations are higher temperature and higher risks of brittleness due to increased exposure to radioactivity).

7. Glass and Clay

The interactions between the glass matrix in vitrified waste and clay backfill are difficult to assess at high temperatures. [103]

8. Steel, Cement and Clay

The introduction of foreign materials such as alkaline cement is being reconsidered as the benefit of lowering radionuclide solubilities and corrosion passivation is offset by difficult to predict detrimental effects on clay-like materials in the repository system. [104]

An excavation in clay would need steel and concrete to keep it open (during operation) - There is a 'growing consensus' that 'only a minimum of additional foreign material should be introduced, at least into a facility built in clay. [105]

9. Possible Container Failure

Research on the failure of waste containers is ongoing. [106] Work on corrosion rates of steel and copper is still required. [107]

10. Gas

Corrosion gases generated and their migration is an important area of study. [108]

11 Clay and Problems Due to High Temperature

The role of clay backfill in a High Level Waste (HLW) disposal facility is meant to be to 'hold-up' the overlying rock; to stop leaks; and to 'take-up' or (through 'sorption') radionuclides. However, these safety functions are 'challenged' by the inevitable drying of the clay after the emplacement of hot waste canisters. [109] The OECD's Nuclear Energy Agency is working on a report on clay as a barrier. [110]

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100 Page 11 – Col two – top third of page
101 Page 11 Col two – two thirds down page
102 Page 12 – Col two – top third of page
103 pp 11-12 - bottom of Col two on p11 to top one on p 12
104 Page 12 – Col one – top third of page + see also Page 20 – Col two – bottom of page
105 Page 14 - Col two – half way down page
106 Page 12 – Col one -- bottom two thirds of page
107 Page 12 – Col one – bottom of page
108 Page 12 – Col two – top of page
109 Page 12 – Col two – bottom third of the page
110 Page 13 – Col one top third of page

12 Clay and High Temperature

High temperatures would affect the chemical, flow + mechanical properties of clay. [111] It is intended to keep the surface temperature of containers below 100°C at the time of emplacement. The waste storage period and the repository layout are critical to achieving these temperatures. [112]

High temperatures and the presence of corrosion products would alter clay chemistry and therefore possible clay flow characteristics. A new research programme is being set up on this. [113]

13. Problems Due to Corrosion

Corrosion and what happens to the corrosion products 'is not yet fully understood' and is due to be the subject of new research. [114]

14. Problems with Clay

While many of the basic phenomena in clays are understood their quantification for given cases 'remains difficult'. [115] While the response of bentonite clay to changing conditions such as water saturation, temperature salinity and pH are reasonably well understood, the combined effects and possible interactions between different mechanisms are still difficult to predict quantitatively. More research is needed. [116]

15. Rock Damaged by Excavation

Properties of the damaged area of rock around an excavation continue to be studied in detail – as it would have an effect on how much water could leak through the rock. [117]

16. 'Constructability'

More research is being done on construction issues including the issue of 'constructability'.[118]

17. Compromise needed during Construction

Construction safety measures such 'rock anchors' introduce 'additional foreign material' – that would have to be considered in the long-term risk assessment. This means that there would be the need for a compromise. [119]

18. Oxygen

The impact of the oxygen that would be present during operation (both chemically and mechanically) is being researched. [120]

19. Impact of 'Open' Phase

111 Page 13 – Col one – half way down page
112 Page 13 – Col one – two thirds down page
113 Page 13 – Col one – bottom of page
114 Page 13 – Col two – top of page
115 Page 13 – Col two – top third
116 Page 13 – Col two – half way down page
117 Page 14 – Col one – half way down page
118 Page 14 – Col one – bottom third
119 Page 14 – Col two – bottom of page
120 Page 14 – Col two – half way down page

New proposals to keep the excavation open (for retrievability or extended underground storage) have raised new issues – such as the collapse of the excavation and also the chemical effect of the air (which will contain oxygen and also humidity – and so would lead to 'weathering'). The implications of this have not been fully investigated. [121]

20 Fractures – Problems Getting Data

It is difficult to find out the frequency, spatial spread, and location of fractures in rock. [122] Experiments are underway to try and develop methods for measuring the properties of rock fractures – including their ability to allow water to flow through them. [123]

21. Fractures – Regional Flow

The regional flow through fractures 'cannot be known with certainty'. [124]

22. Time and 'Scenario' Problems

Even more difficult than regional flow are the difficulties of working out changes over time – or changes due to different predictions (scenarios) of what might happen in the future. [125]

Predicting future ice cover (which would have an impact on underlying flow system) is 'fraught with many uncertainties'.[126]

23. Clay and Chemistry

Salty and alkaline water can allow more water to flow through clay. [127] Possible chemical changes in clay – which may affect its ability to take up ('sorb') radio-nuclides – are not quantitatively understood. [128]

24. Fractures and Sorption

Owing to generally lower geochemical retention capacity in granites compared with clays, safety cases would need to rely more on materials used in the disposal facility. [129] The retention capacities of fractured rocks are lower and more difficult to predict quantitatively over the long term.[130]

25. Chemical Data – Wrong Conditions

Most of the fundamental chemical research of the series of chemicals that includes uranium and plutonium has been carried out under conditions that are 'far from those occurring in nature. [131]

26. Gaps in Chemical Data

121 Page 14 Col two – bottom of page & Page 15 – Col one – top of page
122 Page 15 – Col one – two thirds down
123 Page 15 – Col one – bottom third
124 Page 15 – Col one – bottom of page
125 Page 15 - Col two – top of page
126 Page 15 – Col two – half way down page
127 Page 15 – Col two – bottom of page
128 Page 16 – Col one – top of page
129 Page 16 – Col two – top of page
130 Page 17 – Col one – top of page
131 Page 17 – Col one – half way down page

There is a project underway identifying the gaps in chemical data. [132] Not only are there gaps in the knowledge base about the chemistry of uranium and plutonium, but there are also gaps in chemical data for common major elements. [133]

27. Problems with Equilibrium Temperature Correction

In a chemical reaction there is a measure of how far a reaction will go from turning the reacting chemicals at the start to the product chemicals at the finish. This quantity is 'Constant' under given conditions (such as temperature) – and is know as the 'equilibrium constant'. However the report notes that a major gap throughout the chemical databases is the 'temperature correction' for reactions that take place at different temperatures than the conditions under which the equilibrium data has been measured. [134] There is a gap in the chemical data for the temperatures between 25^{o}C and 150^{o}C (the expected temperatures). [135]

28. Problems with Data for 'Salty Water'

Another chemical consideration is the effect of 'salty water' which can have a considerable effect on how chemicals react together – this effect is difficult to predict. This is 'another well known gap' in the chemical dataset for disposal. [136]

29 Pu / U Series Data

More work is planned on the chemical dataset for the plutonium / uranium series of chemicals. [137]

30. Sorption Data – Known to be Wrong

The take up of radio-nuclides from water onto solid surfaces (known as 'sorption') has been studied for decades. [138] The 'batch' experimental technique has been used to measure this phenomenon – however it was soon realised that this technique generated data that was 'far from any realities in the field' [139] Furthermore – the usual method for evaluating the data – through producing just one value to represent all of the different results 'was recognised as not reflecting the field conditions – or having any predictive capability'. Despite these problems – the same methodology continues to be used. This is because the computers used to calculate disposal risks – are simply not capable of coping with data requirements that would be needed describe sorption more realistically. [140]

31. Studies in Natural Systems often not Possible

Uranium has been widely studied in natural systems – but many other radio-nuclides do not occur in nature – and therefore cannot be studied in this way. [141]

32. Lack of Data on Reaction Rates for Natural Systems

There is a severe lack of data on the rate of reactions for natural systems. (Natural systems in this context are mineral surfaces, groundwaters and underground chemicals such as 'colloids'. Microbes are also a consideration.) [142]

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132 Page 17 – Col one – bottom of page
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134 Page 17 – Col two – top third
135 Page 17 – Col two – half way down page
136 Page 17 – Col two – half way down page
137 Page 17 – Col two – bottom third
138 Page 17 – Col two – bottom of page
139 Page 18 – Col one – top of page
140 Page 18 – Col one – top of page
141 Page 18 – Col one – bottom third

33. Oxygen and 'Mobility'

Different forms of a given chemical element present in radioactive wastes can have very different tendencies to escape (ie 'mobilities'). The presence of oxygen and hydrogen is assumed to play an important role in this. [143] Although it is thought that there wouldn't be oxygen gas underground – in practice it is very difficult to carry out experiments (either in the lab or underground) without oxygen being present. [144]

A hole in the ground, created for the disposal facility, would have oxygen in it. This would be out of keeping with the chemistry of the surrounding rock and also would mean that the radio-nuclides would tend to be in their more mobile form. Risk calculations for disposal are based on the assumption that the radio-nuclides do not have access to oxygen. [145] However, for fractured rock in particular, there is concern the initial oxygen present in the excavation may mean that the radio-nuclides may remain in their 'mobile' form – (ie the chemical form that they adopt when oxygen is present). [146] This issue remains to be studied in depth. [147]

34. Very Very Big Chemicals (Colloids)

Radio-nuclides are able to attach to very very big chemicals (known as 'colloids') – and be carried away by the flowing water. These chemicals have proved to be difficult to study, both because their behaviour varies so much, [148] and also because the very process of sampling and analysing them changes their behaviour. [149] Due to the fact that work in this area has concentrated on uranium (due to difficulties found with working with other radio-nuclides) there are considerable knowledge gaps remaining. [150] A solution to these problems is not straight-forward, and much more experimental work is required. [151]

A particular reason why the attachment of radio-nuclides to big chemicals is of concern is that disposal risk calculations often assume that radio-nuclides will find themselves in a pore in the rock – and then stay there. However – as these 'colloids' are so big they may not fit into the pores. This would 'considerably speed up' the rate of colloid travel – and thus the rate of the radio-nuclide it was carrying with it. The quantity of radio-nuclides held by the 'colloids' is 'difficult to predict and is the subject of continuing studies'. [152]

35. Microbes

Research on the interaction between microbes, large chemicals, and radionuclides is not very well understood. [153] The potential importance of microbes has long been underrated**.** [154] The lack of attention is in spite of the fact that over the past twenty years microbes have been found at great depth. [155] Overall the role of microbes in proposed disposal systems is not fully understood. [156]

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142 Page 18 – Col two – top of page
143 Page 18 – Col two – top third
144 Page 18 – Col two – half way down
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147 Page 18 – Col two – bottom third
148 Page 18 – Col two – bottom of page + Page 19 – Col one bottom third
149 Page 19 – Col one – top third Page 19 – Col one – bottom third
150 Page 19 – Col one – half way down page
151 Page 19 – Col one – bottom third
152 Page 19 – Col two - half way down page
153 Page 19 – Col one – half way down page
154 Page 19 – Col two – bottom third
155 Page 20 – Col two – top third
156 Page 20 – Col one – half way down

36. Hydrogen Gas – Possible Opening Up of Fractures

A disposal facility could produce a considerable amount of hydrogen. [157] It is still not clear whether the pressure build up could open fractures – and so provide fast migration pathways. [158] The complexity of the system involved is not understood [159] and has been earmarked for further study. [160]

37. Disposal Facility and Disturbance to Natural System

A disposal facility would be a disturbance to the natural – mechanical / flow / heat / and chemical processes. [161] The mechanical, hydraulic, chemical and thermal processes would all be interacting in order to dissipate the various human-made disturbances.[162] This system of interaction 'deserves further investigation'. [163]

157 Page 20 – Col one - bottom third
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161 Page 20 – Col two – half way down
162 Page 20 – Col two – half way down
163 Page 21 – Col two – top of page

Annex D: Research may not solve the problems

The following is a compilation of the points made in the "*Environment Agency, Response to Nuclear Decommissioning Authority Consultation on – Radioactive Waste Management Directorate Proposed Research and Development Strategy*" (November 2008) http://www.environment-agency.gov.uk/static/documents/Research/1976__RWMD_Proposed_RD_strategy.pdf

(The headings and the emphasis are added – and were not in the original document.)

Not all Research Outcomes would be 'Acceptable' wrt Disposal

"*4.3 Setting pre-defined research objectives and clear criteria for evaluating the output of R&D are essential to gain public confidence. A successful strategy to communicate the significance of the research findings will be vital.* ***It is particularly important to counter any suspicion that research findings will be deemed 'acceptable' regardless of what the research actually identifies.***" (page 4 – para 4.3)

Testing is not the same as 'Confirming'

"*4.8 All references to underground R&D activities are stated to be to "confirm" aspects of site performance ("confirmatory tests"). No mention is made (in Figure 3.2 or elsewhere) of the role of URLs to enable trialling, testing or demonstrations of competing techniques.*" (page 5 para 4.8)

Confirmation Bias

"*4.9 The words "confirm" or "confirmatory" appear 15 times throughout the document. NDA should provide assurance that it can manage issues associated with "confirmation bias".* [1] (page 5 – para 4.9)

[Footnote 1].

"Confirmation bias results in a situation where, once a view has been formed, new evidence is generally made to fit. Strong initial impressions structure the way that subsequent information is interpreted."

Research may identify additional questions

"*Further* ***research has the potential to increase uncertainties****, e.g. by revealing unforeseen complexities or additional processes influencing the system under study. While a well defined and executed research programme can answer fundamental questions, uncertainty is a normal characteristic of science, and as such, additional questions (and uncertainties) are often raised. It is the management of these uncertainties, e.g. prioritising and deciding how to address them that is important.*" (page 6)

Research / System Development - Relationship not easy to trace

"*Much R&D has been commissioned over the last 20 years but its impact on the evolution of NDA's facility design is not easy to discern … The claimed link between R&D and the development of the DSS [Disposal System Specification] and facility design needs further substantiation. Similarly for the feedback between the generic safety assessments and R&D."* (pp 6 – 7 Re: Section 3.1.1)

Annex E: a summary of key points to emerge from a review of the Posiva Safety Case on behalf of the Finnish Radiation and Nuclear Safety Authority (STUK).

The most recent disposal safety case published by Posiva - the Finnish disposal agency is:

POSIVA 2006-05
"*Expected Evolution of a Spent Nuclear Fuel Repository at Olkiluoto*" Posiva Oy - December 2006 (Revised October 2007)

In April 2008, a review of this was produced for 'STUK', the Finnish regulatory agency:

"*Review of Posiva 2006-05: Expected Evolution of a Spent Nuclear Fuel Repository at Olkiloto*" Michael Apted et al (April 2008)

Key points from this review include:

Relevance of Data to Safety – Not Clear

> safety importance of processes and data needs to be set out (p1) and the definitions of the safety functions of the different parts is vague (p7). The report does not set out clearly which outcomes would lead to unacceptable safety hazards. (p8)
>
> "*analyses of the safety importance for many of the evolutionary processes and associated data are absent*" (p9)
>
> "*it remains unclear whether Posiva really understands and can prioritise the safety-importance implications of acknowledged uncertainties in the normal evolution processes.*" (p5) (see also p10)

Posiva have not Demonstrated 'Safe Disposal'

> although the Posiva proposal is expected to lead to safe disposal – "*this remains to be demonstrated by Posiva*" (p10)
>
> "*A main concern with the report is that it represents a mostly qualitative analysis*" (p9)
>
> "*there does not seem to be coordinated efforts to explore if there are as-yet unrecognised processes*" (p5)

Low level of Confidence in Flow Data

> "*in the case of flow and salinity modelling, the uncertainties are so substantial that the level of confidence in the results seems low*" (p5)
>
> (NB – given the role of flow in the carriage of radionuclides back to the surface this lack of confidence seems particularly significant)

Basis of Some Data Inadequate

> some of the data used is out of date (p2) and some underlying reports have not been published (p7) – in addition the justification of some conclusions is not cited "*so the conclusions are no more than working hypotheses*" (p7)

Assigning Values

STUK referred to the "*seeming arbitrariness*" (p8) of assigning values to missing information

(NB – this should be compared to the Nirex (Nov '05) Viability report – in which parameters were chosen in order that the EA target would be met.)

Uranium

SKB have reported on the extreme safety importance of assigning a low value to the rate that Uranium Dioxide dissolves – however Posiva have only considered the chemistry of this reaction in a qualitative manner (p2) (see also p9)

(NB. Page 48 of the Posiva Environmental Impact Assessment – for the Expansion of the Repository for Spent Nuclear Fuel 2008 - states that uranium dissolves very slowly in water in the conditions that would be expected. This should be compared to the variability of measured Uranium concentrations of 100 million)

Buffer Erosion

the extreme safety implications of buffer erosion (during the glacial phase) should not be understated (p2) furthermore Posiva do not consider buffer erosion at all in the geochemical part of the report (p9)

Excavation Damage Zone (EDZ)

"*the issue of the EDZ* (excavated damage zone) *appears to be underplayed*" (p5)

(NB – the EDZ issue was particularly significant in the 1990s Inquiry)

Alkaline Water

"*The issue of hyperalkaline waters and their geochemical interaction with bentonite and rock remains open*" (p6)

(NB – this is a particularly important issue for the UK – as the Government plan that HLW should be 'co-disposed' with ILW. As ILW disposal is planned to be largely cement based & cement is expected to give rise to a significantly alkaline environment – then it can be seen the implications for HLW disposal must be considered. The significance of this issue is also outlined in the Oct '09 EU JRC report.)

Further points to be considered:

- system developments over time that do not meet 'normal evolution' (p1) (see also p10)
- design and emplacement malfunctions (p1)
- full implications of changes in the 'temperature / water system / mechanical / chemical' conditions (p1) – this area of work should be "*substantially improved*" (p7)
- most recent information on the glacial phase (which is presently inadequately considered) (p2) In fact Posiva do not consider the evolution of subsequent glacial reports anywhere in the report. (p9)

- Posiva need to consider the issue of natural resource exploration and exploitation. (p9)

- in numerous places Posiva refer to the fact that decisions on materials and design parameters are not yet fixed. (p8)

- "*possible interactions between bentonite and iron or copper are not addressed*" (p6)

Scientific Method

NB – in analysing the Posiva safety case – STUK's conclusions do not follow 'scientific method'.

Thus, STUK conclude:

> "*By evaluating the safety consequences of such 'unexpected' conditions, some of these may be recognized as inconsequential and others may require further study in order to confidently establish that the overall safety requirements are met*" (p3)

It is well recognized by the Environment Agency (in the UK) that 'further study' into areas of uncertainty may not result in the 'confident establishment' that a safety case may be met.

In fact it may result in the opposite conclusion – i.e. that a safety case may not be met.