Industry and Stakeholder Perspectives on the Social and Ethical Aspects of Radioactive Waste Management Options

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Abstract: *The long-term management of radioactive wastes raises significant ethical issues to potential host communities, future generations and the environment. Following successive failures to site a long-term radioactive waste management facility in the UK, in 2001 the Government set up the Managing Radioactive Waste Safely programme and in 2003 the Committee on Radioactive Waste Management (CoRWM), charged with the assessment of potential radioactive waste management options. CoRWM's option assessment process integrated technical and scientific analysis of risks with social and ethical concerns, and public and stakeholder values. This paper documents the trialing of a Q-method approach to the study of social, ethical and governance issues in the choice of long-term radioactive waste management options. The analysis draws out seven distinct 'discourses' each focusing upon different concerns ranging from citizen-centred decision-making, non-anthropocentric and multinational governance, technocratic and utilitarian policy, anti-nuclear opposition, risk governance concerns, final geological disposal and long-term stewardship of facilities and nuclear materials. Though diverse in nature, discursive consensus emerges on the value of citizen-led input in the decision-making process, the necessary consideration of a broad range of ethical positions from a range of public actors, and the rejection of utilitarian and technocratic decision-making, whilst they remain divided on which actors to trust in communicating and governing scientific and risk information, and upon the value of multinational cooperation in waste transportation and governance. This study discusses the implications of these divergent discourses for future radioactive waste management activities and comments on the use of Q-method in drawing out multiple stakeholders' values in environmental policy processes.*

Keywords: *Q-methodology, radioactive waste management, environmental values, public participation*

1. Introduction

The management of long-lived radioactive wastes is an important and oftentimes politically controversial practice, described by the former UK radioactive waste management organization (RWMO) Nirex as "…like other difficult issue of our time – such as genetically modified foods or embryo research – [it] raises as many social and ethical problems as scientific and technical ones" (Nirex 2005). Radioactive waste management (hereafter RWM) has been an intractable national policy problem in the UK, due in part to significant political controversy resulting from successive rounds of failed siting processes for

long-term RWM facilities in England and Scotland (Blowers and Pepper 1988; Openshaw, Carver et al. 1989; Blowers, Lowry et al. 1991; Kemp 1992; Grove-White 2000; Atherton and Poole 2001; Simmons, Bickerstaff et al. 2007; Blowers and Sundqvist 2010). In response to the last failed attempt by Nirex to site a Rock Characterisation Facility(a laboratory to test the suitability of host rock for geological disposal) in an area close to the Sellafield nuclear site in West Cumbria in 1997, the former Labour Government set up the "Managing Radioactive Waste Safely" (MRWS) programme (DEFRA 2001); an initiative intended to establish a legitimate long-term solution to the problem of RWM that integrates scientific, technical, legal, social and ethical aspects of the problem into the decision-making process.

Integral to the MRWS programme was the appointment of the Committee on Radioactive Waste Management (CoRWM) in 2003. CoRWM was an independent body charged with assessing radioactive waste management options and making recommendations to the UK Government (CoRWM 2005). In doing so, they began with a 'blank sheet of paper', examining a range of potential solutions, including amongst others: managed surface storage, disposal in a deep geological facility, disposal at sea or in the subsea bed or subduction zones, disposal in space, ice sheets or in a multi-national repository (Nirex 2003; CoRWM 2006).

CoRWM's option assessment process was a departure from previous RWM policy proposals in that it moved away from a principal reliance on technical and scientific criteria, towards the consideration of socio-technical issues (see for example Flüeler and Scholz 2004; Chilvers 2007) such as ethics, decision-making structures, policy processes and long-term societal stability. Within this socio-technical reframing of the problem, CoRWM provided extensive opportunities for non-technical and non-industry actors to have input into their options assessment process through successive rounds of public and stakeholder engagement (PSE). Thus, their deliberation combined consideration of the scientific evidence with a process of engaging with, and involving, stakeholders and members of the public on their values and opinions towards different options throughout.

CoRWM's eventual recommendations to the UK Government were founded upon a decision-making process that integrated scientific knowledge both within the UK and from other nuclear producing countries, with the results of successive rounds of PSE, legal considerations (options such as burial in ice sheets or dumping solid wastes at sea were ruled out through international law) and ethical considerations such as protecting the interests of future generations and the environment (Blowers 2006; Collier 2006; Cotton 2009). Though CoRWM's option assessment process has since finished and the UK Government have accepted their recommended strategy of long-term surface storage followed by the construction of a deep geological facility (GDF), an actual disposal solution has yet to be implemented and so there remains an on-going political negotiation. This negotiation process has moved from the arena of national environmental policy to focus more specifically upon the relationship between potential GDF host communities and the implementing body: the Nuclear Decommissioning Authority's Radioactive Waste Management Directorate (NDA RWMD) which was formed from a transfer of Nirex funding, expertise and personnel to the NDA.

Under the proposed decision-making framework, potential host communities for a GDF communities can volunteer an Expression of Interest (EoI) through a partnership organisation (such as a local council), which then prompts an initial scoping exercise to assess the geological suitability of surrounding areas for a GDF (DEFRA, BERR et al. 2008; BGS 2010). If the host community is satisfied to continue with the process following the relevant screening exercises, then the partnership organisation can put forward a Decision to Participate (DtP) and start a process of siting a facility. This approach is fundamentally based upon a principle of volunteerism and requires significant engagement with potentially affected host communities and stakeholder organisations run by the partnership organisation in concert with the NDA RWMD, and overseen by (the newly reconstituted) CoRWM. This process is designed to ensure a transparent and socially robust decision-making process. The findings on the social and ethical issues surrounding radioactive waste management options assessment remain important for this new phase, however, as the scientific consensus on the suitability of a geological disposal option continues to be questioned on safety grounds both

by scientists and host community participants (see Cotton 2009; Blowers and Sundqvist 2010; Wallace 2010; West Cumbria MRWS 2010; West Cumbria MRWS 2011) even after the completion of the options assessment phase of MRWS.

The reframing of RWM as a socio-technical problem, and the turn towards integrated PSE throughout the decision-making processes for options assessment and siting has necessitated the use of a range of different research methods and engagement techniques to assess community reactions to proposals, not only towards the technologies being implemented, but also governance arrangements, risk management processes, and other issues such as community benefits packages, local employment opportunities and infrastructure development, and the protection of the environment and future generations from potential harm. This paper documents the trialing of a Q-methodological approach to assess stakeholder responses to a range of social, ethical and governance issues related to choice of RWM options; which although not formally integrated into CoRWM's options assessment process, provides an independent evaluation of a number of socio-political and ethical aspects of RWM options and illustrates differing stakeholder and industry perspectives on them. Some final closing comments on the use of Q-method in the evaluation of pluralistic values in environmental policy contexts are also discussed.

2. Background to Q-Methodology

Q-Methodology (hereafter referred to as 'Q-method') first identified by the physicist-turned-psychologist William Stephenson (1953), presents a means of evaluating subjective 'discourses' that emerge from (in this instance) stakeholder responses to the social and ethical issues in RWM. The aim of Q-method is to render subjective opinions open to analysis, and identifying a number of 'idealised accounts' or 'discourses' (Brown 1996) emerging from the rank-ordering of a sample of preselected statements. In Q-method, the term 'discourse' is used to mean a way of seeing and talking about an issue. Discourses are individual and subjective, they relate to how an individual in particular circumstances and at a particular time, relates to and forms conceptions of certain aspects of the world (Addams and Proops 2000). Discourses emerge from the rank ordering of a set of statements, to create a Q-sort. The statements that are rank ordered are sampled from a larger group called the 'communication concourse' which is collected by the researcher and designed to be broadly representative of the debates surrounding the topic under consideration. The communication concourse is designed to encapsulate the flow of 'communicability' that surrounds the topic (from the Latin "concursus," meaning "a running together," as when ideas run together in thought). This concourse is drawn from subjective and personal opinions regarding such issues as broad as the morality of nuclear power production, the costs to society of geological disposal or the risks of sending radwaste into space. These statements are not empirical facts; they are reflective of subjective reasoning around the topic area itself and are not to be taken as literal truth without interpretation and understanding.

Following the rank ordering process, the data are subjected to statistical analysis and subsequent qualitative interpretation of the outputs. Q-method is often associated with quantitative analysis due to its use of factor analytic techniques, however, as Dennis and Goldberg (1996) suggest, "[Q-method] combines the strengths of both qualitative and quantitative research traditions". Though statistical operations are used, the analysis is not purely quantitative as these operations serve to draw out 'discourses' for further qualitative and theoretically grounded interpretation. Such 'discourses' or 'accounts' are reinterpretations of composite Q-sorts emerging from the statistical analysis. It must be noted that Q-method does not yield statistically generalisable results in the same way as a social survey (sometimes referred to as R-method) where results are applicable to a broader population of individuals; rather, it uses an inverted form of factor analysis, where the respondents themselves act like variables. In essence it is the respondents that are clustered together through factor analysis, not the statements that are rank-ordered. Thus, for Q-methodology it is important that the set of statements presented for sorting is representative for the subject of study as the results can only be generalised to the subject of study, not to the wider population. In short, the sorting process is a *Gestalt* procedure, providing an in-depth portrait of the typologies of perspectives that prevail in a given situation (Steelman and Maguire 1999) in contrast to a statistical model with predictive or explanatory powers over a population,

based upon predefined demographic characteristics (see Brown 1980; Thomas and Baas 1992), so Q-method shows how a segment of an audience thinks as a generalisation rather than deriving results which can be extrapolated to an aggregate population.

Though Q-method is a 'relatively little known form of research methodology' (Barry and Proops 1999) outside of the psychological and political sciences, it has grown in popularity as a tool to research issues in environmental planning and technology policy in recent years (significant recent examples include: Bell, Gray et al. 2005; Ellis, Barry et al. 2007; Fisher and Brown 2009; Venables, Pidgeon et al. 2009; Wolsink 2010; Cotton and Devine-Wright 2011). Its value in this context lies in its capacity to provide an inductive, yet systematic methodology to define public and stakeholder viewpoints, values, and positions within controversial public debates, identify important criteria, explicitly outline areas of consensus and conflict and thus help to develop a common view toward policy-making (Steelman and Maguire 1999).

3. Q-Method in Practice

In practice Q-method research begins through a process of 'defining the domain of subjectivity' - by generating a pool of statements that represent a breadth of subjective perspectives, ideas and values to form the communication concourse. A sampled microcosm of the broader concourse is then administered as a 'Q-sort' to participants in the study. The concourse in this case represents broad perspectives on the social, ethical and governaance issues inherent to RWM options. In this study, the concourse was 'ready-made' (see McKeown and Thomas 1989), in that it used examples from a range of written and verbal statements intended to provide a breadth of personal and institutional perspectives based primarily upon secondary sources. This includes primary data from interview and focus group sources taken from previous social scientific studies and stakeholder workshops run by Nirex and CoRWM, excerpts from newspaper articles, the academic literature on radioactive waste management, press releases, political speeches, technical and scientific literature, NGO publications, statements by religious organisations, online environmental philosophy discussion groups and political party manifestos. This broader concourse is then sampled to produce a smaller Q-sample which is then administered to participants for a process of sorting.

Following Stainton Rogers (1995), the administered microcosm of the concourse (the Q-sample) was selected based upon a combination of structured theoretical sampling and an inductive approach, to ensure a balance of appropriateness and applicability to the issue, intelligibility, simplicity and comprehensiveness. Such an approach involves the selection of statements based upon their pertinence to the case under consideration, whilst paying attention to the overall positive–negative balance of statements within the sample (Steelman and Maguire 1999). Statements were selected in a manner similar to that of stratified sampling used in survey research. The primary aim was to ensure that a comprehensive and representative selection of statements was presented for sorting. Statements were selected to conform to specific categories of relevant social and ethical debate identified within both the academic and policy literatures on RWM (primarily Butler 1979; KASAM 1988; Shrader-Frechette 1991; Shrader-Frechette 1993; Roots 1994; Nuclear Energy Agency 1995; Brook 1997; Hadjilambrinos 1999; Rawles 2000; Shrader-Frechette 2000; Shrader-Frechette 2000; Wilson 2000; Nilsson 2001; Oughton 2001; Damveld 2002; Rawles 2002; Timmerman 2003; Damveld 2004; Grimstone 2004; Rawles 2004; Marshall 2005). A thematic assessment of the statement pool revealed a number of theoretical categories. These are given below, along with an example statement for each. The full list of statements is presented in Appendix 1.

Deontological and rights-based ethical positions or values, whereby moral principles are expressed in terms of responsibilities, rights or duties, e.g.:

- Statement 14: There must be adequate opportunities for those outside the institutions involved, especially those with a particular interest in the given decision, to contribute fully to the decision making procedure.

Consequentialist ethical positions, expressing issues related to wellbeing, or aggregated benefits and hence "the greatest good to the greatest number" e.g.:

- Statement 3: It is legitimate to expect or to ask a local community to bear the costs of a radioactive waste facility site on behalf of society.

Egalitarian and justice-as-fairness ethical positions e.g.:

- Statement 27: There is a disparity between those who reap the benefits of nuclear power and those who take the burden of the waste.

Intergenerational issues – those that refer to the relationships between current and future generations, or to management time frames such as final disposal, retrievable and/or monitored storage, e.g.:

- Statement 4: The future stability of society is not such an important issue, future generations will be capable of dealing with any outcomes from long term radioactive waste management.

Intra-generational environmental justice issues (between existing communities or geographical locations, relationships with other countries, either national, multinational or transnational management strategies), e.g.:

- Statement 26: Sub-seabed disposal, where waste is placed in a pre-dug hole or buried in the soft seabed, may be the best option because then is not directly in any one's 'back yard'.

Relationships between humans and the environment, expressing contrasting anthropocentric and nonanthropocentric perspectives, e.g.:

- Statement 7: For the human race to survive at all requires a radical transformation in our relationship to the interdependent web of life on Earth, putting the health of ecosystems and environmental concerns above generating wealth.

Referring to issues of risk, governance, trust and acceptability: particularly in relation to decision-making legitimacy, honesty, public acceptance, political accountability and so-called Not-In-My-Back-Yard (NIMBY), e.g.:

- Statement 28: The question of what should be done with radioactive waste should be a purely scientific and technological one, public opinion is too subjective.

4. Participant Sampling

Selection of participants (the P-sample) to complete Q-sorts does not share the same characteristics as constructing a survey sample. Participant selection is more akin to the purposeful or strategic sampling characteristic of qualitative research, rather than the selection of participant categories defined by specific characteristics in the manner of a survey. This strategic sampling ensures that all groups who *ex ante* are expected to hold different opinions on the subject of study are represented in the sample (Stenner and Marshall 1996). Participant selection is largely pragmatic; the aim is that they should represent a diverse range of perspectives. As a consequence of 'finite diversity', the number of participants does not have to be large (Addams and Proops 2000). Relatively few participants and Q sorts are needed to give statistical significance, as Barry and Proops (1999) suggest: "as few as 12 participants can generate statistically meaningful results, in terms of the range of implicit discourses uncovered". The key to choosing the right participants for Q-sorting is based upon 'representativeness', but this is not random. Breadth and diversity are more important than proportionality (Brown 1980). Participants were sampled across a range of professional backgrounds, with 12 participants representing 'citizen-stakeholder' viewpoints and 12 drawn from the Nirex radioactive waste management organization, with varied professional backgrounds within it. The breakdown of participant age, sex and occupation is shown in Appendix 2.

5. Q-Sorting

The procedure of Q-sorting involves rank ordering of the microcosm of statements according to a condition of instruction (McKeown and Thomas 1989). Participants were given the 40-statement set and instructed to read and sort them into a quasi-normal distribution, represented by an upside-down bell-curve, from 'most strongly disagree' to 'most strongly agree' along a scale from -4 to +4, where 0 is neutral, with a fixed number of statements in each column along the scale shown in Table 1**.** The sorting is a holistic process in which all elements are interdependently involved (Addams and Proops 2000), in the sense that participants must structure the statements into the specific rank ordered pattern presented. Participants can alter and refit the placement of the statements onto the grid at any stage,

until they feel happy with the distribution that best fits their own personal subjective viewpoints. The act of sorting reveals the individual respondents' personal subjectivity and the structure of the forced quasi-normal distribution allows the comparison of many Q-sorts that are then available for correlation and factor analysis.

***Table 1** – Valence of sorted Q-statements*

	Disagree			Neutral			Agree		
Valence	-4	-3	-2	-1	0	+1	+2	+3	+4
No. cells in column	2	3	5	6	8	6	5	3	2

6. Analysis

Q-method analysis involves the sequential application of three sets of statistical procedures; correlation, factor analysis and then computation of factor scores. PQMethod version 2.11 was used for data input and analysis. Firstly each Q-sort is entered into the computer program which inter-correlates all of the Q-sorts. An inter-correlation matrix is then inverse-factor analysed and the resultant factor solution is rotated (orthogonal rotation) and scores for each factor are produced so that they can be re-expressed as idealised patterns of the Q-sorts that represent them (Addams and Proops 2000). In Q-method, the statistical procedures serve to prepare the data in order to reveal their structure (Brown 1993) i.e. statistical analysis requires qualitative interpretation of the resultant outputs. The analysis of the factors as discourses involves interpretation of a factor to provide a 'label' or 'handle' which is intended to "pinpoint a particularly salient characteristic of the factor type" (Brown 1996). This produces a narrative for each which represents and summarises the views, attitudes and perspectives that the factor represents, and involves a summary of the major points revealed through the statements associated with each factor in order to produce a 'bird's eye picture' of the different accounts produced by Q-sorting (Stainton-Rogers, Hevey et al. 1989).

7. Findings

Seven factors (labeled A-G) were retained, where each factor is statistically significant with an Eigenvalue >1 and has two or more Q-sorts loading on it alone (Watts and Stenner 2005). Clearly Factor A is the 'strongest' in terms of explanation of the total variance, though the remainder are distributed more evenly (11.2%-4.3% for factors B-G). See Table 2:

***Table 2:** Factor selection*

Factor	Eigenvalue	As Percentages	Cumulative Percentages
A	8.3153	34.6770%	34.6770%
B	2.6723	11.1347%	45.7817%
C	2.3263	9.6929%	55.4746%
D	1.5558	6.4825%	61.9571%
E	1.2274	5.1140%	67.0711%
F	1.1511	4.7964%	71.8675%
G	1.0339	4.3080%	76.1756%
H*	0.8590	3.5790%	79.7546%

**Non-significant and thus excluded*

Each of the first seven factors is orthogonally rotated, in this instance using Principle Component Analysis and Varimax rotation for subsequent interpretation as accounts or discourses, though it must be noted that Centroid analysis and "by hand", theoretical rotation are oft-cited alternative analyses preferred by some Q-methodologists (see for example Brown 1996). The accounts produced are not objective statements drawn directly from the data but are in themselves selective interpretations based upon the factor scores. In the following section, the factors are labelled A-G and then explained in first person perspective to illustrate their interpretation as discourses or accounts.

8. Factor Interpretation

8.1 Factor A - The 'citizen involvement' account

In modern UK society the key priority is to allow all citizens to contribute to the debate over finding a long-term RWM solution. One must trust the public to take responsibility and participate in the decision-making process, as their input is equally as valid as the decision-making wisdom of scientific experts, policy makers and politicians. The UK must dispose of waste within its own national borders, as the legacy of waste is the sole responsibility of the UK government and its citizens. Reliance upon other countries is ethically unacceptable; this precludes

the transportation of wastes across national borders. Similarly, sending waste into space and potentially harming societies across the world through technical malfunction is also ethically unacceptable. The central ethical issues involved in RWM management are those that affect human beings, human life and well-being over long periods of time - affecting generations in the future. Citizens of the future may not enjoy the comparative social and political stability characteristic of modern UK society and this should be an area of consideration in long-term RWM planning and implementation. RWM governance should therefore involve the long term maintenance of independent organisations, responsible for differing technical and societal aspects of the ongoing management process.

8.2 Factor B - The 'holistic' multinational account

At the centre of RWM is an underlying pattern of division and alienation of humankind from nature. Humankind's relationship with the broader ecology that supports social life is of primary importance. RWM solutions that involve emplacement of wastes in a manner that could cause harm to the biosphere, away from human monitoring such as in (or below) the seabed are thus morally unacceptable. Waste should be continually monitored for safety and accountability. It is also unacceptable for Government to 'impose' waste strategies upon the country without extensive consultation and engagement, as scientists cannot always be trusted to find the best solution and it is unfair to marginalise and expose comparatively small host communities to elevated risks in exchange for lowered overall risk to the general populace. In this way it is important to try and find multinational approaches to waste disposal involving consultation and debate across national boundaries. This can also involve transporting waste to the countries which have the best technical means for disposing, monitoring and retrieving stored waste.

8.3 Factor C – The 'technocratic' account

Despite a political drive towards public and stakeholder engagement in decision-making, the most practical and ethically acceptable solution still involves centralised governmental decision-making for the benefit of the UK. Scientific and technical criteria are paramount in choosing the best solution; the public will express trust in the Government and RWMOs if they have access to technical information and are encouraged to participate. If the issues are not raised then the public will be reluctant to participate. Thus the public are best served by final disposal, rather than indefinite monitoring, in order to prevent continued political controversy and conflict delaying a solution from being implemented. Transnational exportation may be desirable as multinational cooperation in disposal could prove a practical and efficient solution. Also in a situation where risks from human generated climate change dominate environmental debates in the scientific community, the pressure to reduce carbon emissions will make 'new build' of nuclear power a necessity, alongside the benefit of securing continued electricity production. In either eventuality, the Government is capable of finding an eventual solution to radioactive waste and by working with scientists and experts, one that is both scientifically and ethically acceptable will be found soon.

8.4 Factor D – The 'anti-nuclear' account

The process of nuclear power production and waste management lies in the hands of a potentially dangerous industry that remains secretive in its dealings with other countries and the prospects of building new nuclear facilities. The situation is exacerbated by importing radioactive wastes into the UK. The industry cannot be trusted to implement a solution without rigorous evaluation and third party oversight because the risks of cutting costs at the expense of safety are too great; indeed if these costs had been accounted for in the first place, nuclear power would not have succeeded in the UK. Experts cannot always be trusted therefore to tell the truth about the state of the nuclear industry and the safety of specific RWM options. The public should play the key role deciding which management option (or options) is/are best for UK society. Consistent two-way communication between the nuclear industry and the public is important not just to allay public fears, but to promote genuine understanding about the status and safety of radioactive waste management decision-making.

8.5 Factor E – The 'risk governance' account

At the centre of this issue is the problem of risk, from two primary sources. Firstly from mistakes, half measures and cost cutting from the nuclear industry and secondly from new threats emerging in the international political arena. With the increasing threat of international terrorism, radioactive waste

facilities must be guarded against theft of materials and the potential development of radiological weapons. Therefore, allowing waste to cross national borders should be avoided. Communication between different countries on how best to deal with radioactive waste globally should be a priority dealing with the risk implications across national borders. By monitoring waste, safety and communication will help to prevent radiological risks from damaging UK society. Monitoring and retrievability of wastes is important because of continuing growth and technological change that may eventually result in improved management techniques. This involves encouraging openness within the nuclear industry alongside two-way information sharing and public engagement with contrasting sources of information and expertise, particularly within academia.

8.6 Factor F – The 'final disposal' account

The key factors to consider are that final disposal must occur within the country of origin and that deep geological disposal provides the best means to reduce risk to humans. Deep geological disposal protects against future societal instability and the risks of terrorism, ecological catastrophe or global conflict, all of which may prevent effective long term monitoring and retrievability of wastes. Thus multinational disposal may be undesirable due to the continuing changes in international relations between waste producing countries. The disposal of waste should not be separated from the issue of waste generation, however nuclear power may be necessary to provide secured electricity generation, therefore the nuclear industry must play an active role in both ensuring safe 'new build' of nuclear power stations and also in finally dealing with the legacy of UK radioactive wastes.

8.7 Factor G – The 'stewardship' account

One cannot presume that non-human life is of equal ethical value to human life. Human beings however remain responsible for ensuring the future safety of the environment for future generations. The role of the UK in relation to international RWM is complex and multifaceted and hence confusing; there are both benefits and risks associated with involving other countries so decisions about transnational management of waste must be carefully examined through public consultation and diplomatic relations. Disposal in space is ethically undesirable due to the potential catastrophic risks involved.

9. Assessing Participant Perspectives

When assessing these emergent discourses it is necessary to make comparisons between the idealised accounts and the `real', individualised Q-sorts of the participants by analysing the correlation between individual Q-sorts and the seven factors. This is done in order to assess `who is loading where'. Table 4 presents a simplified version, showing where individual sorters load on each of the actors. Highlighted Q-sorts (*) are those that define the factor descriptions presented above.

It is perhaps unsurprising that account A the citizen involvement account was most clearly defined by Nirex participants (n=7). Since the 1997 failure to site a RCF and the reformation of the Nirex organisation through the MRWS policy process the organisation underwent a significant shift in professional ethos, moving away from science-centred decision-making towards an attitude of openness, transparency, a focus on social and ethical issues, and the involvement of multiple stakeholder actors in both their day-to-day operations and in long term waste strategy (Atherton and Poole 2001). It is therefore unsurprising that the Nirex group both embraced the citizen-focused perspective and rejected the technocratic and multinational, non-anthropocentric accounts, whilst also highlighting issues of final disposal (n=2) and long term stewardship of wastes (n=2). These reactions are unsurprising because they are reflective of the organisational 'mission' as it has been redefined through this politically controversial policy process. What was perhaps more surprising, however, was the non-Nirex group, as the 'public' actors displayed a much broader range of responses, in particular focussing upon multi-national and non-anthropocentric solutions (n=4), alongside a mix of citizen centred (n=2), technocractic (n=2), anti-nuclear (n=2) and risk governance-focussed (n=2) accounts. Clearly it becomes difficult in light of this finding to simply categorise what a homogeneous 'publicly' acceptable solution might be, given the significant range of responses from within this group of participants. Though the findings are not generalizable to the UK population due to the small, non-random sample, it is interesting to note the sheer range of responses, illustrating the evident value pluralism (O'Neill, Holland et al. 2007) inherent to stakeholder responses to long-term RWM.

10. Comparing and Contrasting across Factors

Examining the factor scores allows an opportunity to discriminate between factors and to better contextualise each in relation to the other. Appendix 1 and 2 detail the list of statements in the Q-sort and the loadings on each factor. Comparison involves examining statements which reveal *consensus* and those that are *polarising,* i.e. those statements that differentiate one or more factors from the rest. Please note that the number label of the relevant statement from Appendix 1 appears in brackets (ie. s1).

11. Consensual Statements

When examining the loadings across the seven identified factors a number of distinct areas of consensus emerge. Firstly, consensual agreement emerges on three crucial aspects of radioactive waste governance, namely there is agreement that it is ethically unacceptable to expect or require potential host communities for radioactive waste management facilities to bear the costs, risks and other burdens in the interests of broader society (s3); that the imposition of ethical judgements upon host communities in absence of deliberative engagement is wrong (s5), though G – the stewardship account is the exception in this case; and that the assessment of experts should not be prioritised over that of 'public' actors (s34), except for C which was effectively neutral. These three statements are broadly constitutive of a rejection of both utilitarian and technocratic decision-making perspectives. Thus RWM policy based solely upon defining the greatest good to the greatest number that should override the burdens borne by the few (in this case a host community) and that the ethical dimensions of decisions should take place through expert assessment and without citizen input, are rejected.

The consensus is suggestive of support for measures to ensure a central role for citizen-stakeholder representatives in the design and governance of radioactive waste management processes and the incorporation of localised decision-making control. This egalitarian and citizen-led mode of radioactive waste governance is representative of a 'deliberative turn' in environmental policy (Dryzek 2000; Parkins and Mitchell 2005) whereby actors see the legitimacy of decision-making processes over environmental management as being reflected in opportunities for them to participate and engage directly with policy formulation, as opposed to through representative forms of democratic control (via elected bodies such as ministers or councillors) or technocratic forms such as through reliance on expert committees. In practice, deliberative-democratic forms of RWM governance have been implemented in recent years. In the UK MRWS programme, the implementation phase of finding a suitable site for a GDF is divided into the two aforementioned decision-making points based upon a principle of *volunteerism*, in line with CoRWM's recommendations to Government on implementing a long-term RWM strategy based upon an Expression of Interest followed by a Decision to Participate (CoRWM 2007; West Cumbria MRWS 2010; West Cumbria MRWS 2011). The emergence of consensus across all factors rejecting the utilitarian and technocratic perspectives (and thus implicitly supporting the volunteerist and egalitarian alternatives) provides a degree of support for the legitimacy of this approach from both industry and public representatives.

There was also evidence of what could be terms a broad 'anti-sceptical' position across all accounts, as there was an emergent consensus (most strongly presented by the technocratic account of Factor C) that the Government will likely be able to deal with the waste problem, either now or in the future (s19). This finding contrasts with previous research on public acceptance and trust, in particular the pan-European survey studies of citizen attitudes towards radioactive waste that show that, in the UK, only 8% of surveyed participants trust government authorities to deal with the radioactive waste problem; notably the lowest proportion across the 27 surveyed European countries (Eurobarometer 2008). Though confidence is expressed in an eventual solution, the issue of trust in scientific organisations and the Government remains paramount (s18), supported by accounts A,C and E. Mechanisms to ameliorate distrust, through open and transparent public dialogue are therefore important in reaching an eventual solution, particularly when evidence of broader public mistrust in RWMOs appears to remain high.

Other areas of consensus concerned specific forms of technology options. In particular, disposal in the sub-sea bed (s26), trans-national exportation of waste (except A&F essentially neutral), and disposal

in space (s37) were not favoured. This is interesting in that these options present potential means to alleviate the so-called Not In My Back Yard issue from a UK perspective. These options potentially remove waste from UK jurisdiction, so UK citizens could be said to benefit from potentially reduced *personal* risks. The NIMBY problem has often been used by radioactive waste management organisations and other planners of locally unwanted land uses, as a means to characterise political opposition to RWM facilities as being based upon selfish place-based protectionism, due to misunderstanding and perceived injustice over excessive risk burdens concentrated in specific geographical areas (Portney 1991; Kemp 1992; Lidskog 1992; Welsh 1993; Rabe 1994; Hunter and Leyden 1995). It is interesting to note that the consensus on these three options reveals new information about the public acceptability of the associated risks and a possible rejection of this NIMBY label.

Firstly, their rejection may be due to the fact that associated risks are deemed too 'high impact' to gain public support. Sub-seabed and space disposal options do not provide opportunities for long-term monitoring, and their potential to damage the environment through rapidly leaking radionuclides into the ocean or explosions in the upper atmosphere may be less tolerable than potential radionuclide migration over long periods of time from a geological repository. Similarly, trans-national waste transportation from waste producing countries abroad carries risks of nuclear material theft and land and sea based accidents, not to mention significant inequities between the beneficiaries of nuclear power production and those burdened by waste (particularly if the receiving country is a nation where environmental performance and safety standards may be lower than the UK). Not only are the risks of these options likely deemed too high impact and hence publicly unacceptable, but secondly, their rejection displays a lack of the self-interested 'turf' protectionism of the NIMBY label, suggesting as Burningham (2000), Van der Horst (2007), Cotton (2011), Devine-Wright (2005) and McClymont and O'Hare (2008) have done, that the NIMBY label either fails to resonate with potentially affected public actors, or else is a pejorative terms used principally by technocratic planners to circumvent the political authority of potentially affected host communities. Instead, the consensus on these options presents an environmentally and ethically conscious decision by both industry and stakeholder actors to deal with the waste problem nationally, through UK institutions and on home soil. Thus, there is support for solutions that are national in scope, are 'stepwise' i.e. that provide longer term monitoring and control of RWM risks and facilities through sequential stages of decision-making (as opposed to risky, high impact final solutions) irrespective of their proximity to potentially affected host communities.

12. Distinguishing Statements

One of the most divisive issues between the respective accounts is that of trust in different actor groups in the RWM process. Though there is consensual trust in the Government to eventually reach a publicly acceptable solution to RWM, there is a clear divide between different accounts with regard to trust in specific social actors. In a particular a division emerges between those that favour technocratic governance of RWM (account C) and those that profess an anti-nuclear position (account D) with regard to trust in scientific authorities. Account C displays trust in Government scientists, and favours Government actions to build public confidence (s6), whilst simultaneously regarding 'the public' as being neutral or unmindful of RWM until such a group is forced into a position to react against specific proposals (s13). Account C socially constructs the public as passive, and this passivity is central to the technocratic worldview. As Wynne (1988; 1989) suggests, policy processes in the nuclear industry and in other controversial technology sectors have been dominated by 'deficit model' thinking whereby public actors are construed as fundamentally lacking the knowledge and rationality to process risk information 'correctly' in the manner similar to that of scientific and technical actors. Communicating and governing risk from within this deficit model worldview involves the transmission of technical information to a passive, homogeneous public in order to allay fears and build confidence in proposals, despite the fact that such strategies lead almost inevitably to public backlash against proposals (Wynne 1982; McAvoy 1999; SCST 1999; Allum, Boy et al. 2002). Inherent to such a problem is trust in the institutional actors that control the RWM governance processes. As account C also shows a belief that public actors display more trust in government scientists than those in independent

environmental organisations (s35), this compounds the deficit model assumptions at the heart of the technocratic account. It is clear from the analysis, that the anti-nuclear account stands in direct opposition to the technocratic account on issues of trust (s6, s13, s35): revealing how opposition to nuclear technologies is inherently related to a lack of trust in governmental and technical authorities, and the way in which technocrats conceive of the public as passive, uninterested or ill-informed. The anti-nuclear account is therefore related not just to objections on the technological options themselves, but also a reaction against a technocratic policy style and paternalistic, utilitarian decision-making.

Similarly the technocratic account stood in direct opposition to all others (except G- the stewardship account with was neutral) on the ethical issue of top-down governance from a utilitarian perspective (s32). Whilst the technocrats believe that a national Government level imposition of a RWM solution is beneficial for the country, this was opposed in particular by those advocating a holistic, non-anthropocentric and multinational view (account B), and to a lesser extent by those seeking a final disposal solution (account F) and those that value a public engagement focussed approach to decision-making (account A). Within the top-down governance style, there were also a number of divisions over the role of different organisations responsible for different aspects of radioactive waste management (s40). Accounts A, B, D, and G favoured the division of RWM organisational responsibilities (explained to the participants as different roles such as political oversight, technical design, long-term monitoring and retrievability), whilst accounts C and F did not. Interestingly those that favour technocratic governance and those that favour deep geological disposal also believe that a single radioactive waste management organisation should be responsible for all aspects of the process. In practice this stands in contention with the shared partnership model that has emerged within the MRWS process between the NDA RWMD and partners such as local councils, overseen by CoRWM. It is important to note that whilst a diverse and pluralistic model of public engagement model is generally favoured across the accounts, there is a division over what sort of institutions (and the number of institutions) that should be required to govern and implement the various aspects of the RWM process.

Though some options such as disposal in subduction zones were consensually dismissed, and there was common support for national level waste disposal, the issue of multinational cooperation in RWM was divisive (s10). It was strongly favoured by those advocate of account B, favouring holistic and multinational approaches, as well as account G- those advocating a long-term stewardship role, and to a lesser extent those in favour of technocracy (account C) and those concerned with risk governance (account E) and anti-nuclear opposition (account D). This presents somewhat of a confused picture, as national level disposal was shown to be consensually agreeable, and the transportation of wastes disagreeable, though multi-national disposal was also favoured by five of the seven accounts. There was little support for the idea that transnational transportation of wastes is highly irresponsible (s24), thus implying that it is can be ethically justified. However, accounts E,F and G were concerned with the possibility of the UK becoming a dumping ground for imported wastes (s38), whilst account A opposes multinational disposal on ethical grounds (s36). Together the difference between accounts on this issue of multinational cooperation in RWM and the transnational transportation of wastes illustrates the divisiveness of this particular issue, how different actors will likely favour certain forms of international waste governance (such as cooperation, knowledge sharing or under certain circumstances multinational disposal solutions), whilst being wary of transportation of actual nuclear materials as presenting opportunities for theft or terrorism (s31), or else being unfair to waste receiving countries (including the UK). Overall this issue requires further exploration through qualitative research and multi-party dialogue.

13. Conclusions

An important finding from this Q-method study is the large number of statistically significant factors that result, with seven distinct discourses emerging. This range illustrates the breadth of values brought to bear on debates over long-term radioactive waste management and the diversity between industry representatives principally concerned with ensuring fair, transparent governance, a final disposal solution and long-term stewardship; with a much broader range of public actor responses ranging from the technocratic and expert centred assessment, to anti-nuclear, non-anthropocentric and risk governance related

concerns. This breadth and diversity of values raises the question of thewhat use such Q-methodological studies are to real world environmental policy-making on issues such as RWM. One of the fundamental challenges facing the governance, decision-making and implementation of politically controversial environmental management programmes such as those involved in radioactive waste, is to create a policy that is socially robust, ethically justified and 'bottom-up' in the sense that it involves transparent, bidirectional engagement between decision-makers and those stakeholders and affected community actors involved. Finding the means to understand and negotiate between the often conflicting institutional, public and stakeholder positions on the social and ethical issues involved requires tools to clarify and delineate different stakeholder positions on the social and ethical issues at stake. Within the literatures on environmental valuation are a growing number of environmental philosophers, sociologists and political scientists that adopt pluralist or neo-pragmatist positions within environmental justice debates, realising that negotiation to resolve environmental problems must involve arguments that are both attendant to a range of mutually conflicting anthropocentric and non-anthropocentric ethical values, and that are persuasive to policy-makers and other practitioners involved in environmental management processes (Dryzek 1997; Minteer and Manning 1999; Light 2002; Norton 2002; Minteer 2005). Such theorists have noted that the negotiation of pluralistic environmental values requires democratic modes of governance and importantly, greater input from empirical social sciences into the study of multiple environmental values from the perspectives of different stakeholder actors. Q-method provides a useful input into this crosscutting philosophical and policy debate by articulating the range of normative moral values held by actors involved in the policy making process. Q-method studies such as this, reveal the areas of consensus and conflict between different actors and can thus enable groups who seem divided into factions by political or social differences to see some commonalities of beliefs across factions, and some differences within them—a key step in beginning to reach group consensus (Donner 2001).

In practical environmental policy terms, Q-method can assist different stakeholders to better manage conflicts, firstly by presenting a range of potential options and solutions that would be amenable to different interest groups. This can be done with by extrapolating potential options and solutions to environmental management problems drawn directly from the discourse outputs in an isolated manner (such as that presented here). Secondly however, the outcomes of Q-method studies can be deliberated upon in a group setting, whereby participants in the study are brought together *ex post* to learn about shared perspectives they did not know they had with members of other stakeholder groups (Swedeen 2006). Thirdly, Q-method could be used as a part of a group exercise in a manner consonant with participatory-deliberative environmental management processes (such as the adaptive management approach favoured by Norton 2005), as a *participatory* method in the context of a consensus conference, citizens jury or other form of deliberative exercise, to help facilitate construction of potentially acceptable options and alternatives that are attentive to the conflicting environmental values expressed in each of the discourses . This can then be followed by the use of additional tools, including 'deliberative opinion polls' (Fishkin, Luskin et al. 2000), National Issue Forums (Melville, Willingham et al. 2005), 'citizens' juries' (Smith and Wales 2000), 'planning cells' (Daniel and Renn 1995), multi-attribute decision analyses (Nijkamp 1989; Atherton and French 1998), multi-criteria mapping (Stirling and Mayer 2001) or deliberative mapping (Burgess, Chilvers et al. 2004; Burgess, Stirling et al. 2007). These can assist in elucidating more thoroughly the socio-technical aspects and trade-offs between competing values, and thus can help to select among alternative courses of ethically and socially robust action based upon further rounds of deliberative evaluation. In each case Q-method can serve as the backbone to a broader understanding of stakeholder positions within controversial policy debates, by articulating the mutual goals, values and conflicts between them. By laying bare conflicting and consensual values, Q-method can help to foster mutual learning about conflict and agreement within environmental policy problems such as those presented in the safe long-term management of radioactive wastes.

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Appendix 1. *Statements and composite q-sorts for each factor*

		Factor						
	Statement	**A**	**B**	**C**	**D**	**E**	**F**	**G**
1.	We have equal ethical obligations to non-humans, as we do to humans	-1	+2	+1	0	0	-1	-4
2.	Each country is ethically responsible for the disposal of its own wastes within their own national boundaries	+4	-1	-1	+3	0	+4	+3
3.	It is legitimate to expect or to ask a local community to bear the costs of a radioactive waste site on behalf of a larger society	0	-4	-1	-4	-4	-4	-1
4.	The future stability of society is not such an important issue, future generations will be capable of dealing with any outcomes from radioactive waste disposal	-2	-2	+1	0	-3	-1	-1
5.	Imposing ethical and evaluative judgments on others without recognition, evaluation, wide consultation and debate is morally wrong.	+2	+3	+1	+2	+3	+2	-2
6.	Scientists should be trusted to go ahead with implementing a radioactive waste disposal solution; but it was up to the Government and the nuclear industry to work hard at obtaining that trust	-1	-2	+3	-3	+1	-1	0
7.	For the human race to survive at all, requires a radical transformation in our relationship to the interdependent web of life on Earth, putting the health of ecosystems and environmental concerns above generating wealth	-1	+3	0	0	0	+2	-3
8.	There should be a future for nuclear power in an era where Global Warming is perceived to be a problem	-1	0	+2	-2	0	+3	+1
9.	The fundamental ethical issue, is what ought to be done with radioactive waste, because this material constitutes a threat to human life and well-being.	+2	0	0	+1	+1	+1	+3
10.	We should consider multinational approaches to the management and disposal of spent fuel and radioactive waste	-2	+4	+3	+2	+3	-3	+4
11.	Responsibilities to future generations are better discharged by a strategy of final disposal than by reliance on stores which require surveillance	+1	-1	+4	0	0	+3	+2
12.	Someone will try to cut expenses for the sake of increased profit and thereby increase the danger	+1	0	0	+3	+4	+1	0
13.	In terms of public acceptance of a waste disposal strategy we must bear in mind that on most things the public does not think anything until it is forced to do so	-3	0	+3	-2	+1	-1	-1
14.	There must be adequate opportunities for those outside the institutions involved, especially those with a particular interest in the given decision, to contribute fully to the decision making procedure	+4	+1	-2	+2	+2	0	+1
15.	The nuclear industry is not open enough, despite improvements in recent years.	+1	+2	-2	+4	-2	0	0
16.	Because deep geological disposal reduces risk as far as is reasonably achievable, given current knowledge, it does as well at satisfying our moral demands for risk reduction as any concept is likely to do	+2	-1	0	+1	+1	+3	+2
17.	Our enchantment with nuclear energy — and the toxic mess we have wrought — reflects the larger pattern of human alienation from nature and destruction of the environment	0	+4	-1	0	0	-1	+1
18.	The public will support the decisions of Government and the nuclear industry if it feels confident in placing its trust in those institutions	+3	+1	+2	-2	+2	0	-1
19.	The British Government still has no idea of how to deal with nuclear wastes safely, and likely never will	-3	-2	-4	-1	-1	-3	0
20.	People will understand the issues surrounding radioactive waste management if they are encouraged to participate in the process	+2	+1	+2	+2	+2	0	0
21.	The actual need for retrievability (a disposal solution which is not permanent and 'undoable') is a public requirement, rather than a technical one	0	-2	-2	0	-2	0	0

22.	The issue of waste disposal should be separated from the issue of waste generation	0	-1	0	0	-1	-2	-1
23.	Building public trust could establish a consensus which would overcome local planning difficulties	+1	+1	0	+1	+1	0	-3
24.	The trans-border export of nuclear waste from one country to another is one of the most irresponsible acts of the global nuclear industry	+1	-1	-3	-2	-4	+1	-4
25.	Waste ought to be monitored as it gives confidence to people through reduced uncertainty, provides information and data, as well as addressing safety issues.	+1	+2	0	+2	+3	-1	0
26.	Sub-seabed disposal, where waste is placed in a pre-dug hole or buried in the soft seabed, may be the best option because then is not directly in any one's 'back yard'	-2	-3	-4	-3	-3	-2	-1
27.	There is a disparity between those who reap the benefits of nuclear power and those who take the burden of the waste	0	+2	-1	+1	-1	+1	-2
28.	The question of what should be done with radioactive waste should be a purely scientific and technological one, public opinion is too subjective	-4	-3	+2	-3	-2	+1	+1
29.	Firing waste into the sun or into outer space may permanently rid Earth of the problem but the possibility of rocket failure makes this to be too much of a gamble	+3	0	+1	-1	-2	+2	+3
30.	The risk to British society from nuclear wastes should be measured across the whole population, regardless of the risk to individuals	-1	-2	+2	+1	-1	+2	+2
31.	The most important factor is to guard radioactive waste stores against sabotage, terrorism and theft	-1	0	-1	+1	+4	+4	-3
32.	National government should be able to impose a radioactive waste site for the good of the country	-2	-4	+4	-1	-1	-3	0
33.	A waste management strategy should not be based on a presumption of a stable societal structure for the indefinite future	0	+3	-1	-1	+1	0	+2
34.	The public's role in the decision making process should always remain secondary to that of the experts	-2	-3	+1	-4	-3	-2	-2
35.	The public in Britain has less trust in government scientists than in those working for environmental organisations	+2	+1	-2	+4	0	0	+1
36.	Multinational disposal is ethically sound even though it contravenes anti-nuclear proliferation treaties	-3	0	+1	-1	-1	-1	-2
37.	Disposal in space permanently removes radioactive waste from the biosphere, thus it is desirable despite the increased short term risk	-4	-1	0	-2	-2	-2	-2
38.	By importing radioactive wastes from other countries into Britain we are allowing ourselves to become a "nuclear dustbin"	0	0	-3	-1	+2	+2	+2
39.	Given the costs of waste disposal, and clean-up were never factored into the original plans for the nuclear industry, they should never have got any further than the drawing board	0	+1	-2	-2	+2	-2	+1
40.	The British government should maintain separate organisations that are responsible for the different aspects of the task of nuclear waste disposal, so that the short and the long-term issues can be made visible to the decision makers	+3	+2	-3	+3	0	-4	+4

Appendix 2. *Q-sorting participant loadings on each factor*

Sort no.	Age	Job title	Sex	GCSE O-level	A-level	First Degree	Higher degree	Load on factor
Nirex participants								
1	31	Stakeholder involvement and decision framework specialist	F	ü	ü	ü	ü	A*
2	N/a	Waste Management Strategies Co-ordinator	F	ü	ü	ü	ü	A
3	30	Corporate Communications Officer	F	ü	ü	×	×	A*
4	44	Solicitor	F	ü	ü	ü	×	F*
5	38	Purchasing Manager	M	ü	ü	ü	ü	G*
6	30	Finance administrator	F	ü	×	×	×	F*
7	34	Knowledge Systems Manager	M	ü	ü	ü	×	A
8	55	Geosphere Research Manager	M	ü	ü	ü	ü	A
9	37	Container Development Engineer	M	ü	ü	×	×	D*
10	56	Secretarial support leader	F	ü	ü	×	×	G*
11	36	Safety Assessments Co-ordination Manager	F	ü	ü	ü	ü	A
12	40	Packaging Assessments Manager	M	ü	ü	ü	×	A
Non-Nirex participants								
13	34	Part-time Psychology Lecturer	F	ü	ü	ü	ü	B*
14	50	Service Manager in Local Authority	M	ü	ü	ü	ü	B
15	22	Primary School Teacher	F	ü	ü	ü	ü	D*
16	54	NHS Performance Manager	F	ü	×	ü	ü	E*
17	47	Fire Service Training Instructor	M	×	ü	×	×	A*
18	60	Project Manager: Construction of Oil and Gas Platforms	M	ü	ü	ü	×	A*
19	21	Graduate in Maths	M	ü	ü	ü	×	C*
20	78	Retired H.M. Inspector of Schools	M	ü	ü	ü	×	E*
21	74	Parish Administrator	M	ü	ü	ü	×	B
22	22	Public Education Officer at Nature Reserve	F	ü	ü	ü	×	C*
23	50	School Head Teacher	F	ü	ü	ü	×	B*
24	55	Accountant	M	ü	ü	ü	×	D*

Summary

Mean age:	41 yr
GSCE/ O'Level:	96%
A-Level/ Diploma:	92%
First Degree:	79%
Higher Degree:	41%

**Figures highlighted represent defining sorts loading on the factor > .40 at p<.01.*