Projected futures: the political matter of UK higher activity radioactive waste

Nicky Gregson: Department of Geography, Durham University, Science Laboratories, South Road, Durham DH1 3LE UK

nicky.gregson@durham.ac.uk

Abstract

This paper identifies, and works from, the techno-conceptual as a site of intervention for a politics of stuff. Its case is radioactive waste, specifically UK higher activity wastes (HAW) and the policy future of a UK Deep Geological Disposal Facility (DGF). The paper proceeds through three steps. It charts, first, the unravelling of HAW as onto-politics through the democratisation of techno-science, showing that, as the gap between stuff and politics has opened, HAW's future in a DGF has become the preserve of science-technical discourses (currently geology and engineered design). Secondly, it joins with the undone science traditions of STS, to critique existing techno-scientific conceptualisations of a DGF and to anticipate a future in which a DGF is abandoned. Third, and in response to abandonment, it proposes a different future for a DGF. This starts from thinking radioactive waste as thing power but argues that, for a DGF to be materialised in ways that forge attachments with publics, requires a turn to material culture. More broadly, the paper argues that furthering onto-politics requires keeping the demos alive to stuff's vitality. This means engaging in political settlements of techno-scientific controversies; with old, or established, technologies and 'cold' politics; and in politics as practised.

Key words: radioactive waste; materiality; deep geological disposal; onto-politics; UK.

1: Introduction

The case for taking matter, or stuff, seriously as an active participant in politics is now well established. These arguments have been articulated in various strands of literature in the social sciences, particularly within STS and post-humanist inflected work in political theory. Notable are: Bruno Latour's initial focus on the importance of microbial life in the development of a Pasteurian politics, his subsequent calls for the democratisation of science and more recent emphasis on a parliament of things (Latour, 1988, 2004, 2005); related work on hybrid forums (Callon et al. 2001); and Jane Bennett's vital materialist project, which seeks to think slowly the idea of matter, as lively, emergent and vital, through a materiality that encompasses the human and non-human and the distributive action of thing power (Bennett, 2004, 2010). To this work we might add Karen Barad's ethico-ontological politics of mattering (Barad, 2007); Donna Haraway's ethics of respect, curiosity and regard that mark her call for response-able encounters of humans and companion animals (Haraway, 2008); and a variety of studies, informed by these ideas, which point to the relational, unfinished qualities of onto-politics (Born & Barry, 2010), and to what Braun & Whatmore (2010) identify as an originary sense of technicity, grounded in practice, public-ity, creativity and experimentation.

This paper joins with these traditions of thought and, through a particular case, identifies some of the challenges facing furthering onto-politics. Its concern is not with the theoretical case for political matter. Rather, as important in furthering onto-politics is the task of how to keep a parliament of things alive – or, how to constitute assemblies in such a way that stuff's emergent, lively, vital qualities are not just acknowledged but continue to be recognised in the demos. The ongoing, unfinished vitality of matter is what I take to be at the heart of a parliament of things, and it is much harder to accomplish than it is to write – for two sets of reasons. First, and however much advocates of political matter might wish otherwise, a political of the type that makes objects and stuff a focus for human-centred politics, and/or which excludes non-humans from the demos, has not gone away

as a result of the theoretical turn to political matter. Rather, it remains the primary way of thinking politically and of doing politics. This means that a parliament of things can all too easily revert to one of human interest/s. The capacity to revert establishes that to make the theoretical case for political matter is not the same thing as to hold it together politically. Second, even within STS, stuff is largely stabilised. Whilst capacities to overflow are recognised, the primary interest in the field has been in the enrolment of non-humans, as allies or adjuncts. Vitality in these accounts is largely channelled to particular, almost invariably technical and human-centred purposes. Matter is acknowledged but not emergent, lively and open – as vital materialism insists. Combine that sense of a vitality stilled with politics as practiced, in which the closing down of controversy - or what Barry (2002) refers to as the shift from 'hot' to 'cold' politics - is critical, and we see the problem that confronts furthering onto-politics. Keeping matter alive not only means keeping political controversies open to the vitality of stuff. It suggests that to establish the new demos requires engaging in the always unfinished task of keeping political settlements open to stuff.

The case used to develop these arguments is a familiar one in debates over science-technical controversies. It comprises radioactive waste, specifically the UK's store of HLW and ILW (henceforth HAW)[1] and its projected future in a deep geological disposal facility (DGF). [2] I establish first that this matter of concern has unravelled through the turn to deliberative democracy. As a result, the

[1] 'Higher activity' radioactive waste is the designation given to high level (HLW) and intermediate level (ILW) radioactive wastes. The UK's Baseline Inventory of radioactive wastes comprises 1400m^3 of high level waste (0.3% by volume) responsible for 36,000,000 terabequerels of radioactivity (41.3% of the radioactivity of the inventory), with intermediate level waste comprising 364,000m^3 (76.3% by volume) and 2,200,000 terabequerels of radioactivity (2.5% of the inventory) – NDA, 2010a,c. The majority of the inventory of HAW is currently stored at Sellafield in West Cumbria.

[2] Geological disposal is a means of containing and isolating radioactive materials from the biosphere until such time as their radioactivity has decayed to safe levels. Cesium^{137} and strontium^{90}, which dominate radioactivity to begin with, decay to safe levels in 300 – 1000 years, but some fission product decay chains (e.g. plutonium^{239}, plutonium^{240}, iodine^{129}, technetium^{99} and americum^{243}) remain dangerous for geological time. A suitable rock formation is therefore seen as a key component in a multi-barrier containment system, which also comprises immobilised waste forms (in which radioactive materials are held in glass, ceramic or cement) and engineered containment systems, typically of stainless steel, copper and bentonite. Deep geological disposal is being actively implemented in Finland and Sweden (Elam & Sundqvist, 2009, 2011) and is the preferred means of managing radioactive wastes in the US, the UK and France (Barthe, 2009; Berkhout, 1991; Macfarlane, 2003, 2006b; Bloomfield & Vurdubakis, 2005; Macfarlane & Ewing, 2006; Chilvers & Burgess, 2008).

current conjuncture is one in which radioactive waste is positioned once more as the preserve of expert technical knowledge, leaving publics to coalesce around the politics of the siting of a future UK DGF. In more general terms, the details of the case demonstrate that onto-politics has unravelled to become human-centred politics. They exemplify the broader point that, in the course of political settlements, a politics of stuff can all too easily be nullified and reconstituted as human-centred. This state of affairs with respect to HAW needs to be made explicit and contested. The latter comprises the second aim of the paper. I turn initially to the undone science tradition of STS to do so. Yet, this only gets us so far. Whilst turning to undone science can anticipate a future in which HAW in a DGF becomes lost or abandoned, in this instance it can offer nothing to counter a future that accords with the Frankenstein myth. The third, and more speculative, intent of the paper therefore is to suggest a different future for HAW within a DGF; one that starts from onto-politics and particularly from the question of how to keep radioactive waste open, affective and eventful in its disposal. In part, vital materialism can answer that question; by thinking radioactivity as thing power. To effect that disposal, however, is argued to require a turn to material culture – to figure a DGF as a means to HAW's burial, and through absent presence; to forge attachments to it; and to constitute and assemble publics. In such a way, I argue, both HAW and a DGF might be returned to a parliament of things.

The paper proceeds through three sections. The initial manoeuvre (Section 2.1) charts the course of debate and policy formation around UK HAW. Having outlined the current political settlement, Section 2.2 establishes its retreat from onto-politics. Whilst it is recognised in the academic literature that the turn to deliberative democracy within UK radioactive waste management worked to shore-up policy outcomes through framing effects (Chilvers & Burgess, 2008; Bickerstaff et al. 2008; Chilvers, 2008), less remarked upon has been how HAW figured in deliberations. As I show, although fundamentally a matter of onto-politics, HAW was made present in ways that ordered, disciplined and tamed, rather than emphasising its unruliness and liveliness. An effect is that onto-politics became increasingly human-centric politics. That politics is currently focused on the

principles of volunteerism and partnership, and their articulation in staged decision-taking, and it is presently being enacted largely in one part of the UK: West Cumbria (Bickerstaff, forthcoming). The question this raises, however, is 'What happens to HAW when the politics gets hived off from the physical stuff?' As I show (Section 2.3), HAW has been reclaimed as the preserve of techno-science.

In Section 3 I begin to contest this state of affairs, by casting HAW's intended future in a DGF as an instance of undone science. Of particular interest here is work which highlights how knowledge of hazardous wastes gets lost over time (Frickel, 2008). I draw on this to anticipate the abandonment of HAW and a future DGF. Yet, whilst undone science can get us this far, drawing on the arguments of Gabrielle Hecht (2006), I argue that HAW's 'nuclearity' makes it a difficult object to pursue through the civic or community science projects advocated within the undone science tradition. Moreover, I argue that it is difficult to see how such work might address the issue of abandonment prior to the construction and eventual closure of a DGF.

Section 4 takes up the challenge of how to arrest a future in which HAW and a DGF might be abandoned. This starts by thinking HAW through Jane Bennett's vital materialist project, that is, as thing power, and by examining how HAW might be returned to the demos, through opening up channels of communication between HAW and human publics. I establish two foundational questions for a future DGF. These are: 'How might a DFG that is currently cast as a means to HAW's safe disposal be more open to HAW as thing power?' and 'How might a DGF admit channels of communication between HAW and publics (holding them together), whilst recognising the need to hold them apart?' To answer those questions I argue that it is critical to stop thinking about a DGF simply technically, as a means to disposing (safely) of HAW. Rather, a DGF can be thought of as a means to HAW's burial, that is, as a vault or tomb for radioactive waste. I argue that a DGF be materialised in ways that ensure that it is undisturbed yet continues to assemble publics – that is, that it fulfils the conditions of holding together whilst holding apart. In such a way I establish that to effect HAW's burial requires a turn to material culture. The turn to material culture is made by many

contributions to *Making Things Public* (Latour & Wieber, 2005). In this paper, in contrast to the reliance there on exhibitionary and/or experimental forms of material culture, it is material culture's capacity to articulate the absent presence that I find most helpful. As Miller (2011) has recently reiterated, a central premise of material culture studies (MCS) is that the only way 'to apprehend the immaterial is through the material' (Miller, 2011 p 326). Radioactive waste is, of course, absolutely about the material, but the stuff has a transcendent quality. It has that precisely because it is about futures; human generations measured in geological time. One way to imagine a DGF, then, is to configure it through the absent presence; to work with radioactivity in such a way that, although invisible and buried, it continues to be apprehended. In such a way, I argue, it is possible to arrest a future in which HAW, like so many other forms of hazardous waste before it, might be abandoned.

The paper concludes by reflecting on its contribution to the development of a politics of stuff.

2: UK HAW, deliberative democracy and the coming apart of a politics of stuff

2.1: From 'hot' to 'cold' politics – and back again?

In 2006, following three years of extensive deliberation, a major controversy over the role of expert knowledge in decision-making and a substantial programme of public engagement, the UK Commission on Radioactive Waste Management (CoRWM) recommended deep geological disposal as the best available option for the UK's legacy of HAW, supported by underpinning R&D aimed at addressing uncertainties; a risk assessment based approach to unresolved uncertainties; and further supported by a robust process of interim storage (CoRWM, 2006). The subsequent 2008 White Paper, *Managing Radioactive Waste Safely*, came out strongly in favour of deep geological disposal, whilst subscribing to the principles of community volunteerism and a staged approach to siting (DEFRA/BERR, 2008, paragraph 1).

Both CoRWM's recommendation and the 2008 White Paper are instances of what Andrew Barry (2002) identifies as the shift from 'hot' to 'cold' politics.[3] Although constituted in relation to controversy over what to do with the UK's legacy of HAW, CoRWM's recommendation and the White Paper mark a political settlement with UK HAW, and – as such – a means to shut controversy down through establishing a consensus. For some 20 years previously, however, what to do about HAW, how to come to that decision and the implications of decision-taking for places, had been one of the hottest issues in UK politics.

The trajectory of controversy is well established in the literature. Typically, narratives commence with the various attempts by the Nuclear Industry Radioactive Waste Executive (NIREX) in the 1980s to find a disposal route for ILW, and the so-called 4-sites disputes; run through the identification in 1991 of Sellafield as the only site for investigation, the application in 1992 by NIREX for a Rock Characterisation Facility near Gosforth, the refusal by Cumbria County Council to grant that application, and the subsequent 1995 -6 Public Inquiry; and then proceed to the House of Lords Select Committee of 1999, which laid the ground for a shift from 'decide, announce, defend' modes of decision-making to establish the importance of principles of openness, transparency and public trust in radioactive waste management. First applied at the UK CEED Consensus Conference in 1999, in which panels of citizens drawn from across the UK came together to discuss the problems of managing radioactive waste safely, this is the bridge to the work of CoRWM (2003 – 2006). A useful summary of the trajectory appears in Bickerstaff (forthcoming), whilst a number of papers focus on CoRWM as an instance of deliberative democracy (Burgess et al. 2007; Chilvers & Burgess, 2008; Chilvers, 2008).

[3] An important qualification is that, in its deliberations, CoRWM separated the existing stock of UK HAW from future waste arising from new-build nuclear power stations in the UK. A renewed commitment to new-build on the part of UK government in 2009, consequent upon the energy gap and the move towards low carbon, opened the door to further controversy – over the legitimacy of the commitment to new-build and over the terms of reference and legitimacy of the reconstituted CoRWM. Post Fukushima, the future for new-build is more uncertain. The commitment to a UK DGF, however, remains - a clear indication that what to do with UK HAW is cold politics.

Narrated thus, the controversy over UK HAW can be linked to wider debates about governance and governing techno-science. Played out here is the same crisis in the authority and legitimacy of expert knowledge as appears in several other science-technical controversies; a failure of the institutions charged, in this instance with governing radioactive waste, to impose their decisions on publics; and the subsequent realignment of the politics of radioactive waste management through a consensus seeking, deliberative model that was increasingly being applied not just to techno-science controversies but also in development practice (Cooke & Kothari, 2001). 'Hot' politics was discernible throughout: for example, in the refusal of the governed to have decisions about the siting of radioactive waste thrust upon them; in the recourse to the instruments of the Public Inquiry and Select Committee; and in the clash between expert knowledge and participation that occurred within CoRWM.

Chilvers and Burgess (2007) discuss the range of deliberative methodologies that were trialled and applied within the CoRWM process. Although the methodologies differed they had commonalities. They worked to position HAW first in relation to 'options for appraisal' and second through the identification of criteria by which the options identified could be made comparable and calculable (c.f. Davies, 2006; Burgess et al. 2007). Within CoRWM, the options numbered nine in total.[4] Once translated to criteria, deliberation condensed around safety, security, burden (for future generations), worker safety, flexibility, environment, implementability, amenity and socio-economic issues, with each option being evaluated qualitatively and quantitatively against these criteria. Seen thus, the identification of deep geological disposal as the best available option for managing HAW safely is not just underpinned by but produced through, or performed into being by, methodological tools, or the calculative devices of deliberative participatory democracy. Further codified into the instrument of the 2008 White Paper, this confirms a well established point in Foucauldian readings of governmentality; that devices are techniques of governing and a means to condense or stabilise

[4] The options were: ongoing above ground storage and underground phased disposal, both in the UK; international underground phased disposal; sub-seabed disposal; disposal in space; disposal at sea; disposal in ice sheets; disposal in subduction zones; portioning and transmutation.

political settlements. In this instance, they turned what to do with UK HAW from 'hot' to 'cold' politics. But as I now show they did so only by displacing 'hot' politics to the process and places by which communities volunteer to host a DGF.

If the White Paper made the commitment to geological disposal, it also separated out the issues pertaining to R&D and the DGF's optimised implementation from a parallel process of deliberation with respect to siting. The core principle here is volunteerism. In the White Paper potential host communities are envisaged to come forward, first to express an interest in hosting a DGF, and thence to a decision to participate, followed by a staged evaluation of the technical feasibility of a range of candidate sites drawn from a list of volunteer communities. This marks a reconfiguration of the scalar politics of UK HAW. From UK CEED in 1999 through CoRWM 2003 – 2006, debate about HAW was conducted in a world bounded only by the territory of the UK. With the White Paper, the scalar politics of deliberation shifted from the national space to the local spaces of potential host communities. Both nuclear and non-nuclear communities were anticipated as coming forward to volunteer expressions of interest in hosting the DGF. To date, though, only three West Cumbrian communities have volunteered – Allerdale and Copeland Borough Councils and Cumbria County Council; all of them closely associated with nuclear reprocessing, radioactive waste handling and radioactive waste storage.

This course of events has attracted a degree of comment. In its reconfigured advisory role, CoRWM has emphasised to UK government the desirability of promoting expressions of interest more widely, and cautioned about the risks of community withdrawal and/or the potential technical unsuitability of West Cumbrian sites (CorWM, 2009). The prospect being raised is one in which over a decade of investment in the participatory model fails to produce a technically viable host community. Would that to happen, what to do with HAW would once again become hot politics for UK government. Meanwhile, as Bickerstaff (forthcoming) shows, in West Cumbria a potential DGF is anything but cold politics.

Beyond the intensely political process of which territorial units within West Cumbria went forward to express an interest as communities in hosting a DGF, through 2010 – 11 the focus in West Cumbria shifted to extensive rounds of PSE activities. This included community drop-in events, questionnaire surveys, electronic newsletters, advertorials, DVDs and discussion groups (http://www.westcumbriamrws.org.uk) and replicated many of the techniques used within CoRWM's deliberative mapping exercises. General concerns over inter-generational justice and the ethical burden surfaced within deliberation, but this time alongside the package of community benefits to be negotiated in exchange for hosting a potential future DGF (West Cumbria MRWS, 2010). Benefits – in the form of jobs, investment, skills training, education and health care – are core concerns for these West Cumbrian communities. Firmly entrenched in the politics of the disadvantaged regions, the benefits package to be negotiated is not just hot politics in and of itself but also integral to the volunteering process. The next step in that process is the decision to participate. But to take that decision requires evidencing public support. A favourable benefits package is seen to be central to garnering such support. But then the charge is clear: in circumstances where benefits precede evidenced public support, benefits can all too easily look like coercion, thereby undermining the consensual basis that underpins the participatory model.

Stated thus, it can be seen that the political settlement regarding what to do with UK HAW is not quite the cold politics that it might seem. Rather, there is a scalar politics here which means that hot politics is currently being enacted largely in West Cumbria and in ways which have the capacity to derail both the political settlement with HAW and the participatory model which produced it. As clear is that what is fundamentally a politics of stuff is being enacted primarily through a human-centred politics, in which potential future locations are being traded for near time and real time socio-economic benefits. In the following section I examine the unravelling of HAW as onto-politics in more detail.

2.2: The unravelling of HAW as onto-politics

That HAW is onto-politics is never clearer than at Sellafield. Here spent fuel rods from the UK's nuclear power stations lie immersed in deep tanks of blue water, cooling sufficiently such that they can be reprocessed. Vast piles of highly radioactive junk generated by vitrification lie heaped in cavernous spaces shielded by glass of immense thickness. In the HLW store radioactive waste is felt rather than seen. As one stands on the storage silos below that hold vitrified waste, one senses both the heat and the burden of responsibility that attaches to this stuff. Elsewhere there is the stuff that cannot even be seen, which is barely characterised and which threatens to overflow its means of containment – the legacy wastes that go by the name of old stores and old processing technologies: the Magnox wastes; B32. In yet other parts of the site, compression and compaction technologies combine with cement and containers, literally to shove as much LLW as can be shoved into the remaining silos at the nearby site of Drigg. Then there are the ruins in the Sellafield landscape; the old plants that continue to defy demolition because they are too 'hot' radioactively and too difficult to handle; and the rubble – vast, unimaginable amounts of radioactive building waste generated by the phased decommissioning of the site. To visit Sellafield, then, is to be confronted by the wastes of nuclear power generation and reprocessing, by humanity's attempts to manage these, and by the capacities of some of those wastes to defy technical solutions. This is a place which testifies not just to the power of the non-human to object but to the power of the non-human to exceed and overwhelm the human. It is truly a humbling place and a place to trigger thought.

In starting this section in this way, with description garnered from three separate visits to Sellafield between 2007 and 2009, my intent is to do what was impossible for participatory/deliberative work conducted in relation to HAW; to confront the reader with the enormity and unruliness of HAW. My point is that it is only inside places such as Sellafield that the implications of HAW's energetic qualities and unruliness can seriously be appreciated. An effect of 9/11, however, is that Sellafield is one of the UK's most inaccessible places; with access restricted to industry specialists, politicians and security-cleared researchers. So immediately there is a paradox: deliberative methodologies sought to involve publics in decision-taking about managing radioactive waste safely but they were trying to

achieve this in relation to stuff that was far from public. A key question therefore is how was HAW made public in deliberation? How was this unknown and unknowable stuff translated to publics?

As presented to lay publics, HAW takes the form of information. Often this comes as tabular classifications that state facts about the volume, weight and radioactivity of the UK's radioactive waste inventory. Tabular representations are often accompanied by images. So, for example, images of the high level waste store at Sellafield are commonly reproduced – in which little is to be seen other than a cavernous space with circles coloured yellow and black on the floor, depicting the presence or absence of high level radioactive waste stored below. Images are often accompanied by cut-away cross-sectional diagrams of the various technologies of containment currently used for UK radioactive waste. The visual, then, performs the same task as tabular representations: both present radioactive waste as ordered, disciplined, contained and tamed. Critically too, these representations are devoid of radioactivity. So, whereas when standing in the HLW store at Sellafield radioactivity enters the realms of the sense-able, in deliberative mapping radioactivity is a (large) number attached to volumes (often similarly large) of material – see note 1. It is in the realm of the cognate not the sensate. This has effects. So, whereas the first foregrounds an unfinished dialogical relation between radioactivity and the human, or the kind of relation that sits at the heart of onto-politics (Born & Barry, 2010), the second tends to push publics to talk, with care and concern, about the long (geological) time frames of radioactive decay associated with certain radioactive wastes and to think about HAW in relation to safety, ethical burden and responsibilities of inter- generational justice.

Further on in the deliberative frame, HAW was figured through future management options and their criterion referenced comparative evaluation. Safety, security, and ethical burden emerged as central, as did the discursive articulation of an ethics of inter-generational (human) justice. Rendered calculable through the quantitative scaling of options, such concerns are human-centric. An effect is to still radioactive waste, through options, their comparison and then by the option that is considered its best available future. In deliberation, HAW plays no active part in its future other than

to comply with a consensually built technology of sequestration, until such time as it becomes safe. We see here, then, how democratising techno-science stills the stuff of HAW; smoothing it, taming it and ordering it through the processes and practices of deliberation. Onto- politics has not only unravelled but has also been reframed, largely through what Cooke and Kothari (2001) term the tyranny, or straitjacket, of participation. Combine this with the commitment to community volunteerism and its demonstration and it is possible to see not only that onto-politics has unravelled but also that it has been cast increasingly through well established practices of doing politics, which centre the benefits to be exchanged for the act of hosting HAW and which see the political exclusively in terms of the negotiation of such an agreement. However, this does not mean that the stuff itself has elided attention. Rather, as I show in the next section, the stuff has been reclaimed by science-technical discourses.

2.3: The return of techno-science

Two science-technical discourses prevail currently around UK HAW: geology and engineering design.

With respect to geology, the initial expressions of interest by the three West Cumbrian communities led procedurally to a desk-based study of Cumbrian geology, guided by a set of pre-determined exclusion criteria. The final technical report states that the purpose of this study is to rule places out, not rule them in:

> "This screening is desk based, uses existing information and will not produce sites that could definitely host a facility, but will rule out areas that definitely could not host a facility for obvious geological reasons" (BGS/NERC, 2010 p. 2).

Its key output is a map, widely reproduced in West Cumbria, whose boundary has performed the mirror of the intention, suggesting to publics that siting will be confined to particular areas. Not only this, the return of West Cumbrian geology to debate about UK HAW has worked to raise the ghosts of the 1990s controversy. Thus, the site of the proposed Rock Characterisation Facility at Longlands

Farm near Gosforth figures prominently in discussion (Bickerstaff, forthcoming).At the same time, geological work is inflected through, whilst attempting to assert its difference from, the scientific disputes first rehearsed in the NIREX period (Oldroyd, 2002; West Cumbria MRWS, 2010 – 3.4.2). This is made all the more challenging as some of the scientific figures involved in the 1995-6 Public Inquiry have returned to debate, to recite a key finding of that Inquiry: that West Cumbrian geology fails to meet internationally agreed criteria for HAW's safe disposal. Furthermore, the case for the politicisation of current geological work has already been made, with Smyth (2011) stating that public domain evidence and academic research assembled by the Public Inquiry has been 'airbrushed out'. He goes on to argue:

> "[the BGS's] remit was tightly constrained, to give the misleading impression that some parts of West Cumbria are to be considered suitable for nuclear waste disposal – after further site investigations, of course. At no point will the BGS be permitted to conclude that no part of West Cumbria is suitable" (Smyth, 2011).

What the Public Inquiry had rendered a 'cold' controversy, then, has suddenly become a 'hot' scientific controversy again. Further, tying the processes of technical evaluation to a parallel process of staged community volunteerism raises fundamental questions for geological science, namely: what happens to scientific knowledge when the boundary conditions for site evaluation are determined politically, through volunteerism; will scientific knowledge refuse those boundary conditions, and – if so - how; and how will geological science navigate a situation in which established knowledge suggests certain locations in the UK to be more suitable technically than others but where there might be political pressure to produce a 'good enough' resolution? Inevitably, those questions remain as yet unanswered.

At the same time as desk-based geological feasibility studies are being conducted, engineering design has begun the work of conceptualising a future DGF. Although decades off construction, and dependent in its details on the geological site eventually decided upon, the concept of a future DGF

has been developed by the NDA (NDA, 2010 b, c). Representations of an imagined facility figure as part of PSE events within West Cumbria, in display galleries at Sellafield's off-site reception facility, and on the NDA's web site. Diagrammatic cutaways show a reception facility of office buildings, long shafts tunnelled underground, to depths of up to 650m, and separate vaults of layered shafts for ILW and HLW. Static public displays are supplemented by animated virtual simulations featuring a choreography of packages, cranes, robots, underground transportation systems and (a few) people. They follow the journey of an intermediate level waste form – fabricated at an industrial plant at Sellafield – through its reception at the DGF, to its emplacement in the ILW vault.

Together, these animations and diagrams suggest an imaginary of a mine, in reverse. Indeed, it is the known technologies of deep mining which work as the tacit demonstration of a DGF's efficacy. Also contained in these representations is the DGF's future closure. A voice-over on the NDA animation states: "deep engineered vaults allow the waste to be kept until it is decided they can be closed", and is affirmed by visuals which anticipate the site hundreds of thousands of years into the future; as a surface with no visible trace of what lies beneath. Above ground, the site is depicted by the NDA as forestry, farmland or as reverting to nature – although, interestingly, the DECC website also includes the possibility of future construction (http://www.decc.gov.uk/en/mrws). Records of what lies beneath are anticipated as being held separately in a National Nuclear Archive.

Two points strike about the public display of an imagined future DGF. First, these animations and graphic representations illustrate what Hecht (2001) labels as the techno-politics of the nuclear industry. We see here how the NDA mobilises the technologies of deep mining to perform the world as the current political settlement with UK HAW would like that world to be. HAW is disciplined and ordered by geological and engineered containment systems, by transport systems and by ICT storage recording systems. In this way it is imagined to be safely disposed of, forever more. A second point concerns imagined future land uses. Using the case of the Rocky Flats Plutonium Factory, Colorado, Shiloh Krupar (2011) has recently shown how the category of a wildlife nature reserve can aid

decommissioning and 'clean-up' in relation to radioactive wastes. The category 'Nature' in that instance works to purify and mask; to accommodate and to erase the presence of radioactive wastes buried within the site, their trace within workers' bodies, and as a means to manage legacies economically. For the NDA to imagine the site of a DGF as reverting to nature performs an identical conjuring trick, resonating strongly with the remediation activities now commonplace in relation to open cast mining and landfill reclamation in the UK (c.f. Gross, 2007). But the NDA's conceptualisation includes other land uses besides nature (farming and forestry). Domesticated animal and plant life are also seen as having the capacity to purify HAW. This is significant. Not only does it signal a degree of ambivalence as to which cultural categories have the capacity to mask radioactive waste (nature or agricultural life) but it flags also that demonstration is being performed through these representations of a DGF. The logic here appears to go something like this: technocratic conceptualisation imagines a future DGF as safe sequestration; but safe sequestration is recognised to require demonstration that is more than technical, if it is to convince publics; to cite domesticated life is to perform that demonstration. Publics here are supposed to be quiescent witnesses (Reno, 2011); convinced by the concept demonstrations, confident in technology's capacities to order and corral HAW into distant futures, and trusting of the nuclear waste management industry's technological capacities and decision-taking (c.f. Zonabend, 1989).

When we look at what is going on with HAW, then, whilst West Cumbrian publics deliberate, we find a reversion to a familiar story – HAW's positioning as the preserve of expert scientific and technocratic discourses. If there is one lesson from the long, contentious debate over UK HAW it is that such developments need to be watched closely. Not only does this situation mark the unravelling of HAW as onto-politics and its reclamation by techno-science, but it shows too the return of old scientific controversies and their previous resolution. The details of the case indicate that the turn to deliberation has not erased these controversies but rather has created a gap in which techno-science returns to be haunted by its past.

In the next section I begin to contest this state of affairs. The initial manoeuvre is to join with the undone science tradition of work in STS to highlight the knowledge gaps in the NDA's public displays and to anticipate a future DGF as abandoned.

3: A DGF as undone science: anticipating abandonment

In an early paper on public experiments, Harry Collins (1988) makes the distinction between experiments and other forms of scientific display. One example used to develop that argument is of the then British Nuclear Fuels Limited's (BNFL's) 1984 televised scientific test, comprising a collision between a diesel train and a nuclear flask wagon. Designed to demonstrate the safety of rail transportation of spent fuel from the UK's nuclear power stations to Sellafield, the experiment asked publics to draw a general principle (safety) from a single test. Nearly 30 years on from that experiment, the NDA uses public displays to assert the general principle that a DGF is a safe means to the disposal of HAW. These displays position publics not as witnesses to the event of a scientific test but as audiences, to be educated and convinced by the idealised representations and concept models of nuclear techno-science. These representations obscure a parallel process of scientific experimentation. Currently, major programmes of experimental work on HAW are being conducted across a range of UK universities and by the NDA. These research programmes focus on radioactive waste characterisation, candidate matrices and their integrity, waste loadings, the simulation and experimentation of radioactivity's effects on candidate matrices, and various technologies of encapsulation and packaging (Lee et al. 2006). As such, there is much that is unknown about the sequestration of UK HAW.

Identifying the knowledge gaps masked by the NDA's public displays of a DGF signals a connection with the undone science tradition of work in STS (Gross, 2007; Hess, 2009). Frickel et al. (2010) argue that the identification of knowledge gaps is a key point of intervention for work in the undone science tradition, and that this is one of the means by which issues of knowledge-power can be brought into STS, to show how certain science is done or not done. Much of this work is linked to the

environmental justice/science activism tradition (Frickel, 2004a, 2004b) and is exemplified by Frickel's work on New Orleans post Hurricane Katrina (Frickel, 2008; Frickel & Bess Vincent, 2007). Two points of importance emerge from that work. First, that knowledge regarding hazardous residues or wastes gets lost over time, creating knowledge gaps that become a means to overlaying hazardous wastes with other land uses. Secondly, the withdrawal of monitoring or testing is one means by which what is known becomes lost or abandoned and thence potentially open to disturbance. Both points are pertinent to a future DGF, particularly as this is performed by the NDA's public displays and simulations (Section 2.3). Indeed, turning to the undone science tradition can clearly anticipate a future in which both a DGF and knowledge about the radioactive wastes contained within it becomes abandoned.

Latour (2008) highlights the perils of abandonment, linking this to the Frankenstein myth. Nonetheless, the political question raised by the prospect of a DGF's abandonment is 'How to intervene to attempt to arrest such an anticipated future'? For the undone science tradition, intervention is achieved by positioning the undone, or knowledge gaps, as a task for civil society science. A key question though is how amenable is HAW to such traditions of work? Critical here is that whilst activist-based science has been highly effective in monitoring the leakage of radioactivity beyond Sellafield, it cannot gain access to the radioactive wastes contained within. This is because HAW is political waste; shrouded in secrecy and bounded by state-within-state security discourses materialised as border crossings, check points, surveillance technologies, razor wire, submachine guns and people profiling. To develop the arguments of Gabrielle Hecht (2006), UK HAW is constituted in such a way that it not only counts as nuclear but such is its degree of what she terms 'nuclearity' that it is territorially concentrated and bounded. It is not just sequestered within the confines of the UK nation state but primarily in one place: Sellafield. That makes it a difficult object for civil society science to know. So, whilst such work might address the more open science of West Cumbrian geology, or of groundwater flows, its capacities to know the stuff that will be placed in a

DGF can only ever be limited, making it as vulnerable to the charge of knowledge gaps and undone science as the work it mobilises to contest.

In the final section of the paper I take up the challenge of how to contest an anticipated future of a DGF's abandonment, turning not to civil society science but to onto-politics and to a tradition of work that joins with Latour (2008) to recognise that to address abandonment requires working with attachments.

4: Countering Frankenstein-ian futures: materialising a DGF as attachments

My starting point in this section is to think HAW through Jane Bennett's vital materialist project, specifically her turn to Rancière to think through Bruno Latour's concept of a parliament of things (Bennett, 2010). Bennett draws attention to unruliness, or the power to disrupt, as an explicitly non-human capacity in the demos. For her, the key political intervention is to change what is seen, or to overthrow the regime of the perceptible (2010, p 106), to admit the objections of non-humans. Radioactive waste's capacity to object is well-known, both within the nuclear reprocessing industry (Bolter, 1996) and through the work of anti-nuclear campaign groups and NGOs who have long documented leakages of radioactive material. But the difficulties of making radioactivity perceptible are considerable. This is not just a matter of radioactivity's invisibility and the consequent need for inscription devices. It is also a question of radioactivity as thing power. Radioactivity's vitality in relation to the human is widely appreciated. Less so is that such is its vitality that it ruptures the integrity of all that comes into contact with it – be that organic or inorganic life. More than this, radioactivity is a colonising materiality. So, to monitor HAW through a combination of robotic and inscription technologies makes radioactive waste of these devices, whilst to sequester HAW as waste forms constitutes more radioactive waste of the very technologies that are enrolled to stabilise HAW – that is, of industrial scale plants and process technologies. Radioactivity, then, is a particularly energetic thing power. Recognising this is important to thinking about HAW in a future DGF. What this does is to contest techno-centric accounts which highlight the capacities of engineered and

geological barriers to contain HAW safely into an indefinite future. Rather than assuming the capacity to control, vital materialism foregrounds a more humble perspective; one which admits HAW's potential to disrupt, colonise and destroy all forms of organic and inorganic life, and which starts from the premise that HAW can and will overflow.

Establishing HAW as an energetic, colonising and annihilating thing power means that HAW can never be granted equivalence with humanity or animal and plant life. At first sight that statement might seem to trouble the vital materialist project, but, as Bennett argues, 'the *political* (my emphasis) goal of a vital materialism is not the perfect equality of actants but a polity with more channels of communication between actants' (2010, p 104). If we were to follow Bennett, then, a possible means to return HAW to the demos would be through opening up channels of communication between HAW and human publics. This is no straightforward matter; for HAW resists the kind of open regard which characterises Bennett's instances of thing power. Her examples of communication tend toward the mindful regard she (the human) affords to a thing power whose power to object lies in the capacity to enter openly, and always surprisingly, into the regime of the perceptible: dead rats in drain covers, plastic bottle caps, electricity black outs. Radioactivity's vitality, however, is such that the channels of communication between HAW and human publics can never be open. Indeed, they must be forged in ways that recognise the need to keep the parties apart. Yet, if we stick with Bennett's insistence on channels of communication, it is possible to establish two foundational questions for a future DGF. These are: 'How might a DGF that is currently cast as a means to HAW's safe disposal be more open to HAW as thing power?' and 'How might a DGF admit channels of communication between HAW and publics (holding them together), whilst recognising the need to hold them apart?' I take each of these questions in turn.

Current NDA public displays and simulations of a DGF do not admit a sense of thing power. Rather, as befits the discourses through which they are thought, they are about the technical mastery of HAW. Within experimental work, however, the energetic capacities of HAW, specifically its

distributed potential effects within a DGF, are well to the fore, albeit framed within technical discourses of control. They are illustrated by concerns over: gas build up as a by-product of radioactivity's sequestration at depth; the inevitable deterioration and decay of technologies of containment, and their leakage; the capacities of technologies to resist groundwater encroachment; and the dangers of co-location of ILW and HLW (NWAA, 2010). Taking these concerns as a starting point makes for thinking a DGF not as an operational emplacement facility for safely disposing of HAW but as continually (un)becoming. It highlights a DGF as a distributed conjuncture of packages, vaults, tunnels, shafts, rocks, gas, groundwater, faults, dykes and calderas, all in flux with radioactivity. This centres the question of how to keep radioactive waste open, eventful and affective in its disposal. Further, it signals that the relation to a DGF is of the unfinished.

To acknowledge a DGF as thing power and as unfinished requires thinking about channels of communication between HAW and publics. In its imaginings of a DGF as reverted to nature, or as forestry, or farmland, the NDA positions the DGF as a finished project in which HAW is safely ordered, disciplined and tamed by the DGF and disposed of through its erasure from the landscape by a new landscape category (i.e. nature, forestry or farmland – Section 2.3). Such a move would be to close channels of communication between HAW and publics. Section 3 has highlighted the difficulties with such an imaginary, emphasising the potential for a DGF's abandonment and later disturbance. The question this raises is one of responsibility: how might a DGF (and HAW) be figured such that communication between a DGF, HAW and publics remains open? How might it be materialised in ways that ensure that HAW remains in human consciousness, as HAW in a DGF? To answer those questions, vital materialism would suggest thinking about how the material force of HAW might be accommodated by a DGF. That would constitute a DGF as an assemblage. Yet, this is an assemblage that - for reasons of responsibility - has to hold together and endure, even as its vagabond qualities are admitted. To achieve this, a DGF has to continue to be apprehended. To realise that effect requires that a DGF's meaning be stabilised. In the remainder of this section,

therefore, I turn to material culture studies (MCS) to offer some thoughts as to how this might be achieved.

To cast a DGF through material culture means dispensing with thinking a DGF through technical notions of disposal; to think of a DGF as a means to HAW's burial. A basic premise of MCS is that the material culture associated with (human) burial (typically memorials, tombs, crosses) is both a means of memorialising to forget and a way of invoking the absent presence. The range of literature dedicated to the material culture of (human) death demonstrates this. Grave stones, burial sites and the more transient material culture that is placed on those sites and renewed at key dates (flowers, cards, soft toys) all work to figure the absent presence, its connection to human loss, and the capacity of material culture to attend to the immaterial through gathering people to the material, and by doing things with the material (Hallam & Hockey, 2001; Kelleher et al. 2005; Clayden & Dixon, 2007; Maddrell & Sidaway, 2010). Nonetheless, this absent presence struggles to survive beyond two or three human generations. That this is so is evidenced by abandoned, tumbledown graveyards from the nineteenth century in churchyards across the UK. Rather different is the material culture that marks the burial sites of a society's significant humans. The classic case here is from antiquity: the Egyptian pyramids – although the fate of their contents is salutary to note, as well as highly pertinent to a DGF. More recent counterparts include the crypts of European churches and cathedrals, in which the tombs of monarchs, clerics and the aristocracy survive in perpetuity. No longer marking the absent presence, these facets of the material culture of death have become cultural heritage. As such, they assemble publics. It is my contention that, for a DGF not to be abandoned, it will be helpful to turn to exactly these sorts of materialisations of burial. How might this be achieved?

Initial pointers in this direction appear in Julia Bryan-Wilson's (2003) essay and in the paper by Bloomfield & Vurdubakis (2005), in which the architect Michael Brill's designs for the Waste Isolation Pilot Plant at Carlsbad, New Mexico are discussed. Alongside non-linguistic modes of marking

radioactive waste's presence in the landscape, various 'communication projects' were proposed. All involved working with material culture. Whilst two projects used the tropes of disappearance and silence, the most common design envisaged ways of marking and communicating radioactive waste's presence, in stone or rock. One concept ('*Landscape of Thorns*') focused on the affective capacities of radioactive waste. Comprising 80' high basalt spikes jutting in a fan from the ground, and at various angles, and interspersed with thorns, the 'shapes suggest punctures, wounding to the body, and which also seem active, coming up from below, and reaching out like uncontrolled growth of something dangerous ... like mutations' (Michael Brill, quoted in Bloomfield & Vurdubakis, 2005 p 749). Others designs took the brief in the direction of radioactivity's heat: *Forbidden Blocks* featured concrete broken block stones on their side, dyed black and facing the sun, getting very hot, or *Black Hole* – an immense black basalt stone, again facing the sun that would get intolerably hot.

All these concepts materialise and communicate a DGF as an absent presence through working with megaliths. They also attempt to arrest potential disturbance. Yet, it is striking that they work not just by holding publics and HAW apart but also by fabricating relations of separation or even expulsion. Keep away; danger and the risk to human life are central messages in this artwork, as is the beyond-human scale of radioactivity. Less clear, therefore, is how such materialisations would work to assemble publics, or to forge attachments. Latour (2008) has argued that it is only by working with attachment that relations of love and care for technology can be constituted and abandonment arrested. If a DGF is to avoid the fate of Frankenstein's Creature, then, it is to how to constitute those relations of attachment that attention needs to be turned. If a DGF is to be returned to a parliament of things, stones will have to gather publics. So I end this section with the purely speculative. Perhaps what is needed here is a ritual gathering; a moment in time to mark radioactivity's absent presence? Perhaps indeed it is the date of a DGF's closure that should be marked? And perhaps, indeed, that timing might be coincident with solar temporalities? Perhaps, even, that timing might be the Summer Solstice, linking the stones that might mark a UK DGF with some of the most ancient of stones in the UK (Stonehenge), whose capacity to continue to gather

publics provides one of the most potent examples of the enduring capacity of material culture to attend to the immaterial.

5: Conclusions

At the heart of this paper is UK HAW, its projected future in a DGF, and an attempt to intervene in shaping that future, to arrest an anticipated abandonment through an alliance of onto-politics and material culture. Radioactive waste is one of the most established of techno-science controversies in the UK as well as one which, beyond the boundaries of West Cumbria at least, has been turned politically 'cold', through a combination of deliberation and policy formation. That makes it an entirely appropriate vehicle for making a concluding set of observations on the wider field of a politics of stuff.

Through the intricacies of the case, the paper demonstrates the difficulties that confront furthering onto-politics. It is one thing, then, to cite a parliament of things in words – in the Austin-ian sense of citational performativity. That is the manoeuvre performed by much work in the field, precisely because the key interlocutor for such work is political theory and philosophy. But is this enough? Can words alone admit things to the demos? Whilst some might continue to answer a 'yes' to that question, an emergent consensus would seem to say 'no'. Indeed, as Callon, Latour and their co-workers have shown, to admit things to the demos requires an active engagement with things, creativity, publics; a turn to public experimentation – or, to doing things with things not just doing things with words. Much by way of recent work on public experimentation addresses domestic, or consumer-facing, technologies (Braun & Whatmore, 2010). To attempt to keep the demos open to the unfinished qualities of radioactive waste however, is a different order task. To accomplish that requires advocates of onto-politics to engage in politics as practice. The ebb and flow of 'hot' and 'cold' politics is critical here. As the details of the case show, in the course of political settlement, or the transition from 'hot' to 'cold' politics, HAW has become still life. It has been tamed. So, in the course of doing politics with HAW what counts as the political slides all too easily away from onto-

politics to human-centred politics and ways of acting politically; leaving the stuff to be reclaimed by the very techno-centric discourses that first produced the controversy. That is a serious problem – and it may well be a problem that goes beyond the case of radioactive waste. So, how to respond?

On the basis of the paper, I make five suggestions. First, and unambiguously, to affect a politics of stuff requires an engagement with political settlements of techno-scientific controversies. These settlements need to remain open to the unfinished qualities of thing power if they are not to produce, down the line, a re-staging of the controversies that formed the launch pad for the development of onto-politics. This means, secondly, engaging not only in new controversies but also with old controversies and cold politics. Such situations are where controversy has been ground out to constitute consensual political settlements, often through the deliberative process. Radioactive waste is but one example here. Others would include GM, BSE and F&M. To go in this direction of travel implies, thirdly, an engagement 'upstream' with techno-science, but not just with new or emergent technologies (Rogers-Hayden and Pidgeon, 2007; Macnaghten, 2010). For much of the literature on a politics of stuff, the stuff of interest is 'downstream': technologies with a dense or experimental presence in everyday social life. This is to work with the becomings of what techno-science has already produced, rather than to address immanent things, as techno-scientific concepts and as provisionally assembled. So, that means, fourthly, that the immanent conceptual within techno-science emerges as a site for political intervention. Fifthly, the question this raises is: 'How to intervene in shaping that conceptual, in ways that are attentive to thing power?' There are various possibilities here but the one I find most productive, at least with respect to radioactive waste, is an alliance of onto-politics with MCS. It is relatively commonplace, particularly in geographical writing, to posit MCS as deficient to, or as in some sense running counter to, the more-than-human, and particularly to vital materialism. Such representations rest on a caricature, misunderstanding even, of MCS. A more nuanced reading shows that material culture is absolutely about the on-going, unfinished relation of the material and the immaterial – albeit with a human subject. It is for exactly

those reasons that material culture has been critical in manoeuvres that seek to admit things to the demos (Latour & Wieber, 2005). Keeping them there is likely to be no different.

Acknowledgements

This research was funded by the Economic and Social Research Council under The Waste of the World programme (RES 000-23-0007). My thanks to Neil Hyatt and Martin Stennett for allowing me to witness the experimental work of immobilisation; to Sellafield Ltd for access to Sellafield; to Karen Bickerstaff, Mike Crang, Romain Garcier, Lucy Norris and Dan Swanton for comments on an early draft; and to three excellent referees for their generous comments and respective pushes to revise the paper. The usual disclaimers apply.

References

Barad K, 2007, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* (Duke University Press: Durham NC).

Barry A, 2002, "The anti-political economy" *Economy and Society* **31**: 268 – 84.

Barthe Y, 2009, "Framing nuclear waste as a political issue in France" *Journal of Risk Research* **12**: 941 – 54.

Bennett J, 2004, "The force of things: steps toward an ecology of matter" *Political Theory* **32**: 347 – 72.

Bennett J, 2010, *Vibrant Matter: a political ecology of things* (Duke University Press: Durham NC).

Berkhout F, 1991, *Radioactive Waste: Politics and Technology* (Routledge: London).

BGS/NERC, 2010, *Managing Radioactive Waste Safely: Initial Geological Unsuitability Screening of West Cumbria: Non Technical Summary* Commissioned Report CR/10/072. British Geological Survey/Natural Environment Research Council http://westcumbriamrws.org

Bickerstaff K, forthcoming, ""Because we've got history here": radioactive waste, community volunteerism and the haunting of environmental politics" *Environment and Planning A*

Bickerstaff K, Lorenzoni I, Pidgeon N, Poortinga W, Simmons P, 2008, "Reframing nuclear power in the UK energy debate: nuclear power, climate change, mitigation and radioactive waste" *Public Understanding of Science* **17**: 145 – 69.

Bloomfield B, Vurdubakis T, 2005, "The secret of Yucca Mountain" *Environment and Planning D: Society and Space* **23**: 735 – 56.

Bolter H, 1996, *Inside Sellafield: Taking the Lid Off the World's Nuclear Dustbin* (Quartet Books: London).

Born G, Barry A, 2010, "Art-science: from public understanding to public experiment" *Journal of Cultural Economy* **3**: 103 – 19.

Braun B, Whatmore S, Eds. 2010, *Political Matter: Technoscience, Democracy and Public Life* (University of Minnesota Press: Minneapolis).

Bryan-Wilson J,2003, "Building a marker of nuclear warning", in *Monument and Memory, made and unmade,* Eds R Nelson, M Olin, (University of Chicago Press: Chicago) pp 183 – 204.

Burgess, J, Stirling A, Clark J, Davies G, Eames M, Staley K, Williamson S, 2007, "Deliberative mapping: a novel analytic-deliberative methodology to support contested science-policy decisions" *Public Understanding of Science* **16**: 299 – 322.

Callon M, Barthe Y, Lascoumes P, 2001, *Acting in an Uncertain World: An Essay in Technical Democracy* (MIT Press: Cambridge MA).

Chilvers J, 2008, "Environmental risk, uncertainty and participation: mapping an emergent epistemic community", *Environment and Planning A* **40**: 2990 – 3008.

Chilvers J, Burgess J, 2008, "Power relations: the politics of risk and procedure in nuclear waste governance" *Environment and Planning A* **40**: 1881 – 1900.

Clayden A, Dixon K, 2007, "Woodland burial: memorial arboretum versus natural native woodland? "*Mortality* **12** (3) doi 10.1.080/13576270701430700

Collins H, 1988, "Public experiments and displays in virtuosity: the core-set revisited" *Social Studies of Science* **18**: 725 – 48.

Cooke B, Kothari U, Eds.2001, *Participation: the new tyranny?* (Zed Books, London).

CoRWM (2006) *Managing Our Radioactive Waste Safely – CoRWM's Recommendations To Government July 2006*. Committee for Radioactive Waste Management http://corwm.decc.gov.uk/document (Document 700).

CoRWM (2008) *Review of Managing Radioactive Waste Safely: A Framework for Implementing Geological Disposal*. Committee for Radioactive Waste Management http://corwm.decc.gov.uk/document (Document 2431).

CoRWM (2009) *CoRWM Report to Government. Deep Geological Disposal of HAW – Consultation Draft*. Committee for Radioactive Waste Management http://www.corwm.decc.gov.uk/document store (Document 2550).

Davies G, 2006, "Mapping deliberation: calculation, articulation and intervention in the politics of organ transplantation" *Economy and Society* **35**: 232 – 58.

DEFRA/BERR (2008) *Managing Radioactive Waste Safely. A Framework for Implementing Geological Disposal* Department of Environment, Food and Rural Affairs/ Department for Business Enterprise and Regulatory Reform http://www.official-documents.gov.uk

Elam M, Sundqvist G, 2009, "The Swedish KBS project: a last word in nuclear fuel safety prepares to conquer the world?" *Journal of Risk Research* **12**: 969 – 88.

Elam M, Sunqvist G, 2011, "Meddling in Swedish success in nuclear waste management" *Environmental Politics* **20**: 246 - 63

FoE (Friends of the Earth), 2007, *Consultation Response to Managing Radioactive Waste Safely* http://www.foe.org/documents

Frickel S, 2004a, *Chemical Consequences: environmental mutagens, scientist activism, and the rise of genetic toxicology*. Rutgers University Press: New Jersey.

Frickel S, 2004b, "Just science? Organising scientist activism in the US environmental justice movement" *Science as Culture* **13**: 449 – 69.

Frickel S, 2008, "On missing New Orleans: lost knowledge and knowledge gaps in an urban hazardscape" *Environmental History* **13**: http:www.environmentalhistory, net/articles/13-4/Frickel.html

Frickel S, GibbonS, Howard J, Kempner J, Ottinger G, Hess, D, 2010, "Undone science: charting social movement and civil society challenges to research agenda setting" *Science, Technology and Human Values* **35**: 444 – 73.

Frickel, S, Bess Vincent M, 2007, "Hurricane Katrina, contamination, and the unintended consequences of ignorance" *Technology in Society* **29**: 181 – 88.

Gross M, 2007, "The unknown in process: dynamic connections of ignorance, non-knowledge and related concepts" *Current Sociology* **55**: 742 – 59.

Hallam E, Hockey J, 2001, *Death, Memory and Material Culture* (Berg: Oxford).

Haraway D, 2008, *When Species Meet* (University of Minnesota Press: Minneapolis).

Hecht G, 2001, *The Radiance of France: Nuclear Power and National Identity After WWII* (MIT Press: Cambridge MA).

Hecht G, 2006, "A cosmogram for nuclear things", *Isis* **98**: 100 – 8.

Hess D, 2009, "The potentials and limitations of civil society research: getting undone science done" *Sociological Inquiry* **79**: 306 – 27.

Kelleher L, Prendergast D, Hockey J, 2005, "In the shadow of the traditional grave" *Mortality* **10**: 237 – 50.

Krupar S, 2011, "Alien still life: distilling the toxic logics of the Rocky Flats National Wildlife Refuge" *Environment and Planning D: Society and Space* advance online publication

Latour B, 1988,*The Pasteurisation of France* (Harvard University Press: Cambridge MA).

Latour B,2004, *Politics of Nature: how to bring the sciences into democracy* (Harvard University Press: Cambridge MA).

Latour B, 2005, "From real politik to Ding politik, or how to make things public", in *Making Things Public: atmospheres of democracy* Eds B Latour, P Weiber (MIT Press: Cambridge MA) pp 14 – 41.

Latour B, 2008, "It's development, stupid!" or: How to modernize modernization", in *Postenvironmentalism*, Ed J Proctor, (The MIT Press, Cambridge MA) – available at http://www.bruno-latour.fr

Lee W, Ojovan M, Stennett M, Hyatt N, 2006, "Immobilisation of radioactive waste in glasses, glass composite materials and ceramics" *Advances in Applied Ceramics* **105**: 3 – 12.

Macfarlane A, 2003, "Underlying Yucca Mountain: the interplay of geology and policy in nuclear waste disposal" *Social Studies of Science* **33**: 783 – 807.

Macfarlane A, 2006a, "Technical policy decision making in siting a high-level nuclear waste repository", in *Uncertainty Underground* Eds A Macfarlane, R Ewing (MIT Press: Cambridge MA) pp 85 – 99.

Macfarlane A, 2006b, "Uncertainty, models and the way forward" in *Uncertainty Underground: Yucca Mountain and the nation's high-level nuclear waste* Eds A Macfarlane, R Ewing (MIT Press: Cambridge MA) pp 393 400.

Macfarlane A, Ewing R. Eds. 2006, *Uncertainty Underground: Yucca Mountain and the Nation's High-level Nuclear Waste* (MIT Press: Cambridge MA).

Macnaghten P, 2010, "Researching technoscientific concerns in the making: narrative structures, public responses and emerging nanotechnologies" *Environment and Planning A* **42**: 23 – 37.

Maddrell A, Sidaway J, Eds. 2010, *Deathscapes: Spaces for Death, Dying, Mourning and Remembrance* (Palgrave: Aldershot).

Miller D, 2011,"A material culture approach to transcendence" *Journal of Material Culture* **16**: 325 – 8.

NDA, 2010a, *NDA Draft Business Plan 2011 – 14* Nuclear Decommissioning Agency http://www.nda.documents

NDA,2010b, *How a UK Geological Disposal Facility for Radioactive Waste Could Look*. Transcript Nuclear Decommissioning Agency http://www.nda.documents

NDA, 2010c, *Geological Disposal: Steps Towards Implementation*. Nuclear Decommissioning Agency http://www.nda.documents

NII, 2010, *Sellafield, Calder Hall and Windscale West Cumbria Sites Stakeholder Group Report, 1 September – 30 November 2010* Nuclear Installations Inspectorate http://www.nda.documents

NWAA, 2010, *NWAA Technical Report* Nuclear Waste Advisory Associates http://www.nuclearwasteadvisory.co.uk

Oldroyd, D, 2002, "Nirex: the great denouement" http://davidsmythe.org/nuclear

Reno J, 2011, "Managing the experience of evidence: England's experimental waste technologies and their immodest witnesses" *Science, Technology & Human Values* **36**: 842 – 63.

Rogers-Hayden T, Pidgeon N, 2007, "Moving engagement "upstream"? Nanotechnologies and the Royal Society and Royal Academy of Engineering's inquiry" *Public Understanding of Science* **16**: 345 – 64.

Smyth D, 2011, Nuclear waste disposal: mainly UK, West Cumbria http://davidsmythe.org/nuclear

UK CEED, 1999, *Consensus Conference Main Report* UK Centre for Economic and Environmental Development http://www.UKCeed.org/engagement/consensus-conference

UK Nirex Ltd, 2005, *The Viability of a Phased Geological Repository Concept for the Long Term Management of the UK's Radioactive Waste* Nuclear Industry Radioactive Waste Executive (Nirex Report N/122).

West Cumbria Managing Radioactive Waste Safely,2010, *Public and Stakeholder Engagement Round 1 Report* http://www.westcumbriamrws.org/documents

Zonabend F, 1989, 1993 translation, *The Nuclear Peninsula* (Cambridge University Press: Cambridge).