# **Adjudicating Deep Time:** Revisiting the United States' High-Level Nuclear Waste Repository Project at Yucca Mountain

*Vincent F Ialenti*

This paper draws upon perspectives on legal personhood, expert knowledge-practices, and social relations influential in STS and anthropology to revisit the legal-procedural framing of the United States' now-defunct high-level nuclear waste repository project at Yucca Mountain. Specifically, it examines how this project reinvented both (a) conventional figures of legal personhood as what is called a 'reasonably maximally exposed individual' and (b) legal adjudication's familiar 'rule-facts-judge' template as a frame for establishing the repository licensing regime's delegation of roles, responsibilities, and duties in response to its unique regulatory horizons that extended millennia into the future. Unpacking the implications of these familiar legal figures being brought to bear on historically unprecedented 'deep' timescales, this paper concludes by offering alternative lines of inquiry for interdisciplinary analysis of nuclear energy and its associated waste products.

*Keywords:* nuclear waste, temporality, legal anthropology

## Introduction

Nuclear energy has, in recent years, seen increased visibility in both public and academic debates. For instance, Japan's 2011 Fukushima Daiichi nuclear reactor disaster (Kingston, 2012) and ongoing media reports of radioactive leakages from tanks at Washington's Hanford Nuclear Reservation (Johnson, 2013) have raised new concerns about nuclear energy technologies' risks. Meanwhile, countries such as India, China, Turkey, Russia, Finland, Vietnam, France, and the United Kingdom have developed new nuclear reactor initiatives, pushing forward what has been called a 'nuclear renaissance' (Kaur, 2011; Stuhlberg & Fuhrmann, 2013). This has, for some, restaged nuclear energy – which has comparatively low lifecycle carbon emissions relative to the steady and plentiful baseload energy supply it produces – as a pragmatic response to interrelated challenges of energy independence, climate change, and resource scarcity. In this context, the nuclear energy sectors of many countries – including France, Sweden, and the United States – weigh the potential

risks and rewards of investing in updates to extend the lives of existing nuclear power plants. Many also wait to see how Germany will move forward after its post-Fukushima pledge to phase nuclear out of its energy mix by 2022 (Patel, 2011). Such changes have led to realignments in environmentalist sentiment. Some have moved to oppose nuclear energy technologies, as in the case of a January 2012 meeting in which ten thousand experts, politicians, activists, academics, and stakeholders from around the world met in Yokohama, Japan to work concertedly toward "a world without nuclear power" (Jussila, 2012). Still others have moved to support nuclear energy, as prominent figures like Greenpeace co-founder Patrick Moore, scientist-environmentalist James Lovelock, and *Whole Earth Catalogue* founder Stewart Brand have come to comprise what some have called a "rise of the nuclear greens" (Bryce, 2013; Walsh, 2013).

So too has a "new urgency" been said to surround challenges that nuclear energy sectors across the world face in managing the high-level radioactive wastes (HLW) they generate (Galbraith, 2011). As HLW management programs in some countries have faced political gridlock or even all-out failure (see Solomon et al., 2010: 16-17) – as in the case of the Obama Administration's 2009 decision to abandon the United States' nuclear energy sector's longstanding plan to bury its spent nuclear fuel in a permanent geological repository beneath Nevada's Yucca Mountain (Ewing & Von Hippel, 2009) – others have made landmark progress. In 2011 and 2012, for instance, Swedish and Finnish nuclear waste management companies SKB and Posiva Oy submitted construction license applications to the countries' respective nuclear regulatory authorities for what might become the world's first permanent geological repositories for HLW (Posiva, 2011; MEE, 2012). Yet, even while the strategy of burying HLW in geological disposal facilities deep beneath the Earth's surface has achieved substantial international acceptance (NEA, 2009), no country has yet succeeded in licensing and operating such a facility. Hence, much of the 10,000m^3 of HLW generated globally every year can, at least for the foreseeable future, be expected to gradually accumulate in surface-level interim storage facilities located on-site at many of the more than 430 nuclear power plants operating in the world today (IAEA, 2013; WNA, 2013; 2014).

In this setting, approaches to understanding nuclear energy issues that have been influential in the field of Science & Technology Studies (STS) have become increasingly germane. Such literatures have, over the years, provided illuminating ways of reflecting on the broader contexts surrounding nuclear energy technologies. Some have, for instance, examined intersections of nuclear technologies and national identities by contextualizing them within the wider 'technopolitical regimes' (Hecht, 1998) or 'sociotechnical imaginaries' (Jasanoff & Kim, 2009) that constitute them. Others have scrutinized the rationalities of policy-making and public debate enacted in making societal decisions regarding nuclear energy (e.g. Wynne, 1982) or have reflected on the 'anthropological shocks' that nuclear power plant disasters may cause within modern 'risk societies' (see Beck, 1987; 2002; 2009; Irwin, 2000). Others have adopted more ethnographic approaches to study Ukraine's post-Chernobyl circumstances (Petryna, 2002) and to study everyday life in a French community that is home to a nuclear waste incinerator (Zonabend, 1993). Such research has expanded our understanding of what some might call nuclear 'cultures of energy' (Strauss et al., 2013) or 'energopolitics' (Boyer, 2011). In addition, it has provided rich ground from

which to take a step back and, as Hecht (2012) has done recently in her thorough study of the global uranium trade, reflect on just how technologies, markets, and substances come to acquire the tag 'nuclear' in the first place.

Approaches to understanding HLW management influential in STS and related disciplines have become increasingly germane as well, especially in the wake of the Yucca Mountain Project's recent stagnation. Such literatures have provided illuminating ways of analyzing HLW management issues in their broader contexts. For instance, Macfarlane (2003) has demonstrated how the 'co-production' of politics and scientific knowledge in the Yucca Mountain Project led to a shift from the U.S. Department of Energy (DOE) justifying the repository project based on site-specific geological evidence to justifying the project through appeals to engineering solutions. Meanwhile, other researchers – some self-identifying STS scholars, some not, but all working at the interface of HLW issues and society – have widened our understanding of the Yucca Mountain Project in many ways (see Macfarlane & Ewing, 2006). Such research has engaged themes ranging from issues of equity (e.g. Okrent, 1999) to repository site selection processes (e.g. Dunlap et al., 1993; Easterling & Kunreuther, 1995; Jacob, 1990; Short & Rosa, 2004; Solomon & Cameron, 1985). They have engaged themes ranging from the American federalist governance structure's implications for HLW disposal projects (e.g. Kearney & Garey, 1982) to comparisons of the Yucca Mountain case with disparate national HLW disposal regimes across the globe (e.g. Hamblin, 2006). And they have engaged themes ranging from contestations about scientific knowledge in public and policy domains (e.g. Endres, 2009) to risk perceptions and 'stigmas' about HLW in locales near and far from the Yucca Mountain site (e.g. Slovic et al., 1991).

Amidst this all, however, it has been noted that there remains a need to further pursue "cross- or transdisciplinary" methodologies and to "bring together the strength of STS with the effectiveness of the comparative methodology of economic history, geography, political science, or sociology" in analyses of HLW management (Solomon et al., 2010: 24). The present paper develops a case study of the Yucca Mountain Project that is inspired by such calls for further interdisciplinary, trans-disciplinary, or multi-disciplinary social scientific analyses of nuclear energy and its radioactive waste products. Its objective is to, by approaching the Yucca Mountain Project from an analytical vantage not yet tapped in these literatures, contribute to such efforts to analyze nuclear energy issues in their broader contexts from ever more standpoints. To do so, this case study juxtaposes selected perspectives from Anthropology, from STS, and from existing scholarship on the Yucca Mountain Project to revisit what is often seen as one of the most unsettling features of HLW management contexts like the Yucca Mountain Project: their extension of the timescales of law and risk governance one million years into the future (see Carter & Pigford, 2005; NEA, 2009). With regulatory compliance horizons stretching across the millennia (NRC 10 CFR § 63.321, 2013), the Yucca Mountain Project is indeed a zone of engagement with what physicist and science fiction author Benford (2000) or historian of science Rudwick (1992) might call 'deep time.' It is hence entangled with the ethical, epistemological, and temporal challenges of what Brand (1999) might call 'the long now.' In light of this, this case study revisits the Yucca Mountain Project as a site in which distant future societies, bodies, and environments are engaged—in which relations between the living societies of the present and the unborn societies imagined

to inhabit distant future worlds are made and remade (Ialenti, 2013).

I have opted to focus on HLW's seemingly unimaginable and incomprehensible timescales of hazard – and the epistemological, temporal, and ethical challenges they pose – in part because I believe that they are particularly amenable to analysis from a more anthropologically inflected standpoint. This is because anthropologists have had longstanding interests in examining the limits of the human intellect and imagination (Crapanzano, 2003). Anthropology has also seen recent turns toward exploring both "phenomena operating at the limits of calculation and measurement" (Holmes, 2009) and how "theoretical, technical and professional commitments" operate "at the limits of expert knowledge" (Miyazaki, forthcoming). In this sense, this case study of the Yucca Mountain Project's grappling with such immense timescales contributes not only to the existing nexus between STS and Anthropology engaging nuclear issues (e.g. Gusterson, 1996; Masco, 2010; Miyazaki, forthcoming; Petryna, 2002; Riles, 2013; Zonabend, 1993) but also to efforts to re-function anthropological modes of conceptualization (see Holmes & Marcus, 2005) to bring them to bear on contemporary debates about issues ranging from policy to technology, from science to finance (e.g. Fischer, 2009; Rabinow, 2008; Rabinow et al., 2008).

This case study is also inspired by commentaries on HLW's deep timescales put forth by scholars influential in STS. Shrader-Frechette (2005; 1993), for example, has made many arguments addressing issues ranging from intergenerational responsibility to the ethical and epistemological plausibility of the Yucca Mountain Project's efforts to discern multimillennial timescales through modeling practices. Bloomfield and Vurdubakis (2005) have cast the Yucca Mountain Project, with its unprecedented deep timescales, as a context of conceptual boundary making stretched to extremes. And Galison (2012) – reflecting on the novelties of the challenges HLW poses – has elaborated how "with a million years, you're talking not only about the possibility of political, linguistic, material processes, but biological evolutionary processes undergoing great changes". This paper aims to complement such commentaries by taking an alternate analytical route through some of the core temporal, epistemological, and ethical challenges posed by HLW. For one, rather than focusing on the marked novelty or lack of historical precedents available to guide HLW projects' efforts to reckon deep time, this paper focuses on some markedly conventional and historically-established *legal-procedural frames* that – despite undergirding the Yucca Mountain Project since the late 1970s and early 1980s – have long remained largely uncontroversial, undisputed, and unanalyzed within relevant literatures in STS, Anthropology, and related fields. The goal here is to make visible for scrutiny some of the most stable legal-procedural foundations upon which the Yucca Mountain Project has long been grounded despite their having remained largely off-the-radar in social scientific commentaries. In focusing on such figures of marked stability, this case study also distinguishes itself from the voluminous literature on the Yucca Mountain Project that, while rich, has tended to focus primarily on those aspects of the U.S.'s HLW management endeavors most wracked by socio-technical controversy, litigation, public opposition, and instability over the decades.

The present case study aims to situate the Yucca Mountain Project in a much broader historical frame by analyzing it through lens of legal-procedural frames that predate

the Atomic Age by centuries. To this end, it brings perspectives from Anthropology and STS to bear on some of the most enduring legal-procedural foundations enacted in the United States' nuclear waste 'regime'—its "set of integrated laws, organizations, and agencies, principles, norms, rules, and institutional procedures created to regulate and coordinate action for the disposal and management of radioactive wastes" (Solomon, 2009: 1012). To develop this analysis, I took cues from Latour's (2004) reflections on legal procedure in France's *Conseil D'Etat*, from Murphy's (1997) understanding of 'adjudication as a social practice and as a set of governmental techniques', and drew upon STS-inflected renderings of notions like 'black box' (see Latour, 1987; Jordan & Lynch, 1992: 77) and 'boundary object' (Star & Griesemer, 1989). To develop ways of articulating how certain aspects of the project's legal-procedural frames have entered into such immense spans of time and vice versa, I tapped anthropological perspectives on legal personhood (Douglas, 1995; Mundy & Pottage, 2004; Riles, 2011; Supiot, 2007) and on what anthropologists have termed processes of 'invention' and 'reinvention' (Robbins & Murray, 2002; Strathern, 2002; Wagner, 1981). In making visible these aspects of the Yucca Mountain Project, fresh sets of questions were revealed regarding legal knowledge, deep time, and nuclear risk. I suggest in this paper's concluding discussion that these alternate sets of questions ought to be broached in the future by scholars in STS, in anthropology, and in other social scientific fields that engage the Yucca Mountain Project, HLW's deep timescales, and nuclear energy issues broadly construed.

This paper is organized as follows. First, it presents an empirical overview of some of the historical and political backdrops to the Yucca Mountain Project's legal-procedural frames in order to provide context for the analysis I present in the latter half of this paper. Second, it analyzes how the American HLW disposal regime reinvented a classical figure of legal personhood as what is called a 'reasonably maximally exposed individual' to form a baseline standard according to which radionuclide exposures to distant future societies could be gauged. Third, it analyzes how the Yucca Mountain Project reinvented classical figures of legal adjudication – specifically, Euro-American legal thought's historically established relation between rule, fact, and judge – to establish a broad legal-procedural frame through which myriad experts', agencies', and managers' roles, responsibilities, and duties were to be orchestrated. In these sections, both the reasonably maximally exposed individual and the rule-facts-judge adjudicatory template are analyzed in light of the Yucca Mountain Project's markedly long-term compliance horizons that extended millennia into the future. Concluding, the paper reflects on the implications of the present case study for (a) interdisciplinary research trajectories analyzing nuclear energy and its associated waste products in general and (b) extant research on HLW disposal regimes like the Yucca Mountain Project in particular.

## Background

The United States' avenues for managing its HLW have, in recent years, reached something of a crossroads. Repeatedly mobilizing the term 'sound science' in support of the final repository that the DOE proposed to be built beneath Nevada's Yucca Mountain, few were surprised when former U.S. President George W. Bush approved the site just one day after former U.S. Secretary of Energy Spencer Abraham's official recommendation in February 2002 that it be used as a final disposal site (see

Macfarlane, 2003: 794; Vandenbosch & Vandenbosch, 2007: 44). However, just a few years later, the Obama administration declared the Yucca Mountain plan "no longer an option" in March 2009 and drastically slashed the project's funding for fiscal year 2010, allocating financial support only for the NRC's regulatory evaluation of the DOE's then recently submitted License Application for the facility's construction (Deutch et al., 2009: 11; DOE, 2008; Hebert, 2009). In late July 2009, U.S. Senate Majority Leader Harry Reid, a Nevada native and a longtime voice in the anti-Yucca movement, announced an agreement with the White House to discontinue the repository licensing procedure funding for fiscal year 2011. After decades of contestation between scientists, the public, academics, activists, politicians, and local coalitions, the high-level nuclear waste repository project at Yucca Mountain appeared to have been dismantled. Announced less than a decade apart from one another, the Bush and Obama administrations' polarized decisions are perhaps emblematic of the divided politics and epistemic contestations that increasingly challenge the country as it plods forward in the twenty-first century (cf. Conway & Oreskes, 2010).

Not long after the Yucca Mountain Project's collapse, the Blue Ribbon Commission on America's Nuclear Future was assembled to "provide advice, evaluate alternatives, and make recommendations for a 'new plan' to manage" the United States' HLW (Blue Ribbon Commission on America's Nuclear Future, 2012: i). The Commission submitted its final report in January 2012 after two years of examining how the United States can "go about establishing one or more facilities for permanently disposing of high-level nuclear wastes in a manner and within a timeframe that is technically, socially, economically, and politically acceptable". It did this by holding deliberative sessions, listening to expert and stakeholder testimonies, and visiting France, Japan, Sweden, Russia, Finland, and the UK to "learn first hand about their disposal programs". Affirming permanent geological disposal as a viable option for pursuing "integrated" management of the United States' HLW, the Commission stressed how "Americans have benefitted from the energy and deterrent capacity provided by nuclear technology for more than fifty years". It also stressed that America "cannot and must not continue to defer responsibility for dealing with the resulting high-level wastes and spent fuel" (Blue Ribbon Commission on America's Nuclear Future, 2012: ii-iii). Decisions are now left to actors in the United States' executive and legislative branches as to what will come of the Commission's recommendations.

These developments have an extensive backstory that, in the present section, will be reviewed broadly as it pertains to the legal-procedural frames that came to organize the Yucca Mountain HLW disposal regime over the decades. This story could begin with U.S. President Harry Truman signing the 1946 U.S. Atomic Energy Act, which transferred control of atomic energy from military to civilian hands and established the Atomic Energy Commission (AEC) as both promoter and regulator of nuclear power (see Shrader-Frechette, 1993: 2, 23). 1957 saw the publication of the AEC's and Oak Ridge National Laboratory's *Status Report on the Disposal of Radioactive Wastes* and of the National Academy of Sciences (NAS)'s and National Research Council's Committee on Waste Disposal's publication of their *The Disposal of Radioactive Waste on Land* report. That is when the United States begun considering deep geological disposal as a viable option for the long-term management of its HLW.

Years later, the 1975 U.S. Energy Reorganization Act responded to growing

public mistrust in a single agency serving the contradictory functions of simultaneously promoting and regulating nuclear power by dividing the AEC into two agencies: the U.S. Energy Research and Development Administration (ERDA) and the NRC. In 1976, the U.S. Environmental Protection Agency (EPA) was officially delegated the duty of developing dose-limit standards for nuclear waste-induced radionuclide exposure. One year later, the Interagency Review Group on Nuclear Waste Management (IRG) was established to assess the problem of HLW management (IRG, 1979). That same year, the 1977 U.S. Energy Organization Act formally abolished ERDA and transferred its duties to the newly established DOE (see Vandenbosch & Vandenbosch, 2007: 35). While relationships between these three agencies were complex over the decades that followed, the basic structure of this legal-procedural frame maintained until the project's recent stagnation: to generalize, *the NRC has been responsible for regulation and licensing, the EPA has defined radiation protection standards, and the DOE has been responsible for research, development, and the operation of repositories* (see Shrader-Frechette, 1993: 23).

In 1978, the DOE began investigating the viability of Yucca Mountain as a potential HLW repository site. Four years later in 1982, the U.S. Nuclear Waste Policy Act (NWPA) was established as the first piece of legislation specific to radioactive waste disposal, mandating permanent subsurface isolation of waste and establishing decision-making timetables for disposal. The NWPA delegated management and site characterization burdens to the DOE, the duty of setting dose-limit standards to the EPA, and licensing and enforcement responsibilities to the NRC. Financing programs through a Nuclear Waste Fund that levied at one mill ($0.001) for every kWh generated by commercial nuclear power plants, the NWPA also established the DOE's Office of Civilian Radioactive Waste Management (OCRWM) to oversee the repository site selection process (Craig, 1999). Directing the DOE to nominate five potentially suitable repository sites and recommend three to the President for characterization, the act prompted years of not-in-my-backyard politicking and whittling down of possible locations (Carter, 1987; Colglazier & Langum, 1988; Jacob, 1990). This culminated in the 1986 selection of three potential sites: Washington's Hanford Nuclear Reservation, the Nevada Test Site, and Deaf Smith County, Texas (Easterling, 1992). Around the same time, the DOE announced its decision to abandon its initial plans to build a second HLW repository somewhere in the Eastern U.S. (see Blowers et al., 1991: 212; Kraft & Clary, 1991). Since many saw this "surprise decision" as "politically motivated" in a context of "vociferous complaints from potential repository hosts in the East", a "backlash" from states in the Western U.S. on "social equity grounds" arose (Solomon, 2009: 1013).

By 1987, it became increasingly clear the NWPA timetables could not be met, that budgetary constraints would render characterization of three sites unrealistic, and that the DOE's shortlist would face acute political opposition. The subsequent NWPA Amendments Act resolved several disputes by selecting only one site for characterization – Yucca Mountain in the politically weak state of Nevada – sparking wide dissent from local coalitions assembling against what came to be known as the Screw Nevada Bill (see Vandenbosch & Vandenbosch, 2007: 41). This 1987 Amendments Act led to the construction of the on-site Exploratory Studies Facility, an underground laboratory accessible only through an eight-kilometer tunnel, to produce research aiding a site characterization project that the DOE hoped

would meet forthcoming EPA exposure limits (Cotton, 2006). Since then, the state of Nevada has worked for more than two decades to "challenge its political isolation" and "prevent a repository on all possible grounds" (Lemons et al., 1990; Solomon, 2009: 1013). In protest of what many saw as an inequitable imposition of an HLW repository on a politically weak state that in fact had no nuclear power plants of its own, Nevada's legislature passed a 1989 bill that made HLW disposal illegal within its borders (Kunreuther et al., 1990). Since then, Nevada's Agency for Nuclear Projects has introduced several lawsuits aimed at halting the Yucca Mountain repository project (see Solomon, 2009: 1019). Amidst all this politicking, as Bloomfield and Vurdubakis (2005: 739, 742) have noted, the temporal question of how to contain HLW's deep timescales of risk has transformed into a spatial question of "where can the waste be placed?" and of the DOE's capacity to ensure that the HLW "must remain inside the canisters, the canisters must remain inside the repository, the mountain must remain above, the water table must remain below, and the desert must remain around it". In asserting its imperative to contain HLW within and across space, the U.S. nuclear risk governance regime presented itself as it long has in many other contexts: "as a responsible regulator of a potentially runaway technology that demands effective 'containment'" (Jasanoff & Kim, 2009: 119, 130).

The U.S. Energy Policy Act of 1992 clarified the EPA's role in setting standards by directing it to issue health-based radionuclide dose-limits for human bodies within a chosen timescale of compliance. It also mandated that the EPA take into account NAS "recommendations on reasonable standards for protection of public health and safety" (Vandenbosch & Vandenbosch, 2007: 42; NEA, 2009: 119). In June 2001, the EPA released standards establishing dose-limits of fifteen millirems (mrem) per each 'reasonably maximally exposed individual' within a compliance timescale of ten thousand years. These standards were remanded in a 2004 ruling of the U.S. Court of Appeals for the District of Columbia Circuit citing the EPA's failure to heed recommendations of a 1995 NAS report (Reblitz-Richardson, 2005; Shrader-Frechette, 2005). This study suggested that compliance timescales must be extended beyond the time of peak dosage occurring hundreds of thousands of years in the future (Carter & Pigford, 2005). In late 2008, the EPA released a final two-tiered dose-limit requiring exposure to fall below fifteen mrems per year within a ten thousand year compliance timescale, and below one hundred mrems per year within a one million year compliance timescale (NRC 10 CFR § 63.321, 2013). At this time, the question of when and if the Yucca Mountain repository would go into operation remained open as "scientific uncertainty… national and state politics" and "continued legal wrangling" had long imposed delays on the project. As Barry Solomon (2009: 1020) has noted, "[f]irst there was the legislative mandate for the DOE to open the first HLW repository in 1998, then 2010 and 2012 were proposed, and more recently the plan was to open the facility in 2017".

The sections that follow analyze how, despite such ongoing scientific, political, public and legal contestation, this nuclear waste regime remained all the while grounded on a familiar set of legal-procedural frames. These frames are noteworthy in their remaining relatively stable in orchestrating myriad experts', agencies', and managers' roles, responsibilities, and duties over the years. This is perhaps why they have also remained quietly outside of critical, academic, and media debates. In response to this, the next

sections flesh out these legal-procedural frames analytically with the aim of opening them to greater attention, understanding, and scrutiny by scholars in STS, in Anthropology, and in related fields. Of specific interest is how such conventional legal figures maintained unimposingly in the backdrop of a technoscientific regime assumed by many to be novel given its reckonings of historically unprecedented timescales. Turning analytical attention to these aspects of the Yucca Mountain Project brings an alternate depiction of it into view. The implications of this will be unpacked in the concluding discussion.

## Legal Personhood Exposed

It is often noted how the development of nuclear power has left humanity to cope with waste products bearing risks that extend distantly into the future. Elements like plutonium-239 and neptunium-237, for instance, boast half-lives of 24,100 years and 2.1 million years respectively. Therefore, they impose burdens of long-term stewardship on the risk governance regimes delegated as custodians of nuclear power plants' atomic refuse. Such has led to the development of novel practices of long-term scenarios forecast, risk analysis, and stewardship in nuclear waste regimes across the world. In December 2012, for example, Finnish nuclear waste management company Posiva Oy submitted its construction license application and Safety Case for its prospective geological repository to be built deep beneath Western Finland's island of Olkiluoto. Its goal was to demonstrate to the country's Ministry of Employment and the Economy (MEE) and Radiation and Nuclear Safety Authority (STUK) that radiation doses to future populations are unlikely to exceed legally defined radionuclide human exposure limits (MEE, 2012). Taking into account numerous technical models of distant future geological, ecological, and social conditions in the Olkiluoto region to get a sense of the interactions that will occur there over the next few hundred thousand years (Hjerpe et al., 2009), some experts involved with the project investigated topics like 'Climate scenarios for Olkiluoto on a Time-Scale of 120,000 Years' (Pimenoff et al., 2011). Others examined potential earthquakes that might occur as massive glaciers retreat from the region following the next Ice Age (Fälth & Hökmark, 2012).

As in Finland's HLW disposal regime, the United States' now-defunct Yucca Mountain Project too developed computer simulations and technical modeling practices to reckon distant future worlds. In that context, Monte Carlo and Total System Performance Assessment (TSPA) predictive modeling techniques were redeveloped to meld myriad individual subsystem models into composite meta-models. They then laid out probability distributions for many possible future events, assigned them potential sequences, and ran random samples of uncertain parameters that resulted in a number of unique radionuclide dose projections for a body matching the legal definitions of what was called a *reasonably maximally exposed individual* (Macfarlane & Ewing, 2006: 21; Vandenbosch & Vandenbosch, 2007: 110; Whipple, 2006: 60). This reasonably maximally exposed individual was the hypothetical human body according to which the Yucca Mountain Project regime gauged the potential for hazardous radionuclides emanating from the buried HLW to trigger adverse health effects among exposed individuals in futures near and distant. As such, it was legally presumed by the NRC to have the attributes of a present-day human living above the "highest concentration of radionuclides in the plume of contamination", who has the same diet and lifestyle of present residents of the nearby town of Armagosa Valley, who

drinks two liters of well water per day, and is an "adult with metabolic and physiological considerations consistent with present knowledge of adults" (U.S. NRC 10 CFR § 63.312, 2013).

As the legally defined beneficiary according to which the final TSPA models were to evaluate expected radionuclide dosages, this hypothetical body operated as something akin to what an STS scholar might call a 'boundary object' (Star & Griesemer, 1989) to facilitate coordination among the diverse teams of experts involved with the project. Its purpose was to provide a standard according to which statistical curves plotting an individual body's expected annual dose over time could be generated to assess compliance with legally defined human radionuclide exposure maximums (see Vandenbosch & Vandenbosch, 2007: 110-1). With this in view, it becomes apparent how the Yucca Mountain regime came to (a) structure predictive models of the region surrounding the proposed repository site, (b) define radionuclide exposure dose-limit standards, and (c) gauge the prospective repository's safety in light of its future impacts on human health each according to the legal definitions constituting this *hypostatization of a single human body*. And, by way of this legal figure, the end-goals of each of these safety assessment procedures were framed as measures to protect a legal reification of what anthropologists might call the unitary liberal subject, the modern rights-bearing individual, or the bounded legal person (Douglas, 1995; Pottage & Mundy, 2004; Supiot, 2007: 3-29). Hence, it would seem that the Yucca Mountain Project extended into million-year timescales the most familiar *telos* guiding nearly every Euro-American governance project. That is, by taking society to be a journeying unity progressively "going somewhere"—toward greater satisfaction of the needs, rights, happiness, choices, and safety of the *individual* subject enabled according to the Kantian imperative of being treated as an *end* in itself (Strathern, 1996: 37-39).

The Yucca Mountain Project's grappling with deep time can thus be seen as grounded on classical figures of legal personhood or of Euro-American unitary selfhood. It can also be seen to have adapted or – to use a term very familiar to anthropologists – 'reinvented' (see e.g. Hobsbawmn & Ranger, 1983; Robbins & Murray, 2002; Strathern, 2002; Wagner, 1981) this hypothetical person to extend its existence into the multi-millennial futures that the nuclear waste regime gazed upon. In its reinventing the figure of the legal person as a reasonably maximally exposed individual, the Yucca Mountain Project can be seen as just one more context in which humans have gone to lengths to – to quote Huen (2009: 161) reflecting on the contributions of anthropologists Wagner and Strathern – "concretize *new* knowledge *from* what is already known". As such, an anthropologist might see the Yucca Mountain Project as just another site in which humans have drawn upon fragments of the past to reinvent them in the present to serve new purposes in new contexts. With this in view, the next section will turn to another set of legal-procedural figures that have long grounded the American HLW disposal regime. Specifically, it will revisit the Yucca Mountain Project by focusing on a familiar template of adjudicatory process that organized the regime's efforts to protect this reasonably maximally exposed individual from radioactive harm for the radical long-term.

## Adjudicating Deep Time

The Yucca Mountain Project regime empowered the EPA to produce *rules* in the form of radionuclide dose-limit regulatory

standards, the DOE to produce *facts* in the form of million-year technical models, and the NRC to *judge* DOE models according to EPA standards. In practice, this meant that the DOE developed a License Application – thousands of pages long – containing safety analyses, environmental impact statements, descriptions of engineering strategies, and projections of the distant future conditions of the region to surround what is today called Yucca Mountain (DOE, 2008). This pile of technical evidence was then handed-off to the NRC in June 2008 for docketing, hearings, and regulatory review. From then on, the NRC's duty was to judge whether to authorize the Yucca Mountain repository's construction. In March 2009, the NRC formally implemented the EPA's updated set of radiation protection standards developed to protect the reasonably maximally exposed individual throughout multi-millennial futures.

While the NRC's review process commenced upon the License Application's submission, it was halted in September 2011 in light of the Obama Administration's decisions against the Yucca Mountain Project. The review process seemed then to be fated to remain stagnant. This changed in August 2013 when the U.S. Court of Appeals for the District of Columbia ruled that the NRC was "simply flouting the law" by stopping the review procedure and that the NRC still has the duty to determine whether to "approve or reject the Energy Department's application". The appeals court also noted that "[t]he president may not decline to follow a statutory mandate or prohibition simply because of policy objections" (Daly, 2013). Regardless of what the future holds for the License Application review process, its details reveal much about how the Yucca Mountain Project regime adjudicated deep time in practice prior to the 2011 halt or hiatus:

> Once the application was docketed, the NRC's technical staff in the Office of Nuclear Material Safety and Safeguards initiated a detailed, thorough and comprehensive review. This review involves more than 100 staff and contractor employees with expertise in several technical and scientific disciplines, including geochemistry, hydrology, climatology, structural geology, volcanology, seismology and health physics, as well as chemical, civil, mechanical, nuclear, mining, materials and geological engineering. Staff members at NRC's headquarters in Rockville, Md., the Region IV office in Arlington, Texas, and the NRC's Las Vegas office are participating. The Center for Nuclear Waste Regulatory Analysis in San Antonio, Texas, a federally funded research and development center, will provide technical assistance to the NRC. Throughout the review, the NRC staff will request additional information from DOE to help clarify the application… At the completion of its technical review, the NRC staff will issue a Safety Evaluation Report (SER) containing its findings on the repository design. The SER will determine whether the proposed facility will meet NRC regulations to protect public health and safety and whether construction of the facility may be authorized. (NRC, 2012.)

Alongside this were to be held adjudicatory hearings conducted by the NRC's Atomic Safety and Licensing Board Panel (ASLB) (NRC, 2013). The ASLB, composed of judges versed in technical or legal expertises of various kinds, was to appoint judicial boards to hear 'contentions.' Contentions admitted by the NRC generally posed technical or legal concerns with the DOE's application. Twelve groups, each wishing to be admitted as parties involved in the hearings process,

filed 319 contentions in total. Evidentiary hearings – in which interested parties would conduct cross-examinations, put forth arguments, and present witnesses – were also to be a critical part of this legal procedure. In those hearings, ASLB judges were to listen to evidence and to make judgments regarding contestations of technical aspects of the DOE's application or of existing NRC decisions. These were to be supplemented by 'limited appearance' sessions, which temporarily offered the floor to members of the public offering oral or written statements about the repository project. Final decisions about contentions, if appealed, would then be sent to a U.S. Court of Appeals (NRC, 2012).

By reflecting on the broader legal-procedural frames underlying this regulatory review process, one can begin to see how the Yucca Mountain Project moved to contain such distant future timescales by drawing from a rather conventional repertoire of legal figures. Indeed the licensing procedure for building the repository took as its conceptual foundation a systematically reproduced formula of legal adjudication. This adjudicatory formula required, as noted, a set of fixed textual *rules* (as EPA exposure standards), situation-specific *factual evidence* (as developed in the DOE's License Application), and a dispassionate judge responsible for rendering *judgment* (in this case, the NRC) (see Latour, 2004: 102; Murphy, 1997: 42, 56). Hence, it would seem that this rule-facts-judge template – a familiar, perhaps even archaic, figure of legal form – has been transposed rather straightforwardly to organize the Yucca Mountain Project's nuclear waste repository construction licensing procedure in accordance with the conventions of modern bureaucratic delegation. In such modern bureaucratic contexts, it has been noted, practices of "modeling decision processes on ordinary and familiar court systems" are commonplace (Murphy, 1997: 57).

The Yucca Mountain Project, hence, responded to the novel multi-millennial challenges to safely burying HLW by reproducing a legal formula that is, quite literally, ancient. After all, law's rule-facts-judge formula has maintained throughout a long Euro-American legal history in which, to quote Murphy, "the occasional brilliant *apercus* of the Roman jurists… were torn out of the context of the concrete cases of the Pandects and were raised to the level of ultimate legal principles from which deductive arguments were to be derived". Subsequently, Euro-American legal history is said to have seen the coalescence of "purely systematic categories" in which "definitely fixed legal concepts in the form of highly abstract *rules* are formulated" and repeatedly applied to "a set of *facts* disclosed through logical analysis". The result was a "legal unification and consistency" that solidified contextual facts and context-transcending rules as the two variables that must be present if legal judgment is to be performed with legitimacy (Murphy, 1997: 42). Hence today, as Latour has noted, legal adjudications of many varieties require the establishment of "a domain of unquestionable *fact* as quickly as possible… so that it can be subsumed to a *rule* of law… in order to produce *judgment*" (Latour, 2004: 102; Murphy, 1997: 56).

An STS scholar might approach this rule-facts-judge template as one of Euro-American law's cardinal *black boxes*—as a *step* that is "unspoken, unexplored, used ritualistically" and "otherwise taken-for-granted" in its routine enactments. If a black box is understood to be but a preliminary "means for setting up more interesting phases" of an expert practice (Jordan & Lynch, 1992: 77), then perhaps one can say that law's rule-facts-judge template has, over the centuries, served as but a preliminary

means for setting up more interesting phases of legal judgment and evidence discovery in countless adjudicatory contexts across the world. In light of this, one might suggest that the function of this rule-facts-judge template is to simplify the messy complexities of reality into something more comprehensible and hence more amenable to legal adjudication. Thus, this rule-fact-judge template could be construed as but one of law's reductive "devices for making decisions in conditions of uncertainty" to fashion "crude, pragmatic, instruments of probabilistic reasoning" to facilitate judgment (Pottage, 2004: 12).

If such is the case, then the specific pragmatic legal device enacted to uphold the rule-facts-judge template is law's postulate that the 'corporation is a person'—law's consciously fictive assertion of unitary personhood upon complex networks of actors that rarely, in actuality, fit neatly into static boundaries of any kind. Still, in the universe of law, as it is often noted by legal anthropologists, corporate entities are held to be "simple, steady, singular and unchanging… marked by a highly rigid division between inside and outside" (Riles, 2011: 39). The same can be said of how the EPA, the DOE, and the NRC were hypostatized when wedged into their respective positionalities within law's familiar rule-fact-judge template. That is, in the Yucca Mountain Project's repository licensing procedure, the DOE, the EPA, and the NRC were reified respectively *as* fact-producer, *as* rule-definer, and *as* judge. To this end, experts who participated in this adjudicatory ritual, at least in theory, were required to act as if such was actually the case. They were to perform their fidelity to the 'purifications' and 'separations' (Latour, 1993) wedged between these legally discrete agencies that endowed the broader adjudicatory procedure with its semblance of coherence.

Indeed, as in any exercise of legal judgment in any of the past few centuries, *litigants* cannot legitimately be empowered to *judge* their own cases, *legislators* cannot be legitimately empowered to interpret their own *rules*, and a *judge* cannot be personally involved in the disagreements of the *litigants* he or she is to impartially oversee. To cross lines drawn between rule, facts, and judge – or, in this case, for an expert to cross boundaries between his or her allegiance to either the EPA, the DOE, or the NRC – would imply corruption, conflict of interest, or some illicit sort of inter-agency capture. The three entities must, therefore, be imagined as separate and singular, each fulfilling particular roles and functions vis-à-vis one another. All three agencies must be present, functional, and purified and separated off from one another if legal judgment is to be undertaken in conformity with legal protocol. Such could be understood as a reinvention of this classical legal adjudicatory template on a new, perhaps novel, terrain. This is because the rule-facts-judge figure organizing the Yucca Mountain Project repository licensing procedure framed legal judgment precisely as it has framed legal judgment throughout the ages. It is on these legalistic grounds, ancient in origin, that this American nuclear waste regime established that repository licensing decisions be hashed out.

With all this in view, the Yucca Mountain Project, while gazing at radically distant futures, can be seen as bound to legal adjudicatory templates that predate the Atomic Age by centuries. From this perspective, the formal legal-procedural layout of a risk governance project that presents itself as distinctly modern or novel can be seen to rest inextricably on a legal relation between rule, fact, and judge that presents itself as strikingly ancient or conventional. This reveals a legal-

procedural formula with great historical precedent underlying a risk governance endeavor assembled in response to imperatives to render seemingly historically unprecedented timescales intelligible. And, perhaps in the same way that familiar figures of legal personhood were reinvented as the Yucca Mountain Project's reasonably maximally exposed individual, a seemingly ancient legal adjudicatory template seems to have been reinvented to organize a HLW disposal regime with ambitions to reckon distant future worlds. Revisiting the Yucca Mountain Project from this perspective brings into view new sets of questions that will be fleshed out in the discussion that follows.

## Discussion

This case study began with a brief historical outline of the legal-procedural frame that came to organize the HLW disposal regime at Yucca Mountain. Next, inspired by anthropological perspectives on legal personhood, expert knowledge-practices, and social relations, it examined how this regime reinvented familiar figures of legal form in response to its novel mandate to demonstrate repository safety in regulatory horizons that extended 10,000- and 1,000,000-years into the future. In so doing, it focused on how the Yucca Mountain Project reinvented figures of the unitary legal person and of the tripartite rule-facts-judge adjudicatory relation to ground its legal-procedural frame. Both of these examples brought into view how – despite the aura of idiosyncrasy long enchanting the radically distant futures the Yucca Mountain Project engaged – the regime could be cast as just another venture in which humans draw upon fragments of the past to reinvent them to serve new purposes in new contexts. As Strathern (1995: 428) has noted in a similar vein, if "we see present-day cultures as the offspring of past ones, we see new combinations forever being put together out of old cultural elements". This case study hence demonstrated how the Yucca Mountain Project, presented often as somehow idiosyncratic (e.g. Bloomfield & Vurdubakis, 2002) or historically unprecedented (e.g. Beck, 2002: 40; Benford, 2000), is entangled with processes of invention and reinvention that have long been constitutive of the human experience.

More than just an extreme variant of the paradigmatic problem of contemporary 'risk society' – that is, to "predict the unpredictable, to communicate beyond the limits of language, and to bind that which respects no boundaries" (Bloomfield & Vurdubakis, 2002: 752-753) – this case study recast Yucca Mountain Project as having precedents entrenched millennia before key elements of risk society's 'new modernity' are said to have coalesced (see Beck, 1992; 2009). More than resting on governance conventions of public hearings and of technocratic policymaking that have contoured decision-making in capitalist democratic states in the twentieth and twenty-first centuries (see Wynne, 1982), this case study fleshed out how the Yucca Mountain Project communed with a deeper structure of legal-procedural form established in eras past. More than just caught up in national 'sociotechnical imaginaries' like those Jasanoff and Kim (2009) noted in the United States and South Korea or the nationalistic 'technopolitical regimes' observed by Hecht (1998) in France, this case study demonstrated how U.S. nuclear risk governance has been tethered to legal-procedural figures that predate the concept of the nation-state (see Branch, 2011). More than just a matter of ethics, responsibility, or epistemology (e.g. Shrader-Frechette, 1993; 2005), this case study revisited the Yucca Mountain Project with an alternate focus on legal personhood,

legal-procedural form, and expert knowledge-practices. Doing so has unveiled fresh conceptual space in which further social, historical, or cultural research on HLW disposal regimes or on nuclear energy broadly construed could be developed at the nexus of STS, Anthropology, and related fields. Following Solomon et al. (see 2010: 16-17) in advocating more interdisciplinary humanistic and social scientific research on such topics, I conclude now by listing three potentially generative lines of inquiry that developing this case study of the Yucca Mountain Project has unveiled.

First, it has made apparent how revisiting the Yucca Mountain Project as a zone of engagement with distant future societies, bodies, and environments can reveal it as a potentially apt object of comparison with other zones of engagement with distant future societies, bodies, and environments. It could, in other words, be taken as but one context to be juxtaposed with other contexts in which relations between the living societies of the present and the unborn societies imagined to inhabit distant future worlds are invented and reinvented. For example, as carbon emissions reduction programs are increasingly informed by risk projections plotting climate change futures in centurial timeframes, new governmentalities are increasingly assembled to temper irreversible depletions in biodiversity and extractions that alter ecosystems indefinitely. As sustainability discourses increasingly situate entire populations in wider timescales of intergenerational planning and responsibility, regulators and bioethicists increasingly grapple with prospects of emerging human enhancement technologies that may not only alter the tempo of our gradual natural evolution, but could also render irreversible effects on our descendants in futures both near and distant (Bainbridge & Roco, 2003). With contexts like these in view, the Yucca Mountain Project can be recast as but part of a broader historical moment in which human inclinations to know, to destroy, and to protect are increasingly drawn into previously untapped futures. This historical moment could hence be cast as a response to unprecedented rates of resource extraction, anthropogenic manipulation of the environment, population increase, and expansion in technological capacity. In this sense, this paper has laid ground for analyzing the Yucca Mountain Project not only in comparison with the HLW disposal regimes of other nations, but also with other contexts of similarly longsighted risk governance that have emerged elsewhere in the world.

Second, it has carved out analytical space for examining (a) if and how reinventions of familiar figures of legal, scientific, ecological, or technocratic knowledge are unfolding in other contexts of engagement with markedly deep timescales and (b) whether and how such reinventions could be tapped to improve HLW disposal projects' initiatives to engage similarly deep timescales. Presently, for instance, strategies to extend the ambit of risk governance far into the future are being cultivated in contexts like the RAND Corporation's Pardee Center for Longer-Range Global Policy and the Future of the Human Condition, Cambridge University's Centre for the Study of Existential Risk, Oxford University's Future of Humanity Institute, and Stewart Brand's The Long Now Foundation. They have also been cultivated in more idiosyncratic projects like Norway's Svalbard Global Seed Vault, which was designed to preserve millions of seeds in a "doomsday" chamber to "safeguard the world's crops from future disasters such as nuclear wars" and to create a genetic "back-up" of Earth's reserves of plant life in the face of rampant extinctions and climate shifts (BBC News, 2007). With projects like these in view, context is revealed for research

on the reinventions of familiar conceptual figures as they emerge in other contexts of marked long-termism. The goal here would be to explore whether insights garnered amidst similar reinventions unfolding elsewhere could be drawn upon to optimize approaches currently being developed to govern distant future timescales in HLW disposal regimes.

Third, it has perhaps revealed additional clues as to how and why the United States' ambitiously longsighted HLW disposal program ultimately succumbed to conditions so tethered to the here and now. Indeed it is uncertain whether, in the twenty-first century United States, *any* technoscientific project predicated on such conventional or even archaic figures could survive the three decades of political onslaught and epistemic contestation that eroded the Yucca Mountain Project over the years. More specifically, it poses the question of whether the regime's (over) extension of such familiar figures of legal form to encompass such unfamiliar distant future timescales ought to be construed as a response imaginative enough to effectively govern the protracted timescales that it was assigned by law to govern. As an example, while the rationale for reinventing the liberal legal person as a reasonably maximally exposed individual to forge a bottom line standard according to which repository safety was to be gauged might seem self-evident today, it is unclear whether societies thousands of years from now would instead opt to enable entirely different abstract beneficiaries. In other words, rather than working toward enabling a hypothetical individual, perhaps distant future societies would instead frame the HLW disposal project as enabling, say, hypothetical ecosystems, hypothetical human collectives, or sustainable life in general. Or perhaps they would see themselves as enabling conceptual figures of which societies of the present cannot yet conceive.

## Acknowledgements

Some of this material is based upon work supported by U.S. National Science Foundation Graduate Research Fellowship Grant #2011129751. I thank Brian Escobar, Doug Holmes, Marianna Keisalo, Roberto Kersevan, Maarit Laihonen, Amy Levine, Mike Lynch, Martha Mundy, Johan Munck af Rosenschöld, Alain Pottage, Josh Reno, Annelise Riles, Antti Silvast, and the article's anonymous reviewers for their critical comments at various stages of this project. I also thank participants at the Second Aalto Event on Science & Technology Studies: Energy in Society – especially those who attended the 'Nuclear Energy and Nuclear Waste Management I: Expert Practices' session – for their feedback in Helsinki, Finland in November 2012. I thank participants at the 'Disaster Risk Techniques: Practices of Use, Critiques and Reinventions' session of the European Sociological Association meeting in Torino, Italy in August 2013 for their feedback as well.

## References

AEC (U.S. Atomic Energy Commission) (1957) Status Report on the Disposal of Radioactive Wastes (Oak Ridge, TN: Oak Ridge National Laboratories).

Bainbridge, W. & M. Roco (2003) Converging Technologies for Improving Human Performance: Nanotechnology, Biotechnology, Information Technology and Cognitive Science (New York: Springer Press).

BBC News (2007) 'Doomsday Vault Brings Deep Freeze'. http://news.bbc.co.uk/2/hi/science/nature/7097052.stm, 16.11.2007.

Beck, U. (1987) 'The Anthropological Shock: Chernobyl and the Contours of the Risk Society', Berkeley Journal of Sociology 32: 153-165.

Beck, U. (1992) Risk Society: Towards a New Modernity (London: Sage).

Beck, U. (2002) 'The Terrorist Threat: World Risk Society Revised', Theory, Culture & Society 19(4): 39-55.

Beck, U. (2009) World at Risk (Hoboken, NJ: Blackwell Publishing).

Benford, G. (2000) Deep Time: How Humanity Communicates Across Millennia (New York: Harper Perennial).

Bloomfield, B. & T. Vurdubakis (2005) 'The Secret of Yucca Mountain: Reflections on an Object In Extremis', Environment & Planning: Society & Space 23(5): 735-56.

Blowers, A., Lowry, D., & B. Solomon (1991) The International Politics of Nuclear Waste (London: Macmillan).

Blue Ribbon Commission on America's Nuclear Future (2012) Disposal Subcommittee Report to the Full Commission: Updated Report. http://brc.gov/sites/default/files/documents/disposal_report_updated_final.pdf. 01.07.2014.

Boyer, D. (2011) 'Energopolitics & the Anthropology of Energy', Anthropology News 53(5): 5-7.

Branch, J. (2011) 'Mapping the Sovereign State: Technology, Authority, and Systemic Change', International Organization 65(1): 1-36.

Brand, S. (1999) The Clock of the Long Now: Time and Responsibility (New York: Basic Books).

Bryce, R. (2013) 'Rise of the Nuclear Greens', Washington Examiner. http://washingtonexaminer.com/robert-bryce-rise-of-the-nuclear-greens/article/2523570. 07.03.2013.

Carter, L. (1987) Nuclear Imperatives & Public Trust: Dealing with Radioactive Waste (Washington, DC: Resources for the Future).

Carter, L. & T. Pigford (2005) 'Proof of Safety at Yucca Mountain', Science 310(5747): 447-8.

Colglazier, E.W. & R. Langum (1988) 'Policy Conflicts in the Process for Siting Nuclear Waste Repositories', Annual Review of Energy 13: 317-57.

National Research Council's Committee on Waste Disposal (1957) The Disposal of Radioactive Waste on Land (Washington, DC: U.S. National Academy of Sciences & U.S. National Research Council).

Conway, W. & N. Oreskes (2010) Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming (New York: Bloomsbury Publishing).

Cotton, T. (2006) 'Nuclear Waste Story: Setting the Stage', in A. Macfarlane & R. Ewing (eds), Uncertainty Underground (Boston: MIT Press): 29-45.

Craig, P. (1999) 'High-Level Nuclear Waste: The Status of Yucca Mountain', Annual Review of Energy & the Environment 24: 461-68.

Crapanzano, V. (2003) Imaginative Horizons: An Essay in Literary-Philosophical Anthropology (Chicago: University of Chicago Press).

Daly, M. (2013) 'Appeals Court: Obama Violating Law on Nuke Site'. http://www.boston.com/news/nation/2013/08/13/appeals-court-obama-violating-law-nuke-site/PDVfdM5SQRGPG6d3S6jobO/story.html. 08.08.2013.

Deutch, J., Forsberg, C., Kadak, A., Kazimi, M., Moniz, E. & J. Parsons (2009) Update of the 2003 Future of Nuclear Power Study. http://web.mit.edu/nuclearpower/pdf/nuclearpower-update2009.pdf. 01.07.2014.

DOE (U.S. Department of Energy) (2008) DOE's License Application for a High-Level Waste Geologic Repository at Yucca Mountain. http://www.nrc.gov/waste/hlw-disposal/yucca-lic-app.html. 16.12.2013.

Douglas, M. (1995) 'The Cloud God and the Shadow Self', Social Anthropology 3(2): 83-94.

Dunlap, R., Kraft, M.E., & E. Rosa (1993) Public Reactions to Nuclear Waste: Citizens' Views of Repository Siting (Durham, NC: Duke University Press).

Easterling, D. (1992) 'Fair Rules for Siting a High-Level Nuclear Waste Repository', Journal of Policy Analysis & Management 11(3): 442-75.

Easterling, D. & H. Kunreuther (1995) The Dilemma of Siting a High-Level Nuclear Waste Repository (Norwell, MA: Kluwer).

Endres, D. (2009) 'Science and Public Participation: An Analysis of Public Scientific Argument in the Yucca Mountain Controversy', Environmental Communication: A Journal of Nature and Culture 3(1): 49-75.

Ewing, R. & F. Von Hippel (2009) 'Nuclear Waste Management in the United States—Starting Over', Science 325(5937): 151-2.

Fälth, B. & H. Hökmark (2012) Modeling End-Glacial Earthquakes at Olkiluoto: Expansion of the 2010 Study (Posiva Oy Databank). http://www.posiva.fi/files/2758/WR_2012-08web.pdf. 01.07.2014.

Fischer, M. (2009) Anthropological Futures (Durham, NC: Duke University Press).

Flynn, J., Chalmers, J., Easterling, D., Kasperson, R., Kunreuther, H., Mertz, C.K., Mushkatel, A.H., Pijawka, K.D., & P. Slovic (1995) One Hundred Centuries of Solitude: Redirecting America's High-Level Nuclear Waste Policies (Boulder, CO: Westview Press).

Galbraith, K. (2011) 'A New Urgency to the Problem of Storing Nuclear Waste', The New York Times. http://www.nytimes.com/2011/11/28/business/energy-environment/a-new-urgency-to-the-problem-of-storing-nuclear-waste.html?_r=3&adxnnl=1&adxnnlx=1323021955-kUUfprG0xjmtjsqRIzb/FA. 27.11.2011.

Galison, P. (2012) 'Waste-Wilderness: A Conversation with Peter L. Galison', Smudge Studio. http://www.mara-stream.org/think-tank/waste-wilderness-peter-l-galison-smudgestudio/. 22.02.2012.

Gusterson, H. (1996) Nuclear Rites (Berkeley: University of California Press).

Hamblin, J. (2006) 'Hallowed Lords of the Sea: Scientific Authority and Radioactive Waste in the United States, Britain, and France', Osiris 21: 209-228.

Hebert, J. (2009) 'Chu: Yucca No Longer and Option for Nuclear Waste'. http://abcnews.go.com/Politics/wireStory?id=7014620. 05.03.2009.

Hecht, G. (1998) The Radiance of France: Nuclear Power and National Identity after World War II (Boston: MIT Press).

Hecht, G. (2012) Being Nuclear: Africans and the Global Uranium Trade (Cambridge, MA: MIT Press).

Hjerpe, T., Ikonen, A.T.K. & Broed, R. (2009) Biosphere Assessment Report 2009 (Posiva Oy Databank). http://www.posiva.fi/files/1230/POSIVA_2010-03web.pdf. 01.07.2014.

Holmes, D. (2009) 'Economy of Words', Cultural Anthropology 24(3): 381-419.

Holmes, D. & G.E. Marcus (2005) 'Cultures of Expertise and the Management of Globalization: Toward the Re-Functioning of Ethnography', in A. Ong & S. Collier (eds), Global Assemblages: Technology, Politics, and Ethics as Anthropological Problems (Malden, MA: Blackwell): 235-52.

Huen, C. (2009) 'What is context?', Anthropological Theory 9(2): 149-69.

IAEA (International Atomic Energy Agency) (2013) 'Factsheet: Managing Radioactive Waste', IAEA Publications. http://www.iaea.org/Publications/Factsheets/English/manradwa.html. 01.07.2014.

Ialenti, V.F. (2013) 'Nuclear Energy's Long Now: Intransigent Wastes & Radioactive Greens', Suomen Antropologi: The Journal of the Finnish Anthropological Society 38(3).

Irwin, A. (2000) 'Risk, Technology and Modernity: Re-positioning the Sociological Analysis of Nuclear Power', in B. Adam, U. Beck & J. van Loon (eds), The Risk Society and Beyond: Critical Issues for Social Theory (London: Sage): 81-7.

IRG (Interagency Review Group on Nuclear Waste Management) (1979) 'Report to the President'. http://adsabs.harvard.edu//abs/1979nwm..rept. 01.07.2014.

Jacob, G. (1990) Site Unseen: The Politics of Siting a Nuclear Waste Repository (Pittsburgh, PA: University of Pittsburgh Press).

Jasanoff, S. & S. Kim (2009) 'Containing the Atom: Sociotechnical Imaginaries and Nuclear Power in the United States and South Korea', Minerva 47(2): 119-146.

Johnson, E. (2013) 'Tank at Washington State Nuclear Site May Be Leaking Nuclear Waste', Reuters. http://www.reuters.com/article/2013/06/21/us-usa-nuclear-leak-idUSBRE95K18720130621. 21.06.2013.

Jordan, K. & M. Lynch (1992) 'The Sociology of a Genetic Engineering Technique: Ritual and Rationality in the Performance of the Plasmid Prep', in A. Clarke & J. Fujimura (eds), The Right Tools For the Job: At Work in Twentieth-Century Life Science (Princeton, NJ: Princeton University Press): 77-114.

Jussila, T. (2012) 'Guest Column: Fukushima brought extensive changes to attitudes in Japan — but what about Finland?', Helsingin Sanomat International Edition. http://www.hs.fi/english/article/GUEST+COLUMN+Fukushima+brought+extensive+changes+to+attitudes+in+Japan+-+but+what+about+Finland/1329103609246. 13.03.2012.

Kaur, R. (2011) 'A "Nuclear Renaissance", Climate Change, and the State of Exception', Australian Journal of Anthropology 22(2): 273-277.

Kearney, R. & R. Garey (1982) 'American Federalism & the Management of Radioactive Waste', Public Administration Review 42(1): 14-24.

Kingston, J. (2012) Natural Disaster and Nuclear Crisis in Japan: Response and Recovery after Japan's 3/11 (London: Routledge).

Kraft, M. & B. Clary (1991) 'Citizen Participaion & the NIMBY Syndrome: Public Response to Radioactive Waste Disposal', Western Political Quarterly 44(2): 299-328.

Kunreuther, H., Easterling, D., Desvousges, W. & P. Slovic (1990) 'Public Attitudes Toward Siting a High-Level Nuclear Waste Repository in Nevada', Risk Analysis 10(4): 469-84.

Latour, B. (1987) Science in Action: How to Follow Scientists & Engineers Through Society (Cambridge, MA: Harvard University Press).

Latour, B. (1993) We Have Never Been Modern (Cambridge, MA: Harvard University Press).

Latour, B. (2004) 'Scientific Objects and Legal Objectivity', in A. Pottage & M. Mundy (eds), Law, Anthropology, and the Constitution of the Social: Making Persons & Things (Cambridge, UK: Cambridge University Press).

Lemons, J., Brown, D. & G.E. Varner (1990) 'Congress, Consistency, and Environmental Law: Nuclear Waste at Yucca Mountain, Nevada', Environmental Ethics 12: 311-27.

Macfarlane, A. (2003) 'Underlying Yucca Mountain: The Interplay of Geology and Policy in Nuclear Waste Disposal', Social Studies of Science 33(5): 783-807.

Macfarlane, A. & R. Ewing (2006) Uncertainty Underground (Boston: MIT Press).

Masco, J. (2010) 'Bad Weather: On Planetary Crisis', Social Studies of Science 40(1): 7-40.

MEE (Finland's Ministry of Employment and the Economy) (2012) 'Posiva Submits Construction Licence Application for Final Disposal Facility', MEE Press Releases. http://www.tem.fi/en/current_issues/press_releases/press_release_archive/year_2012?110895_m=109105. 01.07.2014.

Miyazaki, H. (Forthcoming) 'Saving TEPCO: Debt, Credit and the "End" of Finance in Post-Fukushima Japan', in G. Urban (ed), Corporations & Citizenship (Philadelphia: University of Pennsylvania Press).

Murphy, W.T. (1997) The Oldest Social Science? Configurations of Law and Modernity (Oxford, UK: Oxford University Press).

Murphy, W.T. (2004) 'Legal Fabrications and the Case of "Cultural Property"', in A. Pottage & M. Mundy (eds), Law, Anthropology, and the Constitution of the Social: Making Persons & Things (Cambridge, UK: Cambridge University Press): 115-141.

NEA (Nuclear Energy Agency) (2009) Considering Timescales in the Post-Closure Safety of Geological Disposal of Radioactive Waste (Paris: OECD Publishing).

NRC (U.S. Nuclear Regulatory Commission) (2012) Fact Sheet on Licensing Yucca Mountain. http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/fs-yucca-license-review.html. 27.06.2014.

NRC (U.S. Nuclear Regulatory Commission) (2013) 'The Hearing Process'. http://www.nrc.gov/about-nrc/regulatory/adjudicatory/hearing-pro.html. 02.07.2013.

NRC (U.S. Nuclear Regulatory Commission) 10 CFR § 63.321 (2013) NRC Regulations Title 10, Code of Federal Regulations, Part 63: Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada. http://www.nrc.gov/reading-rm/doc-collections/cfr/part063. 05.07.2013.

Okrent, D. (1999) 'On Intergenerational Equity and its Clash with Intragenerational Equity and on the Need for Policies to Guide the Regulation of Disposal of Wastes and Other Activities Posing Very Long-Term Risks', Risk Analysis 19(5): 877-901.

Patel, S. (2011) 'Germany's Nuclear Phase-Out Has Widespread Implications', Power 155(10).

Petryna, A. (2002) Life Exposed: Biological Citizens after Chernobyl (Princeton, NJ: Princeton University Press).

Pimenoff, A., Venäläinen A., & H. Järvinen (2011) Climate Scenarios for Olkiluoto on a Time-Scale of 120,000 Years (Posiva Oy Databank). http://www.posiva.fi/files/2763/POSIVA_2011-04web.pdf. 01.07.2014.

Posiva Oy (2011) 'SKB Submits a Construction Permit Application For a Final Disposal Facility', News (Other Topical Issues). http://www.posiva.fi/en/news/other_topical_issues/skb_submits_a_construction_permit_application_for_a_final_disposal_facility.html. 21.03.2011.

Pottage, A. (2004) 'Introduction: the Fabrication of Persons & Things', in A. Pottage & M. Mundy (eds), Law, Anthropology, and the Constitution of the Social: Making Persons & Things (Cambridge, UK: Cambridge University Press): 1-39.

Pottage, A. & M. Mundy (2004) Law, Anthropology, and the Constitution of the Social: Making Persons & Things (Cambridge, UK: Cambridge University Press).

Rabinow, P. (2008) Marking Time: On the Anthropology of the Contemporary (Princeton, NJ: Princeton University Press).

Rabinow, P., Marcus G.E., Faubion, J.D. & T. Rees (2008) Designs for an Anthropology of the Contemporary (Durham, NC: Duke University Press).

Reblitz-Richardson, B. (2005) 'DC Circuit Rejects EPA's Proposed Standard & Extends Timeline for Yucca Mountain Nuclear Waste Repository', Ecology Law Quarterly 32: 743-8.

Riles, A. (2011) 'Too Big To Fail', in M. Strathern, J. Edwards & M. Petrovic-Šteger (eds), Recasting Anthropological Knowledge: Inspiration and Social Science (Cambridge, UK: Cambridge University Press): 31-49.

Riles, A. (2013) 'Market Collaboration: Finance, Culture, and Ethnography after Neoliberalism', American Anthropologist 115(4): 555-569.

Robbins, J. & D. Murray (2002) 'Introduction', Social Analysis 46(1): 1-3.

Rudwick, M. (1992) Scenes from Deep Time: Early Pictorial Representations of the Prehistoric World (Chicago: University of Chicago Press).

Short, J. & E. Rosa (2004) 'Some Principles For Siting Controversy Decisions: Lessons from the U.S. Experience with High-Level Nuclear Waste', Journal of Risk Research 7(2): 135-52.

Shrader-Frechette, K. (1993) Burying Uncertainty: Risk & The Case Against Geological Disposal of Nuclear Waste (Berkeley: University of California Press).

Shrader-Frechette, K. (2005) 'Mortgaging the Future: Dumping Ethics with Nuclear Waste', Science & Engineering Ethics 11(4): 518-20.

Slovic, P., Layman, M., Kraus, N., Flynn, J., Chalmers, J. & G. Gesell (1991) 'Perceived Risk, Stigma, and Potential Economic Impacts of a High-Level Nuclear Waste Repository in Nevada', Risk Analysis (11)4: 683-96.

Solomon, B. (2009) 'High-Level Radioactive Waste Management in the USA', Journal of Risk Research 12(7-8): 1009-24.

Solomon, B. & D. Cameron (1985). 'Nuclear Waste Repository Siting: An Alternative Approach', Energy Policy 13(6): 564-80.

Solomon, B., Andrén, M. & U. Strandberg (2010) 'Three Decades of Social Science Research on High-Level Nuclear Waste: Achievements and Future Challenges', Risk, Hazards & Crisis in Public Policy 1(4): 13-47.

Star, S. & J. Griesemer (1989) 'Institutional Ecology, Translation, and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39', Social Studies of Science 19: 387-420.

Strathern, M. (1995) 'Future Kinship and the Study of Culture', Futures 27(4): 423-35.

Strathern, M. (1996) 'Enabling Identity? Biology, Choice and the New Reproductive Technologies', in S. Hall & P. DuGay (eds), Questions of Cultural Identity (London: Sage): 37-53.

Strathern, M. (2002) 'Afterword', Social Analysis 46(1): 90-91.

Strauss, S., Rupp, S. & T. Love (2013) Cultures of Energy: Power, Practices, Technologies (Walnut Creek, CA: Left Coast Press).

Stulberg, A. & M. Fuhrmann (2013) The Nuclear Renaissance and International Security (Stanford, CA: Stanford University Press).

Supiot, A. (2007) Homo Juridicus: On the Anthropological Function of the Law (London: Verso).

Vandenbosch, R. & S. Vandenbosch (2007) Nuclear Waste Stalemate: Political and Scientific Controversies (Salt Lake City: University of Utah Press).

Wagner, R. (1981) The Invention of Culture (Chicago: University of Chicago Press).

Walker, J.S. (2009) The Road to Yucca Mountain: The Development of Radioactive Waste Policy in the United States (Berkeley, CA: University of California Press).

Walsh, B. (2013) 'Radioactive Green: Pandora's Promise Rethinks Nuclear Power', Time (Science & Space). http://science.time.com/2013/06/21/radioactive-green-pandoras-promise-rethinks-nuclear-power. 21.06.2013.

Whipple, C. (2006) 'Performance Assessment: What Is It and Why Is It Done?', in A. Macfarlane & R. Ewing (eds), Uncertainty Underground (Boston: MIT Press): 57-70.

WNA (World Nuclear Association) (2013) 'Radioactive Waste Management'. http://www.world-nuclear.org/info/inf04.html. 01.07.2014.

WNA (World Nuclear Association) (2014) 'Nuclear Power in the World Today'. http://www.world-nuclear.org/info/Current-and-Future-Generation/Nuclear-Power-in-the-World-Today/. 01.07.2014.

Wynne, B. (1982) Rationality and Ritual: The Windscale Inquiry and Nuclear Decisions in Britain (Chalfont St Giles, Bucks, England: British Society for the History of Science).

Zonabend, F. (1993) The Nuclear Peninsula (Cambridge, UK: Cambridge University Press).

Vincent F Ialenti
Cornell University, Department of Anthropology
McGraw Hall, Ithaca, NY, USA 14850
vfi2@cornell.edu