

**Stakeholder decision-making for radioactive waste management advice given in the
US and UK**

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ABSTRACT

We continue our past research (e.g., [12]) with a study of participation by citizens providing advice on nuclear waste management decisions in the UK and US. This study is unique in that citizen participation programs in both countries are at very different stages: not yet fully operational in the UK, but mature in the US. Our hope is that a review of the programs in both of these countries can lead to findings that may benefit these and other countries as well.

UNITED KINGDOM

UK. Stakeholder participation in nuclear waste issues

This paper develops the themes that we discussed in a previous paper [24]. The authors reviewed a questionnaire (Questionnaire 1) issued to all registered stakeholders participating in the Nuclear Decommissioning Authority (NDA) National Stakeholder Group (NSG). The aim of the questionnaire was to elicit stakeholder views regarding current NDA stakeholder forums, particularly stakeholder perceptions of a 'dialogue based' description of the process and the author's hypothesis that this dialogue is deliberative.

At the time that Questionnaire 1 was issued in November 2006, the NDA NSG was just over a year old and had held 3 national meetings (October 2005, April 2006 and November 2006). The initial NSG work scope and that of the Waste Issues Group (WIG) and Material Issues Group (MIG) was completed by the end of March 2007 (i.e. the end

of the 2006-2007 financial year). The authors have termed this 'Phase 1'. Phase 2 commenced in June 2007, following a change of the facilitation team and a review of the stakeholder process to date by the NDA. We presented the preliminary findings from the questionnaire at WM'07 [14].

We issued the questionnaire at the time of the third NSG in November 2006, prior to an NDA process review and the fourth NSG in July 2007. Seventy-seven stakeholder organizations were invited to the third NSG, with 57 who actually attended. From these, 33 replied to the questionnaire. We issued the questionnaire at an early stage in the process to allow future issue of a second questionnaire to assess any shift in stakeholder perception and attitude towards the process. We anticipate that a Phase 2 questionnaire at a later date so that we can assess any shift in stakeholder perceptions and attitudes towards the process between Phase 1 and 2.

The conclusions that we developed from the questionnaire replies appear to provide a clear indication of participant perceptions regarding the process. However, we then asked the following questions: 1) Are the conclusions drawn from these questionnaires representative of the sample group as a whole or are the primary conclusions skewed by minority views? and, 2) Are the results of the questionnaire influenced by participant attendance at particular forums?

For this paper, we have applied a method of stakeholder analysis to the results of the questionnaire. We use a combination of Social Network Analysis (specifically participant affiliations) and participant attendance at specific forums to provide an indication of the reliability of the information received from stakeholders.

A feature of the NDA NSG up to the issue of Questionnaire 1 was irregular participant attendance, a problem when trying to assess the reliability of responses of individuals and their perceptions of the NDA process. Whilst some participants who replied to Questionnaire 1 had attended 8 out of a possible 10 stakeholder meetings, some participants had only attended 1. From anecdotal evidence, this has less to do with participant commitment and more to do with the way that participating organizations manage the availability of individuals for such events.

Using the Spearman's Rank Correlation Coefficient and simple linear regression, the analysis confirmed a strong correlation between participant attendance and affiliations. This was based on the attendance of named individuals rather than the organizations that they represented, which suggests that there is at least a body of individuals that consistently attend stakeholder events.

Using the same method, we then investigated the presence of a correlation between participant attendance and participant affiliations and each question response. In all cases, for each question, a correlation was shown not to exist. If confirmed, this has significant implications for the research. Earlier work presented at WM'07 confirmed that participants consider the engagement process to be 'deliberative' at this stage (using the definition provided). 30% of participants felt that it was clear how stakeholder views were taken into account by the NDA whilst 60% participants felt that this was not the case. 10% participants had no opinion.

However, current work appears to suggest that participant attendance is not a factor in this response. A second questionnaire is about to be issued during Phase 2, which aims to assess the development of participant views and perceptions of the process since Phase 1, taking into account an NDA review of the process. The findings from this

questionnaire will allow the Author to review his current stakeholder theory and research values.

UNITED STATES

US: SRS-CAB and the disposition of legacy Purex

The U.S. Department of Energy's (DOE) Savannah River Site (SRS) Citizens Advisory Board (CAB) supported the startup of the Consolidated Incinerator Facility (CIF) in 1996 [19]. In March 2000, unexpectedly, DOE told the SRS-CAB that the Consolidated Incinerator Facility (CIF) had been shutdown [20]. The surprise announcement by DOE led to expressions of concern by members of the Board; e.g., "The public believes it is time for DOE to stop spending millions of dollars to develop a facility and then not use it because they can not operate it in a cost-effective manner." [20] Citing a DOE Inspector General report [7] that recommended expanding and increasing the CIF's rate of incineration, the SRS-CAB recommended that "DOE reverse its decision to suspend CIF operations ... until such time that an alternative treatment option is available." [20] SRS-CAB voted to establish a Focus Group to investigate the CIF's closure in depth, to work with South Carolina's Department of Health and Environmental Control (DHEC) and SRS to find a solution agreeable to the agencies and the public, and to report back to the Board with proposed actions for DOE.

US: Savannah River Site Citizens Advisory Board (SRS-CAB)

There were nine CAB's advising DOE in 2005 on waste management and environmental cleanup activities [11]. The original DOE guidelines mandated the use of consensus rules (CR) [1]. Seeking consensus (CR) remains a part of the new interim guidelines revised in June 2006: "To enhance compliance with ... DOE ... Encourage the Board [CAB's] to listen carefully to all points of view and to work toward consensus" (p. 9 [25]). However, only four of the CAB's chose consensus rules (CR), with five CAB's permitted by DOE to use majority rules (MR).

SRS-CAB is a non-partisan group of individual stakeholders from South Carolina and Georgia (see [26]). Chartered under the Federal Advisory Committee Act, SRS-CAB uses MR to provide recommendations to DOE on waste management, environmental remediation, and other activities affecting SRS (e.g., recommending that SRS be converted into a Congressionally protected National Environmental Research Park, or NERP, which Congress has not yet enacted into law). The 25 SRS-CAB members represent a wide cross-section of the residents who live, work and play close to SRS. Fifty-two percent of CAB members reside in counties adjacent to SRS and an additional 12 percent live within 50 miles of SRS; most of the balance are drawn from among those who live downstream of SRS (e.g., Beaufort, SC and Savannah, GA) [23]. SRS-CAB had significantly more diversity and college graduates among its members than the other CAB's across the DOE complex, including the Hanford-CAB [12].

US: Decision Models

From a social physics perspective [11], agents act as a collective or as individuals. Consensus-seeking rules (CR) are widely considered to be the primary approach for a collective to reach a decision [1]. Under CR, agents are supposed to aggregate their individual beliefs into a single worldview. CR depends on enforced cooperation designed to preclude challenges to any view articulated; its goal is to allow those who normally would not speak in public a chance to contribute their views no matter how bizarre without fear of challenge, especially by scientists or those participants armed with technical facts. An immediate barrier to reaching a consistent worldview, however, is that when the preferences to be combined are three or more, no rational approach is possible to aggregate individual preferences into a single collective decision [28]. Consequently, CR decisions tend to be non-focused, increasing the uncertainty confronting a group, but also precluding calls for concrete action. Surprisingly, the lack of support for concrete action and the inability of CR to weed out risk perceptions combines to promote inter-group conflict with those determined to act, specifically, the DOE sponsor, slowing action [11].

The social welfare value of CR is that it reduces the competition among participants to dominate a discussion [1]. In contrast [12], we had found that CR tended to increase the number of risk perceptions over risk determinations, thereby promoting illusions at the expense of social welfare. Associated with the “gridlock” experienced at DOE’s Hanford site, the consensus-seeking Hanford CAB has become an extreme example of this effect. That is, CR decisions foster more illusions in the form of increased risk perceptions, clogging the decision process significantly more than occurs under MR [15]. Negative perceptions surrounding nuclear issues are abundant. For example, in 1991, Slovic had predicted that adverse risk perceptions about Yucca Mountain would harm the Las Vegas community [17]. We countered to Slovic at a National Research Council meeting that in the decade since his original thesis, Las Vegas was the fastest growing community in the US. But while Slovic subsequently acknowledged our criticism in 2001, he continued to maintain the validity of his prediction (pp. 102-3 [17]).

In contrast, majority rules (MR) tend to be driven by competitive individuals who appear to favor open conflict. As a result, most MR participants become neutral to the arguments bruited about by the few individuals who drive discussion to a conclusion and vote. But those driven by their self-interests to win must sway those more neutral to the argument to vote in their favor [29], consequently dampening conflict [30], but producing concrete, specific, and better decisions. The reason why is that armed with the best empirical evidence available, competition disambiguates the problems being confronted [31], increasing the concrete solutions available to a group. However, the polarization between the drivers reduces the likelihood that a consistent worldview emerges.

But if the conflict generated by MR is managed by the presence of neutrals, in contrast to CR, the dominant voices during a group’s struggle to a decision tend to reduce risk perceptions, to increase the value of risk determinations more than risk perceptions and, as a result, to produce more practical recommendations to DOE [13]. Our findings agree with those by Dietz [3] that conflict managed by majority rule promoted learning. Our findings also agree with Kruglanski and his colleagues [10] that CR can be hijacked to serve authoritarian and special interest groups. Further, in preliminary data from a laboratory experiment nearing completion with college students making

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recommendations to improve their college experiences, as expected, we are finding that CR produces more oral comments, takes a longer time to reach a single decision, but that MR produces more total and practical recommendations.

UK and US: Theory

From a theoretical perspective, it is important to note that dominant voices are constantly heard during SRS-CAB discussions. As in the UK, interviews and surveys of the SRS-CAB indicate that these dominant voices are not uniformly appreciated [1]. But they have driven the process forward by accelerating cleanup at SRS in comparison to the gridlock observed at Hanford [12,13]. Moreover, even though negative comments about the presence of dominant voices are picked up on interviews and surveys of SRS-CAB members, they have not been articulated in public by members of the SRS-CAB and consequently have had no observed impact on its decisions to accelerate cleanup.

We have recently proposed [16] to adapt feedback control theory to a theory of organizations. Control theory describes inputs versus outputs in complex systems [2]. We propose that it as a more objective methodology to evaluate the Hanford CAB where worldview stability governs the decisions of its members and the SRS-CAB where accelerating cleanup governs its members. To implement control theory, we need to quantify systems level models. In line with earlier arguments, a CAB controls at least four aspects of the decision-making process. First, by helping to set or choose its reference or threshold set-points (e.g., culture, decision processes, expectations, planning). Second, by damping unexpected disturbances. Third, by filtering and transforming incoming information about system internal states, inputs, and responses to form patterns and decisions. Finally, by taking actions such as collecting new information or to produce CAB advisory decisions.

Four interdependent metrics have been proposed as control measures. These are the uncertainties associated with planning and plan execution; and the parallel uncertainties associated with the resources available for execution and the time of execution. For example, in a retrospective field study, we had found support for the only two of these four factors that were available to be measured [11]: In 2003, all nine of the existing boards were requested by DOE to support thirteen recommendations by DOE scientists to accelerate the shipment of transuranic wastes to WIPP. As predicted, four of the five MR boards supported the DOE scientists, whereas three of the four CR boards rejected their advice. The MR boards on average took about 1/4th the amount of time to make their decisions compared to the CR boards. This lengthy duration to reach consensus can be draining to the participants [41].

In related research [15, 16], we have begun to convert the metrics above into four interrelated standard deviations. In the revision, first, working backwards, duration data (t) is transformed into frequencies (ω) for which we can calculate energy and the standard deviations for both, where $\sigma_t \sigma_\omega \geq 1/2$. Initial results are supportive: organizations make decisions regarding mergers and acquisitions in order to seek stability; e.g., Washington Group International, the primary contractor at SRS, recently merged with URS Corporation to form the nation's biggest engineering and construction firm that is "more diverse, nimble during economic slowdowns, and better positioned for contracts ... and alternative energy ventures." [32] Second, in line with the work begun by Lewin [37], for

the other metrics, we are crafting our theory as the propagation of elastic social wavefields which can be modeled with coupled partial differential equations for the virtual displacement of beliefs and their velocity across two or three dimensions.

US: Technical background on Purex

Purex (Plutonium-Uranium Extraction) is an organic liquid composed of solvents to reprocess plutonium at SRS. Purex has been described as part of “A solvent extraction process in which uranium and plutonium are selectively separated from each other and from fission products by extraction from nitric acid solutions with tributylphosphate [and n-paraffin] in a hydrogen diluent” (p. L13 [9]).

A total of 553,000 gal of degraded solvent had been shipped across SRS from its reprocessing Canyons to its Old Radioactive Waste Burial Grounds between plant startup in the 1950's until 1984 (p. 153 [4]); during that period of time, about 380,000 gals had been burned in open pans until the practice was discontinued in 1972, but over time rain mixed with residues in the pans to release significant quantities of contaminants into the groundwater.

During the time that the legacy purex was stored in underground tanks in the Old Burial Ground, an estimated 425 gals of solvent were released into the groundwater as a result of pan burning, compromised tanks and process upsets (e.g., in addition to open pan burns, spent solvent was once inadvertently pumped directly into a monitoring well). Some of the radioactive products measured in wells today are attributed to these sources (p. B38 [5]). For example, even though plutonium does not migrate in the clayey soils at SRS, average concentrations of alpha-particle radiation in the groundwater has for years significantly exceeded drinking water standards in monitoring wells G-21 and I-13 (e.g., p. 128-9 [8]).

Of the spent solvent sent to the Old Burial Ground at SRS and stored in steel tanks S23-S50, the remaining 31,700 gals of solvent were transferred into new storage tanks in H-Area sitting atop a concrete slab (pp. B6-7 [6]). The slab drained to a sump collection area designed to prevent additional releases from entering into the ground water. The remaining purex stored in these tanks, known as legacy purex, was radioactive and contained lead, mercury, silver, benzene, trichloroethylene, other inorganics and an inorganic layer.

The CIF had been built primarily to treat benzene generated from a process in High-Level Wastes (HLW) tanks that separated Cesium-137 from HLW. The plan had been to send the separated cesium to the Defense Waste Production Facility (DWPF) where it would be vitrified inside of steel canisters. However, the primary function of CIF ceased after the rate of benzene generation was discovered to be greater than predicted, posing significant safety concerns (i.e., potentially explosive releases from the HLW tanks). Until CIF operations were suspended by DOE in 2000, the CIF was used to incinerate lightly contaminated combustible wastes such as the legacy solvent [19]. In addition, an estimated 100,000 gals of spent solvent not considered legacy purex had been planned to be treated by CIF.

US: Problem confronted

In March 2000, DOE at SRS announced that it would suspend operations at CIF due to excessive operational costs (~ \$20 million per year) and to the lack of radioactive shielding sufficient to treat the radioactivity existing in the legacy purex [20]. At the new storage facility in H area, the legacy purex had settled into two main fractions, an aqueous phase and another with organic solvents, the latter fraction containing a majority of the radionuclides. CIF had treated 5,330 gals of the aqueous fraction, which effectively amounted to “boiling water” at a cost of \$20 million per year; i.e., of the legacy purex treated in CIF, only the aqueous phase had been sent to CIF because of the lack of sufficient shielding. Left behind untreated were 36,670 gals of the legacy purex consisting of about 12,500 gal more of aqueous and less than 25,000 gal of organic solvents. The remaining organic purex contained hazardous waste constituents leading DOE and DHEC to categorize it as Mixed Low-Level Waste (MLLW).

Over the next decade, about 100,000 of additional purex wastes was anticipated to be generated by the shutdown of solvent extraction in F-Canyon. But in comparison to the legacy organic purex, the additional spent purex would have been classified as non-hazardous and not MLLW, making it relatively straightforward to treat.

US: Solution proposed

Although suspending CIF had reduced operational costs significantly, several issues arose [21]. First, DOE estimated the cost of closure under DHEC’s regulations to be \$80 million. Second, DOE had to develop alternative disposition paths for the legacy and Canyon purex wastes. Finally, the CIF would have had to remain a viable alternative treatment process until a new process could have been chosen and certified by DHEC in a public process. Listed under the Federal Facility Agreement (FFA) for SRS, the DOE regulated milestone remained in force to complete the treatment of all of the legacy purex by 2019. The SRS-CAB had chartered a Focus Group to follow the CIF which had made its first recommendation to DOE that it keep CIF as a viable option until an alternative treatment process was available.

By 2005, DOE had disposed of the remaining aqueous fraction in its Effluent Treatment Facility, approximately 33% of the total legacy purex. The acceleration of treatment, a decade before the FFA milestone was to have been completed and repeatedly endorsed by the SRS-CAB, provided a significant success for DOE [22]. Its achievement led DHEC to give DOE leeway with its treatment plans for the legacy organic solvents and the ultimate disposition of CIF. Until recently, DOE had appeared to be on schedule to treat all of the legacy purex by the end of FY 2007; that date had become the new FFA milestone, well-ahead of DOE’s original 2019 deadline. Based on DOE’s progress, SRS-CAB recommended to DOE and DHEC that the CIF closure be transferred to the FFA program which meant that it would become a newly negotiated milestone between DHEC and DOE. Doing so postponed closure of CIF until after 2011, saving DOE substantial funds and allowing it to continue to address the research needs associated with the final treatment of the organic purex.

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US: Status of the solution

The legacy aqueous purex treatment was completed in March 2004 [18]. In addition, the total volume of F-Canyon spent purex to be treated was reduced to 60,000 gals, all of which was solidified commercially by April 2007. However, the legacy organic purex, also scheduled for commercial solidification with organo-clay by the end of FY 2007, remains open. Regarding the latter, the vendor unexpectedly discovered naphthalene in a laboratory analysis. Naphthalene is a RCRA Underlying Hazardous Constituent (UHC) that requires treatment to meet RCRA's Land Disposal Restriction (LDR). This discovery has delayed legacy organic purex shipments since April 2007 until tests can be performed by the vendor to determine if solidification meets UHC standards for naphthalene. In the event the UHC criteria cannot be met, one alternative is to macroencapsulate the solidified organics in a stainless steel welded box; another alternative under consideration is to pretreat the organics by entraining phosphorous and then treating it with vacuum thermal desorption. If either of these alternatives become necessary to the previously planned treatment with organo-clay before the discovery of naphthalene, an additional 6-9 months would be added to the current FFA milestone commitment of September 30, 2007 made by DOE at SRS to DHEC. But at the SRS-CAB meeting in late November, the milestone had slipped further to become a FY 2009 Planned Accomplishment [38].

US: Related problems

Existing problems with the funding of the Savannah River Ecology Laboratory (SREL), one of the SRS CAB's favorite organizations, has strained the relationship between DOE and SRS-CAB [33]. Dr. Eugene P. Odum and his students from the University of Georgia began ecology baseline studies of SRS and then founded SREL in 1951 under a Cooperative Agreement with DOE. SREL's mission was to independently evaluate the ongoing effects of SRS operations on the surrounding ecology through an integrated program of research, education, and outreach.

Since then, SREL has become recognized as a leader in many ecology disciplines including radiation ecology and toxicology, serving as a training ground for hundreds of future scientists and engineers. Over 3,000 papers have been published in peer-reviewed scientific journals based upon research conducted by SREL scientists at SRS, some reaching canonical status (e.g., the first published long-term data set on the worldwide decline of amphibians [39]). These papers have covered topics such as the restoration of degraded wildlife habitats, the environmental impact of the use of nuclear materials and the effects of environmental contamination.

This productive history for SREL may be coming to an end as DOE has been ordered by the White House to forcibly close SREL [40], an action that SRS-CAB has struggled to stop since 2005. Even before the House Committee on Science and Technology conducted hearings on DOE's shutdown of SREL, its future has become more tenuous. In a June 15, 2007 letter, UGA's president committed to "reducing significantly the core laboratory facilities" of SREL (see Ref. 1, in [33]). In 2007, some employees have been terminated, some tenured faculty have been transferred to the UGA campus, and the Head of SREL has been fired. The few remaining employees at SREL will attempt to complete SREL's commitments on its active extramural grants. After that the future of SREL is uncertain.

SRS-CAB has fought to keep SREL alive by continuing to “pressure Congress to provide funding” [42] because it had concluded that SREL was a national treasure and a vital component of the SRS community. After hearing from the public about the impending closure of SREL, the SRS-CAB stated that the general public and the scientific community consider SREL to be an independent and more credible source of information than DOE about the ecology of SRS, and whose very presence at SRS makes the public feel more positive about DOE. The SRS-CAB further noted that it was extremely disappointed to hear that funding for SREL had been zeroed out by DOE.

UK and US: Summary. Lessons learned

1. Decision structure has a significant impact on the advice given by the public Citizen Advisory Boards to DOE. The control scheme used by an organization can lead to more rational decisions or more practical ones. Rational decisions are more likely to occur under consensus-seeking while practical decisions are more likely under majority rule (“truth seeking” [11]).
2. CR, designed to reduce conflict, appears to promote it. The source of this conflict appears to be the inability of agents under CR to manage risk perceptions and other illusions, to produce advice that is sufficiently practical to accelerate or even to advance cleanup, and the production of a single worldview incongruous with that of its sponsor, DOE.
3. Counterintuitively, building a consistent worldview sufficient to accommodate all of the parties to a decision deemphasizes uncertainty and disagreement. For example, “Setting aside or minimizing the importance of key structural uncertainties in underlying processes is a frequent outcome of the drive for consensus.” (p. 1505 [41]).
4. CR produces pernicious side effects often sought by authoritarian rulers. After the new EU constitution was rejected by the voters of Europe in France and Denmark, it left the EU leadership in gridlock; they had previously rejected CR because it holds its member states hostage to the dictates of a few [35]. The new treat signed by EU leaders on December 13, 2007 “alters the EU’s decision-making architecture. More decisions are to be taken by majority vote, removing the need for unanimous endorsement which in the past has stymied the bloc’s efforts to present a united front.” [36]
5. These comparative studies have been very helpful in advancing a theory of organizational dynamics. As an analogy, we have begun to think about these ideas as the propagation of “elastic social wavefields”, and hope to construct mathematical models to mimic them. In a sense, the addition of competitive or oppositely-voiced driven decision making can be modeled as heterogeneities in the medium in which the wavefield propagates, or as additional forcing functions that influence periodic behaviors.

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