Comment from:

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My ***overall assessment*** of this report is that it is a highly valuable contribution to future decisions about nuclear waste management in Canada. The report employs conceptually appropriate methods; it has applied them in ways that are adequate and innovative given the nature of the issues; it has provided important insights about the key tradeoffs involved in selecting among the alternatives; and it has provided a thoughtful basis for fostering public debate about the alternatives. The participants should be congratulated for their important contributions.

I organize my detailed comments below under a series of headings: methods, application, and key issues that could be expanded on in future studies on this topic.

Method

The method used in this report (which comprises a version of multiple objective decision analysis, as applied to a public sector problem) is in my view the best approach for analysis of complex and high stakes decisions. In essence, the approach starts from the recognition that there are multiple values important to the people of Canada in making decisions about managing used nuclear fuel, and that these values should serve as the basis for any analysis. Given that the decision involves multiple and conflicting objectives, tremendous uncertainties associated with the consequences of the alternatives, and a relatively small number of alternatives, then the overall approach of multiple objective decision analysis is clearly appropriate. In my view, this is only responsible approach for such an analysis. I note that analysis of similar decisions in the United States and Finland (and probably other countries) make use of the same overall methods, although only a few other such studies have been published. Multiple objective decision analysis is a sensible and widely recognized analytical approach for any kind of risk management problem.

The screening approach summarized in Section 3.2 is an important part of the analysis. I have no objection to the approach adopted here, but I would also note that screening methods must be applied with care in order to avoid prematurely rejecting what could otherwise prove to be an attractive alternative. Hence, this step of the analysis is important.

Application of the methods

The method was applied with the help of an experienced decision analyst who has worked extensively on analysis of nuclear waste management decisions in the United States. Like all decision analyses, and all decisions, the method relies heavily on the judgments of the participants to serve as input to the decisions. The major kinds of judgments include technical judgments about how well the given alternatives would

perform in terms of the alternatives, and preference judgments about which values are more important. The assessment team provided both sets of judgments.

Generally speaking, the application of the methods is explained adequately and I could understand how the analysis was conducted. The application of the methods generally followed how decision analytic studies have been conducted in the past, although there were some unusual aspects, which I will briefly discuss below.

Cost objective The cost of the alternatives is addressed in the analysis as part of the economic viability objective, as shown in Figure 6-13. Considering cost as part of economic viability is reasonable, and in keeping with work others have done in the past. On the other hand, it is often useful to cast that sub-objective a bit more directly and explicitly, in terms of keeping costs to electrical consumers low. Objective 7 includes the notion that the costs must be reasonable, and that there should be confidence that the costs are affordable. These expressions of viability are somewhat different than saying that, all else being equal, less total cost is preferred to more total cost. However, I recognize that these are value judgments, and the assessment team may have felt that Canadian values were best represented in the way shown in the influence diagram.

It is also worthwhile to note that the issue is particularly relevant for this effort as a risk management process, because if costs were lower, then that funding could be used for other risk management purposes, or other public or private priorities. I can understand that perhaps the notion of minimizing cost was not raised by public comments or within the background documents, so the assessment team may have been hesitant to add it, but in general good analysis needs to consider that lower costs to the public are preferred to higher costs.

The importance of the discount rate in this work, and the treatment of costs far into the distant future, is also a crucial part of this analysis. Virtually all standard approaches to addressing financial flows over time are not effective at dealing with costs hundreds of years into the future. Nuclear waste management is perhaps unique among public infrastructure investments in terms of the potential impact on very long term costs. Hence, new, creative analytical approaches are needed. The way the analysis addresses economic viability is, I believe, an attempt to develop a new way to deal with these very long term costs.

I do not think that a problem was created in the analysis by treating the objective as economic viability, without explicitly addressing minimizing cost. The reason is because the assessment team concluded that cost differences were not great among the alternatives, depending on the choice of the discount rate (while also recognizing the limits of discounting approaches to dealing with very long term costs). Assuming the alternatives did not differ substantially in terms of costs, then it is reasonable to omit minimizing costs as an explicit objective for comparing alternatives.

Performance measures Generally, after the objectives are structured, then specific performance measures are created for each of the lowest level objectives in the hierarchy.

Then these can be combined using value judgments to create an overall performance index for each higher-level objective. Alternatively, one of the lowest level objectives can be used to represent the whole set of sub-objectives under one high level objective. In this case, a different approach was used. It entailed the approach discussed in Section 5.6, in which each objective is summarized in a sentence, and the expanded on in terms of a "general principle for guiding the assessment". Hence, how well the alternative would, in the judgment of the participants, meet with the precepts of the general principle outlined for each of the eight objectives comprised how the performance was judged. While this approach is unusual, I could understand why it was adopted. It is invariably harder to get an overall agreement on specific performance measures than on the objectives. However, it should be recognized that the approach to performance measures adopted here may lead to somewhat different visions of what an objective means among the team and among the audiences for the report, and hence the potential for differences in the basis for the judgments.

Treatment of uncertainty in technical judgments This analysis was unusual for a major study of managing nuclear waste in that there did not seem to be emphasis on quantitatively addressing uncertainties. Perhaps such methods were discussed and I missed it, or perhaps such analysis is in the background reports. Regardless of whether any uncertainty analysis was conducted, I would say that how the technical assessments were done remains a part of the report that could have been better explained, and is perhaps the most unusual step compared to standard practice. The ideal for how to conduct risk analysis is to ask technical experts to provide judgments and data about domains of expertise for which they are the most knowledgeable. Again, in the ideal, probability distributions for key variables would be elicited from the experts most knowledgeable about a given topic, to be used along with other information to quantitatively address uncertainties. In this case, all team members provided judgments on scales based on what they learned from the assessment team members and reports. The differences in their answers might be taken as one reflection of uncertainty (as well as a reflection of differences in their knowledge base or in their understanding and framing of the problem). I can understand the reasons for this approach, since no one person is an expert on obtuse but fundamental issues such as what society may be like 150 or 500 years from now. In fact, I think this is an interesting new way to tackle expert judgments on such issues, which I would consider using myself in future work. Yet, I remain a bit uneasy about group assessments of technical judgments such as these, because of the potential for group-think, and because in the ideal, different experts would address the questions that fit with their professional knowledge. I am not saying these issues have caused major problems with this analysis, but rather that it is important to be alert to such issues.

Dominance of an alternative I liked the way the analysis looked to see if one alternative dominates on most or all the objectives, as a means of seeing if one is clearly superior. In this case, the deep repository alternative seems to dominate on most objectives, assuming the mean technical performance scores provided by the assessment team. However, it would have been informative to find out how sensitive the dominance of a deep repository is to differences in the technical judgments, by considering the extremes of the

judgments and not relying on the means. Yet another approach would be to rely more heavily on the judgments of those who are more expert in a given aspect of the assessment. Regardless, the dominance of the deep repository alternative does rest on a small number of key conclusions drawn by the assessment team, which are highlighted in the conclusion of the report:

-that a site for a deep repository can be selected in a fair manner and accepted by the community (this is a sensible assumption, given the objective of the exercize is to compare the alternative management strategies);

-that cost differences among the alternatives are minor;

-that the additional flexibility of easy recovery from monitored centralized retrievable storage is outweighed by the robustness to a wide range of future societal conditions afforded by a deep repository.

These conclusions are the crucial judgments in the whole analysis. They involve both technical judgments and value judgments, as well as inferences about how future societies may respond to nuclear waste storage. It would be helpful to better emphasize these judgments, and perhaps subject them to more analysis to help inform these judgments when they are considered by others.

Key Issues that could be addressed further in subsequent efforts
Here I offer some suggestions on issues to address if future analysis is conducted, or when communicating to governments, agencies and interested publics about this analysis.

Objectives and performance measures A future analysis may want to consider whether it could expand on and improve the clarity of the objectives and performance measures used as a basis for analysis in this study. In the ideal, more specific statements of the objectives, and clear performance measures would be desirable. These could also be used, with refinement, for more detailed design decisions, organizational management and performance measurement over time.

Treatment of uncertainty and technical judgments A future analysis may want to consider whether a more explicit effort to address key uncertainties in the technical assessments, and whether approaches to rely more directly on probability to represent uncertainty in a few key technical judgments, would be helpful.

Fundamental Importance of key conclusions and their basis While the key conclusions are already highlighted in the report, they should also be emphasized in any summary reports or interpretations of the current report. The factual, ethical and conceptual basis for these conclusions should be expanded upon if possible. For example, a bit more detail about costs and the implications of different discount rates on costs beyond that in tables 3-11 and 3-12, could be provided. (Note that the information in those tables is unusual in the sense that there are no uncertainties provided for the costs of a deep repository, even though is considerable uncertainty about costs for repositories in other countries). Finally,

the discussion in Section 6 that lays out the reasoning that could lead to a different choice than the conclusion of the committee is an informative approach.

Implications of a staged approach and the timing of decisions
I suggest that subsequent documents could more clearly stress the sequential nature of decisions for handling of used nuclear fuel, and clarify that there will be opportunities to learn more over time that could lead to better-informed decisions. I would also note that I would have liked to see a diagram in the report that shows the chronological differences among the alternatives in terms of what would be done in handling the material, when, for each of the alternatives. My impression is that for the next few decades, the material would be handled the same way, regardless of which option is selected. Hence, while a near-term commitment to one of the options is likely desirable from the view of your agency, it may also be helpful to say there will also be flexibility and future opportunities to learn more about this decision. This is a key to getting the best possible strategy.

Expert-based analysis
I understand that this assessment team report is the first major public effort from NWMO that relies on experts to structure and conduct an overall analysis. As a Canadian, and a risk and decision analyst committed to the roles of values and technical information in complex policy decisions, I strongly urge you to conduct more such analysis. Public values are why we want to manage nuclear waste, and so are fundamental to any analysis. Yet there are useful and well-tested methods to represent the public value information you have compiled, which would involve refining the objectives and performance measures. In my view, what NWMO needs to do at this point is make more use of experts in decision analysis processes, and technical experts regarding key aspects of these issues, to provide more insights on those sides of this complex decision.

Conclusion
This is an important report that will serve the public interest in fostering better understanding of this decision. While I have pointed out places above where the analysis could be expanded or improved, I want to stress that any analysis ever conducted could be made better.

The true test of the relevance and merit of an analysis is not whether it is perfect compared to a theoretical ideal, but whether it provides insights and moves along understanding of the issues. Seen in this manner, the assessment report is an enormously valuable contribution to future decisions about managing used nuclear fuel in Canada.

Biography: Tim McDaniels

Tim McDaniels is Director of the Eco-Risk Research Unit at the University of British Columbia, where he is an associate professor in the Institute of Resources and Environment and the Graduate School of Community and Regional Planning.

Trained in economics, policy analysis and decision sciences, Tim's professional activities focus on decision making for risk management questions, in prescriptive and descriptive terms. His recent work emphasizes judgmental aspects of ecological risk management questions, as well as technical and value modeling for complex facilities, and methods of value elicitation and public involvement.

He is a member of the Institute for Risk Research at the University of Waterloo, and a member of the Canadian Research Network for Environmental Risk Assessment and Management. He is also an adjunct professor in the Heinz School at Carnegie Mellon University, where he is a co-investigator in the Center for Integrated Study of the Human Dimensions of Global Change. He has held previous appointments at the University of Washington and at Western Washington University.

Tim McDaniels holds a B.A. in economics from the University of Minnesota, an M.A. in economics from Simon Fraser University and a Ph.D. in decision sciences and policy analysis from Social and Decision Sciences and the School of Urban and Public Affairs at Carnegie Mellon University. Tim has also worked extensively as a consultant on risk management, strategic planning and decision analysis for a wide range of public and private sector clients, including electric utilities, regional, provincial and national governments, regulatory and advisory commissions, and major corporations. He has also served on national advisory panels, including as a member of the advisory committee for the Economics of Climate Change Research Program of the National Oceanographic and Atmospheric Agency, and a member of the peer review panel for the Socioeconomic Research Program of the Office of Experimental Research in the Environmental Protection Agency. He also served as a member of the advisory panel on risk management for the Canadian Inquiry on the Safety of the Blood System. Tim is the Secretary of the Society for Risk Analysis, during 1998-99.