SAMPLE APPROACH TO EXPLAINING TRANSPORTATION RISKS IN DOE'S ENVIRONMENTAL IMPACT STATEMENTS

What We Analyzed and Why

Most of the options under consideration will require the transportation of radioactive and hazardous materials. As part of this environmental study, we identified the potential impacts that may arise from transporting these materials, and the associated risks to people and the environment.

Many radioactive material shipments emit some radiation through their containers. As the shipments travel by truck or by train, there is the potential for some radiation exposure simply resulting from routine, incident-free transportation. There is also the potential for radiation exposure as the result of an accident. The people who might be exposed to radiation or other hazards from shipments are:

- Members of the public who reside adjacent to or in the vicinity of the shipping routes;
- Members of the public sharing the right of way;
- Members of the public who encounter the shipments at rest stops or other types of en route stops;
- Truck drivers, rail crews, and other workers (e.g., inspectors, emergency responders).

In addition, there are transportation impacts beyond the radiological hazard. These are primarily caused by vehicle emissions and traffic accidents that do not involve the radioactive material cargo.

We have calculated the potential impacts for each of the alternatives being considered for [the subject of the study]. Some of the alternatives under consideration will require considerably more shipments than other alternatives. The transportation risk for these alternatives will, therefore, be somewhat greater.

Choice of Transportation Mode

Generally, rail transportation of [category of nuclear waste/material] has fewer predicted health impacts than truck transportation. This holds for both the radiological and nonradiological impacts, for the following reasons:

- Trains haul larger loads, meaning fewer shipments are needed, resulting in fewer shipment miles during which either workers or public along the route are exposed to any radiation;
- Train crews are further separated from radiological cargoes than truck drivers;
- Rail transport has fewer accidents per ton mile than truck transport;
- Rail tracks are generally isolated from the traveling public, whereas trucks travel interstate highways with private vehicles in the same traffic flow; and
- Exhaust emissions per ton are lower for rail.

There may be offsetting considerations, however. For example, rail routing is limited, and often trains must pass through areas of high population density. In addition, the volume of material and the forces involved in a rail accident can be much larger than those in a highway accident. Lastly, in the aftermath of an accident, emergency access to rail accidents may be more limited than access to highway accidents.

Alternatives A, B, C and D would result in the following number of rail or truck shipments during the years 20XX – 20XX. [Insert table with number of shipments and timeframes, plus map (Figure X) of representative routes for each alternative.] For the purposes of this study, we looked at routes that *could* be used for shipping this material or similar types of materials. These are not necessarily the routes that we will actually use. Action on our proposed plan would not commence for at least X years, and during this time there are likely to be many changes to the transportation infrastructure. The representative routes in Figure X include actual routes that have been used in the past [if that's the case], as well as routes that would be available options if we were to begin shipping today.

Our Results and How They Affected Our Decision-making

We found that the non-radiological impacts — vehicle emissions and traffic accidents not involving the radioactive material cargo — are small, no matter the alternative. The impacts from adding a few trucks a week to highways and interstates that experience thousands of truck shipments per week — or a few train cars to the existing rail system — are measurable from a statistical standpoint but negligible from a practical perspective. In terms of radiological impacts — both in routine transportation as well as in accident situations — the impacts are again small, and even smaller than the non-radiological impacts. In all of the options we're considering, the number of potential cancer-related fatalities associated with the proposed actions would be no more than one. Since radiation effects are of particular interest, we describe them in greater detail in the next section. The results of all our calculations are contained in Appendix X.

It is our conclusion that the potential risks posed by transportation activities from this proposed action — no matter the option — are small. Because the transportation impacts are not significant by themselves, and none of the options has a significantly higher transportation risk than any other, these impacts will not affect our selection of a preferred option.

A Closer Look at the Radiation Health Effects of the Alternatives

How do we measure potential impacts, and what does it mean to say they would be small? Scientists estimate health effects of exposure to radiation by calculating "latent cancer fatalities" or LCF. This is a standard measure of risk from exposure to cancer-causing agents, or "carcinogens." The calculated LCF represents the risk associated with a dose of radiation, expressed as a potential fatal cancer. The dose risks associated with radioactive material shipments represent small increases above the dose risks from normal background radiation. We refer to these cancer fatalities as "latent" because it may take many years for cancer to develop and for death to occur.

Latent cancer fatalities are calculated using statistics about doses to groups of people, or "populations." They are not based on any particular individual's exposure to radiation. Individual responses to similar doses of radiation vary widely. To understand how we arrived at a particular estimate of LCF, let's start with an explanation of dose.

Radiation affects people's body tissue by emitting energy. An individual may be exposed to radiation externally, from a radioactive source outside the body, or internally, from ingesting or inhaling radioactive material. An external dose is delivered only during the actual time of exposure to the external radiation source. An internal dose, however, continues to be delivered as long as the radioactive material is in the body, although both radioactive decay and elimination of the radioactive material by ordinary bodily processes decrease the dose rate as time passes.

The energy emitted during disintegration (decay) of a radioactive substance may be in the form of alpha and beta particles, and gamma and x-rays. The total amount of radiation energy absorbed by a certain quantity of tissue is referred to as "absorbed dose." The absorbed dose is then adjusted for the relative sensitivities of various organs and parts of the body, leading to a calculated "effective dose equivalent." In our analysis, we use "dose" as a synonym for effective dose equivalent. The common unit of dose or effective dose equivalent is the rem.

The next step is to add up the estimated doses received by each person to calculate the collective dose to an exposed population (or population dose). The collective dose received by the exposed population over a given period of time is measured in person-rem. For example, if 100,000 people each received a dose of 1 millirem (0.001 rem), the collective dose would be 100,000 persons x 0.001 rem = 100 person-rem. Alternatively, a collective dose of 100 person-rem would result from 50,000 people each of whom received a dose of 2 millirem.

To calculate the number of latent cancer fatalities, scientists multiply the collective dose by the dose-to-risk conversion factors established by the National Academy of Sciences. These factors are derived from various studies of past radiation exposures and represent averages based on experience.[1] For doses less than 20 rem, which apply to our study, the risk conversion factors are 0.0005 LCF for each person-rem of radiation exposure to the general public and 0.0004 LCF for worker exposure. The factor for the general public is slightly higher to account for the longer exposure period (an entire lifetime versus the working years from age 18 to 65), as well as the fact that infants and children are more sensitive to radiation than adults.

The calculation is:

Collective Dose x Risk Conversion Factor = LCF[2]

In our example, if the population dose were 100 person-rem, the corresponding estimate of latent cancer fatalities for the general public would be 0.05:

100 person rem x 0.0005 LCF/person-rem = 0.05 LCF

If the collective dose of 100 person-rem were applied to the worker population, the estimated LCF would be 0.04 because the worker population differs from general population (see footnote 1).

What do these numbers mean? A calculated latent cancer fatality of less than one means that the risk of an actual cancer fatality is low. An LCF of less than one is a statistical estimate. That is, 0.05 is the average number of deaths that would be expected if the same exposure situation were applied to many different groups of 100,000 people. In most groups, not a single person would incur a latent fatal cancer from the 1-mrem dose each member would have received. In a small fraction of the groups, one latent fatal cancer could result. In exceptionally few groups, two or more latent fatal cancers would occur. The average number of deaths over all the groups would be 0.05 latent fatal cancer — just as the average of 0, 0, 0, and 1 is ¼ or 0.25. The most likely outcome is zero latent cancer fatalities.

In all of the options we're considering, the number of LCFs would be no more than one. Depending on the option under consideration, the numbers range from .0X to .XX. All the numbers are less than one, however, and the differences are not statistically significant. For more information on these results, please see Appendix X. As we stated previously, because all the options result in transportation impacts that are neither significant by themselves nor significantly different between the alternatives, these impacts will not affect our selection of a preferred option.

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[1] *Health Effects of Exposure to Low Levels of Ionizing Radiation* (NAS 1990), commonly called the BEIR V report, gives statistics on the number of cancer deaths expected to occur from different exposure situations. For occupational exposures, the study considers a continuous exposure of 1 rem/year above background levels of radiation from age 18 until age 65, resulting in a risk factor of 0.0004 LCFs per person-rem. For exposure of the general public, the BEIR V report looks at the number of cancer deaths expected to occur from a continuous lifetime exposure of 0.1 rem/year above background levels of radiation. This results in a risk factor of 0.0005 LCFs per person-rem. Note that even though the assumed general public exposure (0.1 rem/year) is less than the assumed occupational exposure (1 rem/year), the general public LCF risk factor is slightly higher. This is because the general public dose is assumed to occur over an entire lifetime as opposed to the occupational work period from age 18 until age 65. The younger population is more sensitive to radiation-induced health effects.

[2] This calculation assumes a simple linear relationship between dose and effect. In other words, decreasing doses of radiation have a similar decreasing effect on health. Scientists, however, disagree as to whether a simple linear relationship exists at very low doses, such as 1 mrem. There is some evidence that very low doses of radiation have no adverse affect on health. Since we can't be sure, we use the linear relationship, with the results that the estimate of LCF is conservative.

Table I. Comparison of Alternatives According to Radiological Health Effects Resulting from Transportation *(expressed in additional latent cancer fatalities or LCF)*

Alternative	Public LCF resulting from exposure during transport	Worker LCF resulting from exposure during transport	Worker and public LCF resulting from exposure during transportation accidents
A. Descriptor* Rail Truck	 ◓ ○	 ◓ ○	 ○ ◒
B. Descriptor Rail Truck	 ○ ◒	 ○ ◒	 ● ◒
C. Descriptor Rail Truck	 ◉ ◓	 ● ◓	 ◓ ○
D. Descriptor Rail Truck	 ○ ○	 ○ ○	 ○ ○
Range for all alternatives	Low x.xx High y.yy Median z.zz	Low a.aa High b.bb Median c.cc	Low p.pp High q.qq Median r.rr
Median LCF expected from all causes for a comparably-sized group	e.ee	f.ff	g.gg

◉ Many fewer LCF than average

◓ Fewer LCF than average

○ Average LCF

◒ More LCF than average

● Many more LCF than average

*"Descriptors" will identify the options considered in the EIS (e.g., "No-action").