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Cost-Benefit Considerations in Regulatory Analysis

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Direct costs include expenses for medical treatment for specific acute injuries, and delayed somatic and genetic effects. Indirect costs are evaluated in terms of "loss of human capital" (i.e., the productivity loss to society as a result of illness and premature death). Productivity loss is measured in terms of loss of wages, and is sometimes modified to include nonwage-earning labor (household services). The model includes a data base representative of the average mid-1980s U.S. demographic distribution. Site specific data can be substituted.

The Nieves and Tawil report presents a useful and detailed discussion on the loss of human capital approach. As discussed above, the ***value judgment*** made overtly in this approach is that the societal costs of physical and psychological suffering are neglected.

The direct and indirect costs of delayed effects are expressed in terms of present value, being discounted from the time at which the cost or loss of human capital occurred. It must be emphasized that the process of discounting future medical costs and lost wages ***must not be confused*** with the discounting of future radiation exposures.

3.2.1 Estimates of the Value of Averted Dose Using the Human Capital Approach

Following the general methods of the HECOM Model [2], we have made estimates of the dollar value of a person-rem of radiation dose for 20- and 30-year old, male and female cohorts.

The mean earnings of the four cohorts were based on Table A.18 of the HECOM Report, normalized to 1990 dollars. These are listed in Table 3-1. Note that the human capital approach as used here considers only *earnings* and gives no value to the labor of the homemaker. Hence, the large disparity between the male and female earnings. The data in Table 3-1 are representative of the 1971-1980 decade. Probably more recent data would reduce this disparity between genders.

In order to obtain the *present value* of the SVOL for each of the cohorts, the discounted cumulative earnings for the life expectancy must be calculated. These calculations are listed in Table 3-2 for 7 percent and 3 percent discount rates as recommended in the NRC's Regulatory Analysis Guidelines. In order to simplify the calculations, the discounting was carried out at the center of five-year intervals, and the life expectancy was taken to be greater than 80 years.

For each cancer type, it was assumed that earnings stopped at the end of the latency period, and that the victim was disabled during the two year course of medical treatment. In the case of non-fatal cancer, it was assumed that the earnings resumed at the end of medical treatment. (Note the minor exceptions: in the case of skin cancer it was assumed that no loss of earnings occurred and in the case of benign thyroid nodules only one year loss of earnings was assumed).

The calculations used the risks for each cancer type listed in Table 2-1 of the preceding chapter.

In addition to the loss of human capital, each illness has associated direct costs for medical treatment. The medical costs for first and second year treatment were taken from Table A.17 of the HECOM Report [2] and normalized to 1990 dollars. Since medical treatment begins at the end of the latency period, the costs must be discounted to present value. The present value medical costs for each cancer type are listed in Table 3-3.

The contribution of each cancer type, j, to the value of the dollar per person-rem, V_j, is the product of risk, R_j, and the total cost (loss of earnings plus medical costs), C_j. The total value, V, of dollars per person-rem is the sum over all health effects. The detailed calculations for each of the cohorts are listed in Tables 3-4, 3-5, 3-6, and 3-7 respectively and summarized in Table 3-8. As can be seen, the 1990 \$/person-rem values yielded by this approach range from \$73/person-rem (30 year female cohort as the product of SVOL and the number of latent cancers:

$$LFC(r) = SVOL * \sum_{j=1}^{N} \frac{LF_j(r)}{(1+d)^{l_j}}$$

where

$LF_j(r)$ = number of latent fatalities due to cancer type j at an interdiction limit r (mrem/yr),
l_j = latency period of the jth type of cancer,
d = discount rate (%/year),
N = number of cancer types, and
r = long-term interdiction limit (mrem/yr).

The total cost, *TC(r)*, of an accidental release can then be written as:

$$TC(r) = ODC(r) + SVOL * \left\{ EF + \sum_{j=1}^{N} \frac{LF_j(r)}{(1+d)^{l_j}} \right\}$$

An approximation to the above expression for latent fatality costs is:

$$LFC(r) = SVOL * \frac{LF(r)}{(1+d)^{\bar{l}}}$$

where $\bar{l}$ is an approximate average latency period across all cancer types and $LF(r) = \sum_{N}^{j=1} LF_j(r)$ is the total number of latent cancers due to all cancer types for an interdiction limit of r (mrem/year). The total costs then simplify to:

$$TC(r) = ODC(r) + SVOL * \left\{ EF + \frac{LF(r)}{(1+d)^{\bar{l}}} \right\}$$

We have used the above equation to obtain the variation in total costs out to 50 miles as a function of long-term interdiction level for each of the five plants. These calculations assumed: SVOL of $10 million, a discount rate of 7%, average latency period of 6.7 years and values of LF, number of latent fatalities, and ODC, offsite costs, taken from Tables 4-30 through 4-34. The values of EF, early fatalities, were taken from Table 4-22; early fatalities do not change with variation of the long-term interdiction limit.

The results are shown in Figures 4-11 through 4-15 for each of the five plants. These results display quantitatively the qualitative curve shown earlier in Figure 1-1. For most of the plants, the minimum of the total cost curve for the chosen SVOL lies at an interdiction limit r in the range of 500 to 700 mrem per year. For this particular SVOL, an interdiction limit of 500 - 700 mrem per year thus represents an optimum from the cost standpoint with the offsite costs calculated by the MACCS code. A lower value of SVOL would generally lead to a higher value of the optimal interdiction limit.

For the purpose of estimating the offsite cost/person-rem averted ratio, we take the value at the 500 - 700 mrem per year interdiction limit as shown in Figures 4-6 through 4-10 for each of the five plants respectively as this provides an optimum from the standpoint of minimum total cost. At this range of interdiction limits, the value of the offsite cost/person-rem averted ratio is: $2500/person-rem at Grand Gulf, $3300/person-rem at Peach Bottom, $3000/person-rem at Sequoyah, $3500/person-rem at Surry, and $3000/person-rem at Zion. The mean of these values across the five plants is approximately $3000 per person-rem averted.

4.2 Onsite Damage Costs

The primary goal of the NRC in the licensing and regulation of commercial nuclear power plants is the protection of the public health and safety. Onsite damages at nuclear power plants due to accidents, or purely economic losses caused by extended outages, have traditionally been viewed as being the responsibility of the operating license holder (i.e., the utility and its owners). However, due to the regulated and interlinked nature of the electric power industry, the onsite costs of accidents or outages also imply costs to society as a whole. For example, an accident or the mandated closure of a nuclear power plant could have other impacts besides the loss of benefits and possible cleanup costs to the operating utility. Decreased system