Appendix M
DEBRIS FLOW DAMAGE ESTIMATION

Following are the steps taken to estimate damage from debris flow.

Step 1. *Assess the frequency of significantly damaging debris flows*. This is the most challenging step. For the Multnomah County regions affected, two precipitation-induced (low energy source) debris flows occurred in a seventy-year period. In addition, when corrected, a geologic evaluation of debris material accumulations led to estimates of 17-35 years per debris flow for the sites in question. One prominent geologist in charge of natural hazards for geology and knowledgeable about the area estimated a 50-year return interval. She noted that a high-energy source might occur about every 500 years. One other geologist who had made extensive studies thought that a 35-year return interval was reasonable given the paucity of the data. A third geologist, in charge of hazard mapping for the region, claimed that this hazard mapping was designed for land-use and other planning purposes, and not for analysis of risks. All noted that there had been debris flows in the region, even as recently as 2002, that had not caused damage.

Recommendation: Assume a 35-year return interval, with 17-years and 50-years as assumptions for sensitivity evaluations. Assume that a high-energy source might initiate debris flows every 500 years.

Step 2. *Estimate the damages to the six residences based on significantly damaging debris flows.* (see also step 4) In the original benefit-cost evaluation, a very high dollar amount was put on such damages, about 80 percent higher than the market value of properties. This step consists of estimating the replacement value of these six residences and then estimating the degree of damages expected from debris flows. Data should be gathered to estimate replacement values. Since the debris flows selected in Step 1 are "significantly damaging," it is assumed that losses are 100 percent of replacement value. This at least is consistent with the original benefit-cost evaluation. Costs to clean up the debris, should the damage be less than 100 percent, should be made in consultation with a knowledgeable contractor.

Step 3. *Estimate casualties from significantly damaging debris flows.* There is to date no indication of casualties in the 1996 debris flow. There is much evidence, however, that debris flows worldwide cause many casualties. Debris flows that have low energy sources (precipitation-induced) provided days of prospective warnings. Thus, even though debris flows may only take a few minutes to cause damage once they begin, preparations for precipitation-induced debris flows can occur days in advance. Debris flows caused by high-energy sources may be another matter. They do typically require some degree of prior precipitation, but they may have less warning. In this case, simplified accounts of how many people might be present, and how many might be able to evade, say, 500-year events could be devised. However, because such a simplified technique is highly speculative, it should not govern the benefit-cost ratio. Therefore, assume one death per 500 years as a conservative (lower bound) estimate, and conduct sensitivity evaluations to estimate a possible range of answers.

Step 4. *Determine the degree of damage in the 1996 event.* This step should help not only in refining the prospective degree of damage in debris flows, but more critically should define more clearly the "marginal costs" of buyouts. If the residences are substantially damaged, then buyouts can be a substitute for other payments, such as those through FEMA directly, or from FEMA/FIA (Federal Insurance Agency).