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# WHO PAYS THE BILL: INSURING AGAINST THE RISKS FROM LOW LEVEL NUCLEAR WASTE DISPOSAL\*

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## I. INTRODUCTION

Responsibility for uncertain financial consequences of low level nuclear waste disposal is an important unsolved problem.<sup>1</sup> Three overlapping expenses are of concern: first, funds for decommissioning a site once it is full, that is, preparing the site for (minimal) long-term care; second, funds for long term care, called "perpetual care and maintenance" (PCM), and third, funds for risks associated with radioactive waste disposal, such as unexpectedly expensive decommissioning or PCM costs because of site difficulties, or cleanup and stabilization costs should radiation spread from the site in significant quantity, or public health costs. Because of the third category, the first two cannot be provided for by accumulating funds during the entire planned operating life of a low-level waste (LLW) facility. Unexpected difficulties may force premature closure of the facility. Accumulated funds will then not be sufficient to cover normal decommissioning and PCM.

The risk of premature closure is far from remote. Three of the six licensed LLW facilities in the United States are now closed, although it had been anticipated that they would remain open for many years.<sup>2</sup> Decommissioning and PCM funding is problematic at all three. Additionally, two of the sites require extensive clean-up.

Lack of assured funding for future expenses or for risky consequences is causing problems for current disposal as well. First, the parties involved—regulators, disposal site operators, and generators—are not facing prices that will cause them to take optimal safety pre-

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\*The opinions and conclusions expressed in this paper are those of the author and do not necessarily reflect the opinions of policies of The Rand Corporation or its sponsors.

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1. Low Level Waste is usually defined to be any nuclear waste that is not high level, that contains only small concentrations of transuranic nuclides, and that is not mine or mill tailings. In 1979 half the volume of low-level waste disposed of came from reactors. Nineteen percent is estimated to come from medical and research facilities, 22 percent from industrial activities, and 9 percent from the Department of Energy. G. Levin, *Low-Level Radioactive Waste Management in the U.S.: A Proving Ground*, 24 NUCLEAR NEWS 72 (August, 1981).

2. Of course this track record is not expected to persist. Experience with LLW facilities should lead to far more accurate use projections at future sites, and for better sites altogether. The dismal record to date may, however, exacerbate insurance and bonding problems currently and in the immediate future.

cautions. Briefly, the cost of disposal risks is not included in the price of disposal, so waste disposal prices are too low and generators will consequently purchase inefficiently large amounts of disposal services. Operators and regulators, on the other hand, will not be paid for undertaking safety-enhancing, or risk-reducing, actions, and so presumably underinvest in these activities.

In addition to uncertainty over site safety, uncertainty over future compensation for accidents and liability for decommissioning and PCM has made the siting of new LLW disposal sites virtually impossible. New capacity will be needed to service expanded nuclear activities, as well as for replacement of closed sites. Consequently, a solution to the liability problem is necessary.

Since 1962, federal policy has dictated that commercially generated low level waste be disposed of in commercial, privately operated disposal sites. The sites are regulated by the federal government and the host states.<sup>3</sup> However, the government recognized the difficulty in giving private industry responsibility for necessary long-term isolation and care of the facilities. Consequently, the sites are all located on public lands that are leased to disposal operators. When the sites close, care reverts to the site owner, generally the state in which the site is located.<sup>4</sup> Thus, in effect, the states are responsible for the financial commitments discussed above. However, the states have not made adequate provisions to pay for contingencies.

The liability problem has defied simple solution. Assigning liability to the site operator, a theoretically pleasing solution, does not work. The problem with the concept is that financial obligations do not appear until the operator's source of revenues (disposal activity) has ceased, and indeed until his chief asset (the disposal site) has turned into the chief liability. Liability is in fact constrained by ability to pay. The site operator cannot be counted on for long-term risks.

Requiring the operator to prove financial soundness for risks, by

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3. 42 U.S.C. § 2021 (1978) provides for the NRC to enter into an agreement with the states for states to regulate byproducts materials, source materials; and special nuclear materials in quantities less than a critical mass. Five of the six sites are located in "agreement states," so that LLW disposal is generally regulated by the states. However, at Beatty, Hanford and Barnwell, NRC licenses special nuclear material, as the sites handle quantities in excess of the maximum. The Sheffield site is regulated by both the NRC and the State of Illinois as Illinois is not an agreement state. See NRC TASK FORCE REPORT ON REVIEW OF THE FEDERAL/STATE PROGRAM FOR REGULATION OF COMMERCIAL LOW-LEVEL RADIOACTIVE WASTE BURIAL GROUNDS, OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS AND OFFICE OF STATE PROGRAMS, U.S. NUCLEAR REGULATORY COMMISSION (NUREG-0217, 1977) [hereinafter NRC TASK FORCE REPORT].

4. The sole exception is the Hanford site, on federally owned land leased to the State of Washington. Long-term care of Hanford will eventually revert to the Federal Government. NRC TASK FORCE REPORT, *supra* note 3, at 2.

either posting a bond or purchasing insurance, has proven impractical. Insurance and bonds have not been available at a price that regulators believe is reasonable.

Numerous critics of the status quo have called for federal involvement in insurance.<sup>5</sup> They claim that as the sites benefit the entire country, serving the public interest by accepting nuclear wastes and allowing development of nuclear technology, the federal government should logically assume risks of disposal, or at least should provide necessary insurance to the operators.

Federal assumption of risk, however, raises potential problems. A good solution to the liability problem gives proper safety incentives to all the parties involved in disposal. In particular, federal policy should consider the other federal goals of involving private and state parties in disposal activities. If disposal is to remain a joint endeavor by the federal government, host states and private concerns, then a solution should involve all three parties.

In this paper the problem sketched here is considered. Section 2 gives a brief history of LLW commercial disposal activities. Section 3 analyzes the problem, considering general requirements for insurance both from the ex-ante incentives and ex-post solvency perspectives. The conclusions are applied to the LLW disposal problem and possible insurance arrangements are evaluated.

## SECTION 2: COMMERCIAL LOW LEVEL WASTE DISPOSAL

Prior to 1962 the Atomic Energy Commission accepted commercially generated LLW at AEC disposal sites.<sup>6</sup> In accordance with its pro-commercialization policy, the AEC ceased accepting LLW with the opening of privately-run disposal sites in 1962 at Beatty, Nevada and Maxey Flats, Kentucky. Eventually four other commercial LLW dumps opened: West Valley, N.Y. in 1963, Hanford, Washington in 1965, Sheffield, Illinois in 1967, and Barnwell, South Carolina in 1971. Nuclear Engineering Co. (NECO)<sup>7</sup> runs (or ran) the Beatty, Maxey Flats, Hanford and Sheffield sites, while Chem-Nuclear, Inc. runs Barnwell and Nuclear Fuel Services, Inc. (NFS), a subsidiary of Getty Oil, operates West Valley. States' motivations for encouraging the dumps differed. A Nevada official talked of productive use of Ne-

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5. See e.g., LOW-LEVEL RADIOACTIVE WASTE DISPOSAL, HEARINGS BEFORE THE SUBCOMM. OF THE COMM. ON GOVERNMENT OPERATIONS, HOUSE OF REPRESENTATIVES, 94th Cong., 2d Sess. 311 (1976) (statement of Heyward Shealy) [hereinafter cited as 1976 HEARINGS ON LLW].

6. See NRC TASK FORCE REPORT, *supra* note 3, at 28. The Report includes a fairly comprehensive survey of LLW disposal activities prior to 1977.

7. *Id.* at 30.

vada's "barren lands,"<sup>8</sup> while Kentucky hoped to encourage development of nuclear industries within Kentucky.<sup>9</sup> The Sheffield site largely disposed of waste generated within Illinois. The other three LLW sites are located within major complexes that deal (or dealt) with other parts of the nuclear fuel cycle. The sites are regulated by the host states, with the exception of Sheffield. As Illinois is not an "agreement state" both the NRC and the state regulate the site.

The federal government requires state or federal ownership of LLW disposal sites. Because the dumps require maintenance and protection virtually forever, private ownership with concomitant responsibility was, and is, considered infeasible. All the sites except Hanford are state owned. Hanford is owned by the federal government and leased to the State of Washington. Eventually the site will revert to federal control. Aside from requiring state responsibility, the federal government did not concern itself with PCM: states are not required to have financially viable PCM programs in place or on the drawing boards.

The states have made efforts to shift financial responsibility for PCM back to the commercial dump operators. The typical arrangement is a per cubic foot charge levied on the operator and deposited in an escrow fund. In theory the funds will be large enough by the time the sites close to support PCM. However, until recently states did not seriously consider the adequacy of these funds. When the Barnwell site opened in 1971, South Carolina levied a charge of 8¢ per cubic foot on waste for the PCM escrow fund.<sup>10</sup> At the time, this was the highest charge of all the sites. Not until 1974 did the State commission a study to estimate what charges would be needed to cover PCM costs. The study concluded that the charge should be at least 14¢ per cubic foot.<sup>11</sup> While the fees increased subsequently in New York and South Carolina, by 1977 the charge at Beatty was only 7¢ per cubic foot, while no fees were collected at Maxey Flats between 1972 and 1976, pending renegotiation of a contract.<sup>12</sup> Illinois, in the early disposal years, was further constrained by a policy against

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8. *Id.* at 49.

9. *Id.* at 46.

10. LOW LEVEL RADIOACTIVE WASTE, *supra* note 5, at 315.

11. 1976 HEARINGS ON LLW, *supra* note 5, at 315; NUCLEAR WASTE MANAGEMENT, HEARINGS BEFORE THE SUBCOMM. ON NUCLEAR REGULATION OF THE COMM. ON ENVIRONMENT AND PUBLIC WORKS; U.S. Senate, 95th Cong., 2d Sess., 739-756 (1978).

12. See NRC TASK FORCE REPORT, *supra* note 3, at 49; IMPROVEMENTS NEEDED IN THE LAND-DISPOSAL OF RADIOACTIVE WASTES—A PROBLEM OF CENTURIES, GAO REPORT RED-76-54, at 35 (1976) [hereinafter cited as GAO]. The GAO Report contains a history of the events leading up to the closure of the Maxey Flats site.

earmarked escrow funds. Initially NECO paid 5¢ per cubic foot into general state treasury funds. By 1977 the state required 10¢ per cubic foot, paid into an earmarked fund.<sup>13</sup>

A series of events in the 1970s has shaken the complacency of states regarding their financial commitments. In 1972 radiation was found to have migrated off the Maxey Flats site.<sup>14</sup> The state issued a study in late 1974, identifying radioactivity in the environment. While the level of radioactivity is low, and has been judged then and since to pose no immediate health hazard, further studies were recommended. In June 1976 the Kentucky legislature levied a 10¢ per pound charge on waste disposed at Maxey Flats, an action that virtually stopped all disposal at the site. By the time Maxey Flats closed, in December, 1977 (twenty to fifty years ahead of schedule),<sup>15</sup> the PCM account contained \$180,000. While NECO continues to care for the site and pay for dewatering activities that are necessary to prevent further migration,<sup>16</sup> arrangements to pay for decommissioning, a process that will be much more complex than originally anticipated, have not been settled. Once decommissioned, PCM is estimated at \$150,000 annually, which the fund obviously will not cover. Long-term arrangements have not been made.<sup>17</sup>

During the same period, technical problems emerged at West Valley.<sup>18</sup> The LLW site was closed in March 1975 when seepage was discovered at some trenches. After a year of inconclusive actions, NFS announced its intention of turning the site over to the state. The state has refused the honor. Currently the LLW escrow fund contains several hundred thousand dollars, totally inadequate for PCM let alone cleanup and decommissioning.<sup>19</sup> In February, 1981, NYSERDA convinced a state court to make NFS stay in charge of LLW at West Valley, and also to enjoin Getty from withdrawing funds from NFS, so as to make NFS unable to pay its share of the cleanup.<sup>20</sup> The issue of who will pay for the cleanup remains far from resolved, as does the cleanup itself.

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13. SHEFFIELD NUCLEAR DISPOSAL SITE, memo on the status of the Sheffield site, Department of Nuclear Safety, State of Illinois, Springfield, Illinois, April 1981 (available from author).

14. See GAO, *supra* note 12. More recent attempts to cope with the problems at Maxey Flats are described in R. LIPSCHUTZ, RADIOACTIVE WASTE: POLITICS, TECHNOLOGY AND RISK, at 134 (1980).

15. See NRC TASK FORCE REPORT, *supra* note 3, at 47.

16. LIPSCHUTZ, *supra* note 14, at 132.

17. NRC TASK FORCE REPORT, *supra* note 3, at 47; LIPSCHUTZ, *supra* note 14, at 134.

18. NRC TASK FORCE REPORT, *supra* note 3, at 36-37.

19. *Id.* at 52-54.

20. NFS-N. Y. Dispute Site Responsibility, 24 NUCLEAR NEWS, 98-99 (Feb. 1981).

In 1976 the federal government issued a series of reports on LLW activities. Most influential was a GAO report entitled "Improvements Needed in Land Disposal of Radioactive Wastes—a Problem of Centuries," criticizing NRC and ERDA, and government in general, for poor regulation of sites, particularly inadequate standards defining appropriate sites, disposal techniques, and packaging, and inadequate financing of long-term needs.<sup>21</sup> Issued on the heels of the problems at Maxey Flats and West Valley, the report alerted state officials belatedly to their financial vulnerability, and triggered a series of not very comfortable hearings on LLW disposal.<sup>22</sup>

The Sheffield site closed in early 1978 when the last licensed trench was filled.<sup>23</sup> Although, of all the sites, Sheffield has the largest apparent benefit to its host state—in 1977 70 percent of the waste buried there originated within the state<sup>24</sup>—NECO was frustrated in its attempts to get licenses from Illinois and NRC to enlarge the site. In 1979, after withdrawing its application for renewal, NECO notified Illinois and NRC that it was terminating all licenses, i.e., abandoning the site. Illinois brought suit to force NECO to remain and has obtained an injunction. NECO continues to act as licensee while conditions for decommissioning and closure are litigated at the NRC and at a state court.<sup>25</sup> When the site closed, the PCM fund contained \$50,000. The state has already spent half of that on its lawsuits, leaving little for the estimated annual PCM cost of \$57,000.<sup>26</sup>

The Beatty site is currently open and accepting LLW. It too has had problems, though of a management nature. The site closed in 1976 when it became known that radioactive equipment and items had been pilfered from the site and used in the neighboring town.<sup>27</sup> The site was called locally "the store," because the practice had continued over at least a decade. Both Beatty and Hanford closed for a short time in 1979 over concerns that waste was being transported to the sites in an unsafe manner. At that time the governors of the three remaining host states took actions to insist that the federal government take more responsibility for, and improve, transportation of

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21. GAO REPORT, *supra* note 12.

22. Most comprehensive of these hearings are the 1976 HEARINGS ON LLW. *See supra* note 5. The NRC TASK FORCE REPORT, *see supra* note 3, includes summaries of and citations to other hearings and studies conducted during this period.

23. SHEFFIELD NUCLEAR DISPOSAL SITE, *supra* note 13.

24. NRC TASK FORCE REPORT, *supra* note 3, at 42-44.

25. SHEFFIELD NUCLEAR DISPOSAL SITE, *supra* note 13.

26. *Id.*

27. *See* NRC TASK FORCE REPORT, *supra* note 3, at 36; LIPSCHUTZ, *supra* note 14, at 134-135.

radioactive wastes.<sup>28</sup> Nevada has decided that it will need \$2.7 million in the PCM escrow fund by 1993. The fund currently contains over \$600,000, and the state charges NECO 25¢ per cubic foot along with a license fee. If the site were closed now—an issue taken up periodically by the state legislature, with whom nuclear waste facilities are very unpopular<sup>29</sup>—the PCM fund would not be adequate. Moreover, the state might have to pay for decommissioning should it close the site prematurely.<sup>30</sup> Finally, the State of Nevada has become alerted to the possibility of unanticipated difficulties that are expensive to mitigate, such as has happened at Maxey Flats and West Valley. Expenses would have to be paid out of the PCM fund, further emphasizing the fund's inadequacy. The financial incentive against closing the plant has not been lost on at least some state officials.<sup>31</sup>

Meanwhile the fees at remaining sites have escalated. Barnwell has risen to preeminence among LLW sites and now takes wastes that nearly all originate outside the state, as compared to 1976 when about 30 percent of the wastes were generated in South Carolina. In April 1981 the State raised its fee to \$1.00 per cubic foot and now has a PCM fund of \$4 million and a decommissioning escrow fund of \$2 million.<sup>32</sup> A leader in concern over long-term arrangements for LLW dumps as well as current safety, officials in the state have called for more insurance and bonding.<sup>33</sup>

Starting with the South Carolina study in 1974, the financial shakiness of LLW arrangements has been recognized repeatedly. Initially South Carolina wanted to require Chem-Nuclear to post a declining performance bond for decommissioning and PCM. The bond notion was also endorsed by the Conference of Radiation Control Program Directors, who issued a report on PCM in 1976.<sup>34</sup> The bonding requirement was abandoned by South Carolina when it became appar-

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28. A description of the events leading up to the closure, along with a brief discussion of current legislative moves to improve regulation and siting of LLW facilities is contained in Levin, *supra* note 1, at 72-76.

29. See NRC TASK FORCE REPORT, *supra* note 3, at 49. Current charges were quoted to the author in an interview with Mr. A. Edmondson, Bureau Chief, Consumer Health Protection Services, Carson City, Nevada, April 6, 1981. The political unpopularity is discussed in Levin, *supra* note 1, at 72-76.

30. See NRC TASK FORCE REPORT, *supra* note 3, at 48-50.

31. See Levin, *supra* note 1.

32. Current charges were quoted to author in an interview with Mr. H. Shealy, Chief, Bureau of Radiological Health (DHEC), Columbia, South Carolina, April 6, 1981.

33. This concern dates back to before the Maxey Flats furor. See the testimony of Mr. Shealy in 1976 HEARINGS ON LLW, *supra* note 5, at 300.

34. TASK FORCE REPORT ON BONDING AND PERPETUAL CARE OF LICENSED NUCLEAR ACTIVITIES, 4815 W. Markham St., Little Rock, Arkansas, April 5, 1976.

ent that the bond, if bought commercially, would cost at least 10 percent of its face value, a price that was judged exorbitant.<sup>35</sup>

The experience with LLW sites is that risk of closure is high. The risk generates from several sources. Most expensive are the technical problems that complicate decommissioning and PCM as well as further operation. The risk may come, as at Beatty in 1976, from poor management, or, as with the transportation problems of 1979, from poor coordination and regulation of other parts of the nuclear industry resulting in action by states in the activity that can be leveraged for wider cooperation. Finally, the risk may come from direct regulatory action, as in Sheffield and as has been threatened at Beatty, essentially arising from changed attitudes toward the desirability of the facilities.

While those escrow funds that are still growing are now growing rapidly, arrangements have still not been made to deal with the riskiness of the LLW endeavor. That is, the states are still by and large responsible for risks. Unpreparedness may not be conducive to safety, and provides precedent against allowing new sites. Moreover, because the states also regulate the sites, their financial stake in continued operation may result in the moral hazard of less rigorous regulation.

This situation may eventually be repeated over nuclear power plants. Decommissioning costs have not been as yet covered, while the costs when something goes wrong are evidently far underinsured. In its lawsuit against the NRC, GPU estimated its losses from the Three Mile Island accident at \$4 billion, including \$1 billion for decontamination and debris removal and \$430 million for repair requalification, equipment replacement and personnel retraining.<sup>36</sup> The numbers are moreover still shaky as some new processes and equipment are required to implement the cleanup. While leaving the site as is constitutes a long-term health hazard, it is not clear who will be stuck with the tab.

### SECTION III

The history of LLW disposal demonstrates unpreparedness for dealing with possible contingencies and in some cases, for financing known future liabilities. In this section two problems are considered: who should bear the risks, and who should pay the premiums. The insurance question is considered in general, then the conclusions applied to LLW.

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35. 1976 HEARINGS ON LLW, *supra* note 5, at 316.

36. *GPU Sues NRC for \$4 Billion for TMI Accident*, 24 NUCLEAR NEWS, 50 (Jan. 1981).

### *A. Insurance: General Considerations*

Insuring against risks serves two safety-related purposes. First, insurance internalizes risk-associated business costs, and provides the right ex-ante behavior by people, firms or governments involved in disposal. Second, insurance guarantees that money will be available should the unfortunate event occur.

“Right ex-ante behavior” involves numerous parties. Disposal site operators should have incentives to run an optimally safe operation: to choose the best site (balancing cost and safety) to monitor and test optimally, to employ the best safety practices and so on. In the long run, operators (or government or entrepreneurs) should invest optimally in research for developing safer disposal techniques. Second, waste generators should have the incentive to generate the right quantity of waste. If disposal costs are too low, inefficiently large amounts of wastes are produced. Furthermore, the generator should face full costs when choosing between disposal sites. The choice should balance long-term disposal risks (e.g. facilities in convenient populous areas may be riskier) against risks and costs of transportation, which rise as waste is shipped to more remote sites.

Ex-ante behavior refers to state and federal regulators as well. Efficiency requires that regulatory requirements (e.g., stringency of site standards, extent of state or federal inspections, and decisions to close or restrict the disposal site) reflect risk reduction and implementation costs.

The second safety-related purpose addresses ex-post activities. The objective is for funds to be available after the event for whatever is necessary: clean-up, decommissioning, perpetual care and maintenance, public health or property loss. If funds are available, consequences perhaps can be minimized. On the other hand, lack of funds and accompanying delays in action may result in extended risk of public harm. Delayed cleanup can be more expensive than an immediate response.

The ex-ante concerns are satisfied when each actor faces the full costs of activities that he controls. That is, he can either be liable for full costs of the risks he can effect, or he can be charged a premium equal the probability of the event times consequences (plus, perhaps, a factor correcting for risk preferences) and the premium must change when changes in the actor's behavior shifts either the probability or the consequences. In other words, optimality depends on enforceable liability, or perfectly rated insurance.

This general requirement can be modified somewhat to reflect its general impracticability. First, several different parties may jointly determine the outcome. In this case it may be most convenient to place

the insurance requirement on one actor who is in the best position to avoid consequences by acting alone (i.e., the actor corresponding to Calabresi's best cost avoider).<sup>37</sup> Alternatively, if one party is in a superior position to monitor the remaining actors' actions and to either directly force them to modify those actions or chage them accordingly, the requirement can be placed on that party with the assumption that he will pass along cost shares and incentives. Second, some activities may be by and large under no one's control. However, liability (or the insurance requirement) must be set so that these risks are reflected in the cost of disposal. Otherwise generators will not have the right production incentive. In this case, responsibility might logically rest with the party who can most cheaply enforce the appropriate prices.

Finally, while this discussion has been in optimality terms, it is useful to note that something like good insurance rating gets something like optimality. The objective of the insurance assignment obviously is to do as well as is reasonable. As rating is costly, perfect rating is probably not the best solution. Costs of administration should be factored into the calculus. This objective is central to the proposals here, which attempt to improve on incentive setting although they cannot be expected to optimize.

The ex-post safety goal of adequate funding or compensation is not necessarily tied to the solution of the ex-ante problem. All that is necessary for the latter is that the best possible set of premiums are collected. But ex-post considerations require that some solvent party actually be insurer. It has been suggested that private insurance companies are not appropriate for LLW disposal purposes, and that the federal government be insurer. There are classes of activities that the federal government insures. Examples are floods and nuclear power plant accidents. The federal government typically intervenes when it decides that insurance is not available privately at "reasonable" cost. Part of the rationale may be a straightforward desire to subsidize the activity. However, subsidizing an activity through insurance may interfere with the ex-ante goals and result in moral hazard. A more efficient strategy would be for the government to charge full premiums, and subsidize some other part of the operation.

A related, but separate argument is that insurance companies are charging too large a risk premium. That is, the government is not offering to subsidize the activity outright, but rather to assume some of the riskiness of that activity. The case rests on the proposition that by insuring the activity, the private company would itself be exposed

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37. G. CALABRESI, *THE COSTS OF ACCIDENTS* (1970).

to significant risk that it would cover with a particularly large premium. Normally, private insurance companies reduce risk by pooling over enough independent events that the probability of claims in excess of the collective premiums is very low. The number of identical events need not be great (e.g. NBC insured against losses due to certain contingencies from its coverage of the 1980 Moscow Olympics), but rather the number of independent events must be reasonably large compared to potential claim size.

A problem can arise with potential claim size. Although insurance companies pool risks among themselves and reinsure, the larger the possible claim, the greater the potential risk assumed by the insurance company. More precisely, the variance for expected pooled claims is larger for low-probability high consequence events than the more mundane alternative, when expected pooled claims in both situations are the same.<sup>38</sup> Problems compound when actuarial premiums are difficult to estimate, due to inexperience with the activity, or the related uncertainty over the probability of occurrence. The end result is reluctance to insure, or a fairly large charge to pay for risk-assumption over the (possibly subjective) actuarial rate.

An efficiency rationale can be made for government insurance if the government is better able to control moral hazard than a private insurance company. This case might arise, for instance, from government advantage in understanding the consequences of different technical processes. Government conceivably could better monitor the insured's actions, and experience rate.

### *B. Insuring Risks of Low-Level Waste Disposal*

Insufficient PCM and decommissioning funding occurs when an LLW facility closes early or when costs are higher than anticipated.<sup>39</sup> Early closure and higher costs ensue from operator default, unforeseen technical problems, or regulatory difficulties unrelated to unforeseen technical problems. The three contingencies require separate analysis.

Consider first the operator default category. By definition, this refers to site closures or cost over-runs due solely to operator behavior. It does not include cases when the operator does not know the consequences of his actions, unless he could reasonably have been expected to know the consequences. The model for this category is the

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38. The variance of pooled claims is proportional to the variance of the underlying distribution. Insurance companies have traditionally viewed themselves as taking small risks because of pooling, like the house in a poker game.

39. Funding deficiencies can also occur when insufficient funds are knowingly collected. This case is not treated here.

temporary 1976 closure of Beatty, brought on by a management scandal. The category can be precisely defined as contingencies that arise due to operator violations of license conditions.

Ex-ante considerations dictate that liability rest on the operator. Clearly, no public considerations balance any moral hazard that would ensue from another arrangement. The operator can be required to purchase insurance against these risks, that is, prove financial capacity to cover liability.

It is difficult to argue here for government provision of insurance. The quantity of money involved is relatively small and predictable: several million dollars is claimed to be all that's necessary for normal decommissioning, and the anticipated PCM costs.<sup>40</sup> If reasonable management practices can be defined so that the operator and regulator understand them, then so could a third party: the moral hazard argument does not hold. The case for private insurance against this contingency—that is, the operator must undertake to prove financial responsibility with government help—is strong.

Regulatory difficulties, assuming that they can be segregated from the other categories, are equally straightforward. The characteristic of this contingency is that everything is working as planned, but the plans become unacceptable for reasons unrelated to operator behavior. Financial consequences again are not large. The regulator clearly should be liable, so that he considers costs as well as benefits in his decisions. However, the risk should be reflected in the cost of the service, to provide the right signals to waste generators. A simple solution is for the regulator to insure against his potential actions, but charge the operator, who will then pass through to generators a fee reflecting expectations about actions. The regulator presumably will have to provide self-insurance, as moral hazard from insuring against this type of event dominates the probability of its occurrence.

Risks of unforeseen technical problems are the most interesting category of problems with LLW disposal. Although not considered as extreme as risks from other parts of the nuclear fuel cycle or other types of nuclear waste disposal, the risks include low probability-high consequence events. Estimation of the likelihood of an event occurring, or its potential impact, is difficult to impossible. Moreover, the natures of LLW problems are not like a power plant accident or earthquake, but tend to be continuous, cumulative problems. Maxey Flats and West Valley, for instance, were not "safe" one day and a health hazard the next. Rather, migration and seepage occurred over a

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40. See *supra* note 34, at 24.

period of years, and finally authorities decided that the situations were unsafe. Indeed, four years passed between the discovery of migration at Maxey Flats and the site's closure.

Risks from unforeseen technical problems are typically influenced by actions of site operators, state regulators, and federal regulators. Insurance arrangements involving only the operator, or state insurance of the operator, or, as has been proposed by states, federal insurance of operators, are not generally desirable in view of the ex-ante goals. Should such a difficulty develop, the operator may discover it most rapidly. Financial consequences are needed to give operators incentives to uncover, report and treat problems. Insurance premiums ideally should be structured to encourage operators to establish good monitoring programs.

Unfortunately, the site operator has (at best) conflicting motives for reporting problems that result in site closure. As long as the site is open, the operator collects revenue. Once closed, it becomes a liability. Moreover, the cost of decommissioning and PCM bonds against early closure increase with higher likelihood of site closure. If operators are thought to report all problems, commercial bond prices may rise. Traditionally, incentives against such action are provided by civil or criminal penalties. However, collecting penalties after the fact involves the same problems as collecting decommissioning or PCM funds. Operators could be required to bond against such possibility. Alternatively, the problem argues for sharing risk of revenue loss. In effect, insurance for PCM and decommissioning can be extended to cover lost revenues as well.

States are in most cases the primary regulators. Consequently, they too, are in the right position to uncover, report and treat problems. Moreover, they have primary responsibility for overseeing normal site operations. Finally, they supposedly will eventually take over the site for PCM. Federal preemption of these state activities is periodically considered by Congress.<sup>41</sup> The issues involved in the debate are beyond the scope of this paper. If the federal government takes over these activities, state involvement in insurance is no longer necessary for ex-ante efficiency. However, as long as the states play a key role in site safety, their involvement in financing is desirable.

While states and operators may be best able to identify problems ex-post, the federal government has expertise for initial site location and standard-setting. Critics argue that unforeseen technical problems at Maxey Flats should have been foreseen, in particular by the AEC

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41. See 1976 HEARINGS ON LLW, *supra* note 5.

when it originally chose the site. Consequently, the federal government's participation in insuring sites is desirable from the ex-ante perspective.

The ex-post goal of solvency essentially requires the federal government to be insurer, at least for very large, presumably remote, consequences. These contingencies fall into the category of risk that private insurance companies are reluctant to assume: large consequences, uncertain probabilities, inexperience with the event. Site operators are unlikely to find adequate private coverage. Similarly, the states are in a poor position to be insurer: although their assets are larger than those of the operator, insuring this class of events exposes the states to considerable risk. Federal involvement is necessary, particularly for catastrophic events.<sup>42</sup>

These arguments for federal and state involvement do not rationalize a direct federal subsidy of disposal activities. Waste-disposal subsidy arguments are not altogether consistent. If host states are providing, as they claim, a service to the whole country, then they can charge a fee for disposal that accrues to general state revenue funds. The fee is paid, via generators, by direct beneficiaries of nuclear technology. Moreover, the subsidy is not essential for government promotion of nuclear technology. When a single input of a process is subsidized, production will be shifted so as to use relatively more of that input. If waste disposal is subsidized, nuclear related production will generate more waste products than would otherwise have been the case. However, in general waste disposal should be as small an activity as possible. If the government wants to subsidize overall nuclear industry, then it does better to subsidize publicly valuable parts of the industry, such as power production, rather than waste disposal.

The analysis here suggests that both state and federal sources be involved in insuring LLW disposal sites, at least as long as states are responsible for regulating operations at the sites. In order for ex-ante goals to be satisfied, premiums must vary with changes in behavior of operator, state or federal agency that affect probable safety at the site. The most traditional way of satisfying, insofar as possible, these criteria, is for the state to insure the operator, and the federal government to reinsure states for losses in excess of some level. That level would be chosen considering the relative advantages of the state or federal agency in controlling an incident of differing dimensions and

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42. There is considerable precedent for this view. Of particular relevance are the perennial discussions about the Price-Anderson Act. *See, e.g.* L. Cohen, A Public Policy Approach to the Study of Optimal Compensation Systems: the Case of the Price-Anderson Act, Feb. 1979 (Kennedy School of Government Discussion Paper No. 61D, Harvard University, Cambridge, Mass.).

in paying for the consequences. The discussion here suggests that an insurance—reinsurance scheme is consistent in both counts.

On the one hand, smaller consequence accidents are more likely to be of a more mundane nature, and hence more amenable to analysis, observation and control by a state regulatory agency. The catastrophic event, alternatively, is presumably remote, subject to more uncertainty, and due to factors that possibly could not be expected to be observable in advance by a state regulatory agency.

On the issue of solvency, as has previously been discussed, federal participation is most defensible at very high damage levels. Consequently state insurance with federal reinsurance satisfies the solvency goals.

#### SECTION 4: CONCLUSIONS

Long-run financial liability for LLW activities is not currently assured. Part of the problem with finding an acceptable solution to liability has been a tendency to lump all long-term financial commitments, both risky and anticipated, together. As this analysis demonstrates, incentive and solvency considerations dictate a variety of solutions.

It is suggested here that only risks arising from unforeseen technical problems require special federal policies. Other long-term costs are more efficiently handled by traditional private insurance. Special policies are needed for the “unforeseen” risks because of several problems. Uncertainty over likelihoods and potential high consequences make private insurance very expensive. The goal of solvent insurer requires federal action. However, joint safety responsibilities of federal, state, and commercial operators argue for a solution that involves all three parties.

The analysis in Section 3 concludes that state insurance of operators with federal reinsurance may be the most reasonable concept. Reinsurance levels should be set to balance federal information requirements, relative control of the three main parties over outcomes, and solvency requirements. While the solution is not yet implementable, it is hoped that this discussion clarifies the problem, and provides guidelines for necessary further research.