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Harold P. Green

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†HAROLD P. GREEN

Use of atomic energy technology, like other human activities, gives rise to waste which must be disposed of in the environment. Much of the waste generated in atomic energy technology is, however, of a different character involving significantly different technological and social problems than other industrial wastes. This is attributable to the radioactive character of such atomic energy waste materials. Radioactive wastes arise from many different activities which are part of the overall atomic energy technology: the mining and processing of uranium, the fabrication of nuclear reactor fuel elements, the operation of nuclear reactors, the reprocessing of nuclear fuel elements, and the use of radioisotopes. The radioactive wastes may be injected into the environment in liquid, solid, or gaseous form, or they may be in the form of scrap material or contaminated equipment, rags, paper, animal carcasses, and the like.

It is useful to recognize at the outset that the problem of radioactive waste and its effect on life is a relatively new one. Until about the beginning of this century, the only ionizing radiation to which living creatures were exposed was that radiation which nature itself provided as part of the environmental background.[1] The amount of this natural background radiation varies from one geographical area to another. People who live at high altitudes are likely to receive substantially higher exposures than those who live at sea level, and in a few areas radiation exposure may be ten or so times the average at sea level.[2] Scientists tell us that there is no reason to believe that life in areas of higher natural background radiation is adversely affected as compared with life in lower natural radiation-level areas.[3]

At about the turn of the century, with the development and use of x-rays, it soon became apparent that radiation exposure was capable of producing serious injury,[4] and this phenomenon was dramatically demonstrated in the case of workers engaged in painting watch dials with radium.[5] Indeed most of our knowledge concerning the somatic effects of ionizing radiation was, until the dawn of the atomic era, derived from cases of exposure to x-rays and radium. In those early days, however, man-made radiation did not pose a threat to the

†Professor of Law, The National Law Center, George Washington University.

1. M. Eisenbud, Environmental Radioactivity 392 (1963).
2. *Id.*
3. *Id.* at 393.
4. *Id.* at 12.
5. *Id.* at 12. *See* La Porte v. U.S. Radium Co., 13 F. Supp. 263 (N.J. 1935).

general public or to the environment. The persons who were exposed were all in a sense volunteers (although perhaps not informed volunteers) in that they were persons whose occupations exposed them to radiation or who consented to the exposure for medical or dental purposes.

With the advent of atomic energy technology during World War II, the area of radiation exposure was tremendously expanded. The public at Hiroshima and Nagasaki was forcibly exposed to radiation; the testing of nuclear weapons gave rise to radioactive fallout which permeated the environment; and the peaceful uses of nuclear technology began to generate high amounts of man-made radiation with an obvious potential effect on the environment and organisms existing in the environment. It has been pointed out that during the first 40 years of this century about two pounds of radium were extracted from the earth and that misuse of this radium resulted in the death of at least 100 persons.[6] On the other hand, since 1942 the radioactive equivalent of many tons of radium has been produced by the atomic energy industry, government and private.[7] This article shall deal exclusively with radioactive wastes generated in the peaceful uses of atomic energy and primarily with those wastes which are generated in connection with nuclear power technology.

It should be recognized that most of the radioactivity generated in the peaceful uses of atomic energy is effectively confined and contained within the physical structures in which the activities take place. Such radiation obviously has no effect on the environment. But almost every activity involving the generation or use of radioactive materials gives rise in one way or other to radioactive wastes which must be disposed of outside these structures, *i.e.*, in the environment.

In some cases, radioactive wastes such as liquid radioactive effluents from nuclear power plants are purposely discharged into streams, lakes, or the sea as the optimum means for disposal; similarly, gaseous effluents from such plants are discharged from the plants' stacks into the atmosphere. In other cases, radioactive wastes may be packaged into containers and dumped into the sea with the expectation that the integrity of the containers will be maintained for a sufficiently long period of time to permit the natural decay of radioactivity so that when the containers finally rupture or leak there will be no adverse consequences.

In considering the problem of radioactive waste disposal, it is necessary to distinguish between what are termed "low-level wastes"

6. M. Eisenbud, *supra* note 1, at 12.
7. *Id.*

and "high-level wastes." The definitions of these terms and the distinction between them is functional and, indeed, tautological.[8] High-level radioactive wastes are those which, because of their radioactive longevity, biological risks, and concentration of radionuclides, must be perpetually isolated from the biosphere. Low-level wastes are those which, it is believed, can safely be discharged into the biosphere. These definitions in themselves tell us much about the manner in which the radioactive wastes are handled.

Obviously, since the high-level wastes must be perpetually isolated from the biosphere, they are never purposely discharged into the biosphere. The general philosophy in managing such wastes, which arise primarily from the chemical reprocessing of spent reactor fuel elements, is to "concentrate and contain" them.[9] A reactor fuel element must be removed from the reactor for reprocessing after a period of usage. At the time it ceases to be useful in fueling the reactor, only a small part of the fuel will actually have been consumed. In the process of such consumption of fuel, waste material, known as "fission products," and plutonium will have been generated. The unconsumed fuel, the fission products, and the plutonium are also extremely hazardous to life, and the fuel element must be carefully handled to prevent escape of these materials into the environment.

The spent fuel elements must be transported to a fuel reprocessing plant. At the present time there is only one privately owned and operated reprocessing plant in the United States, located in West Valley, New York, in addition to three AEC-owned and operated plants in Idaho, South Carolina, and Washington. The New York reprocessing plant presently handles, or has contracts to handle, fuel elements from such diverse points as Illinois, Minnesota, New England, New York, and California.[10] The transportation of the fuel elements to this plant obviously involves the possibility of an accident which might have catastrophic potentialities.[11]

At the reprocessing plant, the fuel element is opened and its various component materials are separated. The unused fuel and the plutonium are extracted and transported for subsequent use. The waste fission products must be disposed of in a manner which will perpetually isolate them from the biosphere. This perpetual isolation

8. *See id.* at 258; U.S. Atomic Energy Comm'n, The Nuclear Industry 1969, 251-52 (1969).

9. *Hearings on Industrial Radioactive Waste Disposal Before the Special Subcommittee on Radiation of the Joint Comm. on Atomic Energy*, 86th Cong., 1st Sess., vol. 2 at 989 (1959) [Hereinafter cited as *1959 Hearings*].

10. U.S. Atomic Energy Comm'n, The Nuclear Industry 1969, 212 (1969).

11. *1959 Hearings*, *supra* note 9, at 341.

is required since some of the components of the waste will be dangerously radioactive for hundreds or thousands of years. Again, shipment of the unused fuel, the plutonium, and the waste products involves accident potential.

At the present time, there are many millions of gallons of these high-level radioactive wastes stored in underground tanks embedded in concrete at Atomic Energy Commission installations.[12] Storage of this material in this manner perpetually involves major technological problems. Radioactive decay of the wastes produces intense heat which must be controlled, and the heat produces boiling and surging of the radioactive brew. Since the technology is only about 25 years old, there is inadequate experience to determine the period of time for which the tanks will maintain their integrity and effectively contain the brew. The possibility exists that it may be necessary to transfer the wastes to new tanks, with attendant risks, at least several times before the radioactivity dissipates sufficiently to permit some form of more effective permanent disposal. In addition, the integrity of the tanks is subject to accidents, sabotage, natural catastrophe, and enemy action in event of war.[13]

These problems, coupled with the sheer volume of high-level radioactive wastes as the nuclear power industry expands, have given rise to efforts to find alternative techniques for managing high-level wastes.[14] These efforts include research and development on the injection of liquid waste into deep wells or into hydraulically fractured layers of shale. A particularly promising approach is the conversion of the liquid waste into solids[15] which can then be encased in stainless steel containers and buried in underground vaults or in salt mines. Salt mines seem to be particularly appropriate for this purpose since "salt is impermeable, soft, plastic, and easy to mine; in addition, it is an efficient natural shield against gamma radiation and is not associated in the earth with potable water."[16]

The AEC announced in June, 1970, that it had selected a site near

12. At the end of 1969, more than 80 million gallons of such wastes were stored in about 200 underground tanks, ranging in capacity from 300 thousand to 1.33 million gallons, at AEC facilities in Washington, Idaho, and South Carolina. U.S. Atomic Energy Comm'n, The Nuclear Industry 262 (1969).

13. For a description of these problems, see Snow, *Radioactive Wastes From Reactors,* 9 Scientist and Citizen 89 (1967).

14. *Id.*

15. On June 2, 1969, AEC announced a proposed new policy requiring that all high-level radioactive wastes be converted to solid form and shipped as soon as practicable to a federal waste repository. AEC Press Release M-132, (June 2, 1969).

16. Report of the Comm. on Geological Aspects of Radioactive Waste Disposal, Earth Sciences Div., Nat'l Academy of Sciences–Nat'l Research Council, 116 Cong. Rec. S. 6337 at S. 6342 (1970).

Lyons, Kansas for an initial salt mine repository for the demonstration of long-term storage of solid high-level radioactive wastes. Although there seems to be general agreement that salt-mine storage of solidified radioactive waste is the optimum form of waste management—certainly better than liquid storage in underground tanks—this decision raises some interesting questions. The State of Kansas presently has little interest in nuclear technology. Nevertheless, a waste disposal facility, which will make only a minimal contribution to the state's economy, will be located there to service the atomic energy activities in remote other states. Whatever the risks of nuclear waste storage may be, and there are certainly risks involved at least in transportation of the wastes to the site, Kansas will bear them.

With respect to low-level wastes, the basic philosophy is to "dilute and disperse" them.[17] Rivers, lakes, and seas provide an excellent medium for the dilution and dispersal of low-level liquid radioactive wastes; and the atmosphere is an excellent medium for dilution and dispersal of such wastes in gaseous form. Nuclear power plants and nuclear fuel chemical reprocessing plants are located near bodies of water, and radioactive liquid effluents arising from operation of these plants are routinely discharged into such waters. Similarly, gaseous effluents are discharged into the air.

In addition, there are low-level radioactive wastes in solid form which must be disposed of, and the seas have been utilized for the disposal of packaged low-level wastes. Hopefully the containment will hold the radioactive materials for a long period of time permitting decay of the radioactivity; even if the containment fails, however, the low-level radioactive materials will quickly be diluted and dispersed.

During the early years of the American atomic energy program, the dumping of packaged low-level radioactive waste in the Atlantic, Pacific, and Gulf of Mexico coastal waters was a favored method of disposal.[18] The radioactive wastes were mixed with concrete in steel drums and dumped into the sea. It was believed that the containment would be effective for about ten years, by which time radioactive decay would reduce most radioisotopes to below hazardous levels.[19] This practice engendered considerable apprehension on the part of inhabitants of coastal areas in the vicinity of the disposal activities. In one case the Mexican Government strongly opposed the dumping of radioactive wastes in the Gulf of Mexico, and the AEC ultimately

17. *1959 Hearings, supra* note 9, at 989.
18. M. Eisenbud, *supra* note 1, at 266-68.
19. *1959 Hearings, supra* note 9, at 1429-1488.

denied a license for such activities on the basis of foreign policy considerations.[20]

In 1960, the AEC announced that it would allow atomic energy licensees to have their low-level wastes buried in land at the AEC's Oak Ridge and Idaho facilities.[21] Later, the AEC announced that it would permit burial of license-generated low-level wastes in land owned by states so as to assure perpetual care of the buried wastes.[22] With these new policies, economic considerations dictated land-burial rather than packaged disposal at sea, and no American-generated radioactive wastes are now disposed of at sea. On the other hand, the European Nuclear Energy Agency has been sponsoring an experimental project which has involved the dumping since 1967 of 20,000 tons of packaged solid low-level waste into the Atlantic Ocean at a depth of 16,400 feet.[23]

It is apparent that the handling of high-level wastes can involve detriment to the environment only in the event of miscalculation or accident, since every effort is made to keep these wastes isolated from the biosphere. Similarly, land burial of packaged low-level wastes is designed to avoid any environmental contamination.[24] On the other hand, direct discharge of radioactive and liquid effluents into the environment obviously can have an impact on the environment.

Atomic energy technology, as it develops, will inevitably result in the generation of ever-increasing quantities of radioactive materials,

20. *In the Matter of Industrial Waste Disposal Corp.*, 2 AEC 70 (1962), 2 CCH Atom. En. L. Rep. para. 11,462.

21. U.S. Atomic Energy Comm'n, Major Activities in the Atomic Energy Programs, Jan.-Dec. 1960, 101 (1961).

22. This policy is reflected in a provision in AEC's regulations which states that AEC will not approve any application for a license to receive licensed material from other persons for disposal on land not owned by the federal or a state government. 10 C.F.R. § 20.302 (1970). One who is licensed to possess and use radioactive materials may, however, himself bury the material in soil within specified quantitative limitations, 10 C.F.R. §20.304(a) (1970), so that the requirement for burial in government-owned land is limited to commercial waste disposal operations. The rationale for this limitation is that the buried waste material may be hazardous for hundreds of years, requiring perpetual maintenance of the burial ground. The presumption is that there is not adequate assurance that any individual or corporation will exist perpetually; therefore, perpetual maintenance will be assured only if the land is owned by the federal or a state government. In 1963, AEC withdrew from providing land waste burial services to licensees based on the availability of commercial waste disposal services which used state-owned burial grounds in Nevada and Kentucky. Since then, additional state-owned burial grounds have been established in Washington, Illinois, and New York. U.S. Atomic Energy Comm'n, *supra* note 8, at 254.

23. U.S. Atomic Energy Comm'n, *supra* note 8, at 267.

24. Report of the Comm. on Geological Aspects of Radioactive Waste Disposal, *supra* note 16, at 6354.

much of which will inevitably have to be disposed of as waste.[25] Such materials involve intrinsic hazards and not only to the present generation. Current enjoyment, now and in the future, of the benefits of atomic energy technology generates radioactivity which will persist, and be a charge upon, successive generations far into the future.

Development and practice of the technology proceed upon the twin assumptions that (1) techniques for containing radioactive waste will be effective in isolating the waste from the biosphere in perpetuity or at least for a sufficiently long time that if the containment fails no harm will result; and (2) to the extent radioactive waste enters the biosphere, it does so in quantities which will have no adverse effects on life.

The first of these assumptions rests upon an assumption of scientific and technological infallibility. Conceding, at least *arguendo,* that the most careful and meticulous consideration is given to planning and implementing techniques for containment and confinement of radioactive wastes, there still remains a substantial margin of risk. The most desirable techniques conceivable can be disrupted, with potentially disastrous consequences, by natural catastrophies, human intervention, or unforeseeable accidents. Beyond these considerations, however, is the basic fact that these techniques, based on the experience with and study of radioactive wastes for less than thirty years, are being applied to protect mankind against mushrooming quantities of waste for periods of hundreds of years into the future. It would be a display of inordinate human conceit to contend that these techniques are, and will be, infallibly effective.

The second of these assumptions involves more complex considerations. At the outset it should be recognized that to date the increment of environmental radioactivity attributable to atomic energy technology is generally less than the amount of natural background radiation,[26] and epidemological studies do not provide any indication that there have been any deleterious effects of any charac-

25. In 1968, the volume of low-level solid radioactive wastes available for commercial burial amounted to about 666,570 cubic feet. It is estimated that this will rise to about a million cubic feet in 1970, to 3 million cubic feet in 1975, and to about 6 million cubic feet in 1980. U.S. Atomic Energy Comm'n, *supra* note 8, at 255. It is estimated that the accumulated volume of high level wastes generated in the civilian nuclear power program will rise from 17,000 gallons in 1970 to 4.4 million gallons in 1980, and to 46 million gallons in the year 2000. *Id.* at 265.

26. *Hearings on Environmental Effects of Producing Electric Power before the Joint Committee on Atomic Energy* (Statement of AEC Comm'r Dr. Theos J. Thompson), 91st Cong., 1st Sess. 180, 190 (1969) [Hereinafter cited as *1969 Hearings*].

ter whatsoever. Moreover, all atomic energy activities, private and governmental, within the United States, including radioactive waste management, are conducted in accordance with radiation protection standards which impose stringent limitations on the quantities of radiation and concentrations of radionuclides which may be discharged into the environment.[27]

These radiation protection standards emanate from an intricate network of organizations concerned with radiation safety.[28] Since it was first recognized that ionizing radiation is harmful to life, the International Commission on Radiological Protection (ICRP) has been developing and promulgating standards for world-wide application. The American counterpart of the ICRP, the National Council on Radiation Protection and Measurements (NCRP), a private organization of radiation experts, has been developing and promulgating standards for application in the United States. Since 1959, the Federal Radiation Council, a government agency, has been promulgating radiation protection "guides" for application by all federal agencies concerned with radiation.[29] Finally, the Atomic Energy Commission has developed and promulgated radiation protection standards for application to activities within its own program and activities of the AEC's licensees.[30] Although there are some minor differences among these four sets of standards, they are basically consistent with each other.

The scientific experts who have established these standards believe that they are highly conservative, *i.e.*, that the maximum discharges and concentrations permitted provide a very substantial margin of safety.[31] It should also be stressed that although these standards fix maximum permissible levels, in actual practice, efforts are made to assure that the actual discharges represent only a small fraction of the established limits.[32]

The facts that the radiation protection standards are in themselves

27. 10 C.F.R. § 20 (1970).

28. *See* Staff of the Joint Comm. on Atomic Energy, Selected Materials on Environmental Effects of Producing Electric Power, 91st Cong., 1st Sess. 81-119 (Joint Comm. Print, 1969).

29. 49 U.S.C. § 2021(h) (1964). The functions of the FRC were transferred to the Environmental Protection Agency under § 2(a)(7) of Reorganization Plan No. 3 of 1970, 35 Fed. Reg. 15623 (1970).

30. 10 C.F.R. § 20 (1970). The radiation standard setting functions of the AEC, to the extent they "consist of establishing generally applicable environmental standards for the protection of the general environment from radioactive material" were transferred to the Environmental Protection Agency under § 2(a)(6) of Reorganization Plan No. 3 of 1970, 35 Fed. Reg. 15623 (1970).

31. *1969 Hearings, supra* note 26, at 221 (statement of AEC Comm'r Clarence E. Larson).

32. *Id.*

extremely conservative and that atomic industrial operations are conducted well within these standards lead to the proposition, advanced by the atomic energy industrial and governmental establishments, that discharge and disposal of radioactive wastes in the atmosphere, ground waters, and the seas are completely safe and do not constitute pollution.[33] This point is repeatedly made in dramatic form. We are told, for example, that a member of the public could drink the liquid effluent coming from the outflow pipes of a nuclear power plant, before it is diluted in the water into which it is discharged, throughout his lifetime without exceeding the radiation protection standards;[34] or that a neighbor of a nuclear power plant would receive in a single round-trip jet flight from Washington to San Francisco an additional radiation exposure equivalent to that which he would receive in an entire year from the nuclear power plant.[35]

These facts are comforting since we seem destined to live in an environment in which atomic energy technology will be utilized to an ever-increasing extent. At the same time, it is necessary to scrutinize the assumption that the generally accepted radiation protection standards validly define radiation exposures and concentrations which are "safe." Such scrutiny is particularly important in view of questions which have been raised concerning the adequacy of the AEC's radiation protection standards by Dr. John Gofman and Dr. Arthur Tamplin of the AEC's own Lawrence Radiation Laboratory. They have contended in essence that (1) all major forms of cancer are produced by radiation; (2) a given dose of radiation will increase all forms of cancer and leukemia to approximately the same degree; (3) if everyone in the United States were exposed to the radiation levels "permitted" in Part 20 of AEC's regulations, this would result in an extra case of cancer or leukemia for every ten that occur spontaneously, or about 16,000-32,000 more cases of cancer or leukemia each year; and (4) children and infants *in utero* are much more susceptible than the population as a whole.[36]

Scientific spokesmen for the AEC concede that "all radiation is potentially dangerous and that radiation exposure should always be kept as low as practicable." They take issue with Gofman and Tamplin across a broad range of scientific conclusions. They point to "new scientific evidence [showing] . . . strong indications that in

33. *Id.*

34. *Id.* at 180 (statement of AEC Comm'r Dr. Theos J. Thompson).

35. Address by AEC Comm'r James T. Ramey, *Radiation Protection–Past, Present, and Future,* July 28, 1969 (reprinted in Staff of the Joint Comm. on Atomic Energy, *supra* note 28, 473, 477).

36. The Gofman-Tamplin position, together with AEC rebuttal material, may be found in *1969 Hearings, supra* note 26, at 640-708.

some instances there may be a threshold effect (a level of radiation below which there are no harmful effects)." They argue that there is no "accepted evidence for any sort of genetic or tissue damage to any human" exposed to the "permissible" maximums. They point out that presently no one in the United States is being exposed to even a small fraction of the "permissible" amount. And they argue that the effects of radiation exposure attributable to nuclear power plants on life is trivial as compared with the effects attributable to coal fumes and smog.[37]

Of course, the issues raised in this controversy involve scientific questions which can be fully comprehended only by scientific experts on the effects of radiation on life. Nevertheless, it is possible for a layman, even a lawyer, to understand the basics of the dispute and to perceive that whether or not Gofman and Tamplin are expressing valid judgments on scientific questions, they are raising legitimate questions of public policy.

Prior to 1959, basic radiation protection standards were set by a private group, the National Committee on Radiation Protection (NCRP). This non-governmental group was organized in 1929 to formulate radiation protection standards for voluntary compliance by persons who worked with radiation.[38] The AEC's radiation protection standards in Part 20 of the AEC's regulations[39] were incorporated, virtually intact, from the NCRP's standards. In 1959, the Federation Radiation Council (FRC) was established to advise the President on radiation matters "including guidance for all [f]ederal agencies in the formulation of radiation standards." In 1960, the FRC submitted a report to the President which included seven recommendations which were approved by President Eisenhower "for the guidance of [f]ederal agencies." These recommendations were basically consonant with the NCRP standards and the standards set forth in Part 20 of the AEC's regulations. The FRC report may properly be regarded as the fundamental document establishing national policy with respect to radiation protection standards.[40]

This Report describes the basic task of setting radiation protection standards as follows:

37. *Id.* These points are succinctly made in lay language in an article by AEC Comm'r Theos J. Thompson and William R. Bibb, *Are U.S. Radiation Exposure Limits Dangerously High? No,* The Washington Sunday Star, Aug. 30, 1970, § B, at 3.

38. The NCRP is now known as the National Council on Radiation Protection and Measurements. For a description of the various groups involved in the setting of radiation protection standards, and for a brief history of these standards, see L. Taylor, *Standards for Protection Against Radiation,* 12 Atom. En. L. Rev. 139 (1970).

39. 10 C.F.R. § 20 (1970).

40. The text of the report may be found at 1 CCH Atom. En. L. Rep. para. 4046.

> Fundamentally, setting basic radiation protection standards involves passing judgment on the extent of the possible health hazard society is willing to accept in order to realize the known benefits of radiation. It involves inevitably a balancing between total health protection, which might require foregoing any activities increasing exposure to radiation, and the vigorous promotion of the use of radiation and atomic energy in order to achieve optimum benefits.[41]

The Report also sets forth the "basic biological assumptions" underlying its Radiation Protection Guides:

> There are insufficient data to provide a firm basis for evaluating radiation effects for all types and levels of irradiation. There is particular uncertainty with respect to the biological effects at very low doses and low dose rates. It is not prudent therefore to assume that there is a level of radiation exposure below which there is absolute certainty that no effect may occur. This consideration, in addition to the adoption of the conservative hypothesis of a linear relation between biological effect and the amount of dose, determines our basic approach to the formulation of radiation protection guides.[42]

The principal recommendation of the FRC was that "There should not be any man-made radiation exposure without the expectation of benefit resulting from such exposure." The very next sentence, however, states that "Activities resulting in man-made radiation exposure *should be authorized for useful applications*" in accordance with the FRC's specific recommendations as to numerical values for "permissible" exposures. On the other hand, the FRC states that "every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable."[43]

Cutting through the verbiage to its essence, the FRC stated that it should be permissible for persons to be exposed to the levels of radiation contemplated in its Guides if the exposure is incident to "useful applications"; but that every effort should be made to keep radiation exposures at the lowest level possible. No matter how low the level of exposure, however, there remains a possibility of injury to human beings. This risk is acceptable in exchange for the benefits flowing from useful application of radiation technology.[44]

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41. *Id.*
42. *Id.*
43. *Id.*
44. As Dr. Lauriston Taylor, Chairman of the NCRP since its inception, put it, the NCRP adopted the general concept that

> . . . any radiation exposure might involve some risk, however small. It further recognized that the setting of protection standards would have to involve value judgments in comparing the risks and the benefits that would somehow offset them.

L. Taylor, *supra* note 38, at 149.

Part 20 of the AEC's regulations, which is consistent with the FRC Guides, applies the same numerical values to radiation exposures resulting from activities subject to AEC regulation. This reflects the AEC's judgment that activities licensed by it are "useful applications." And, although the AEC always informally encouraged its licensees to hold radiation exposures as low as possible, it was not until April 1, 1970, that the AEC proposed an amendment to its regulations which would explicitly require that licensees "make every reasonable effort to maintain radiation exposures and releases of radioactive materials in effluents to unrestricted areas [*i.e.*, into the environment] as far below the limits specified in this part as practicable."[45]

There are two indisputable basic propositions. First, atomic energy technology involves substantial benefits to our society. Second, the use of this technology generates wastes which, if discharged or disposed of in the biosphere, involves some degree of risk. The quantum of risk is uncertain. Gofman and Tamplin take a pessimistic view and contend that the risks are substantial. The AEC, and the scientific establishment generally, take an optimistic view and contend that the risks are trivial. The fact is that there is insufficient knowledge at the present time to determine which view is scientifically correct. This is so because the somatic effects of low-level radiation exposure at low dose-rates (if indeed there are such effects) are non-specific in the sense that they produce somatic conditions such as cancer which result from causes other than radiation exposure. Moreover, the effects of radiation are slow-working, cumulative, and often latent. If such radiation exposure does involve the potentiality of injury to human beings, the only way we can become aware of the injurious propensities is to deduce them through statistical, epidemological studies. But human beings have been widely exposed, without any real scientific measurements or controls, to low-level radiation for only about 25 years—less than a generation—and this may not be a sufficiently long period of time for evidence of radiation effects to become manifest. After all, it was not until automobiles had been used for about a half-century that we recognized the injurious qualities of exhaust fumes; and it took about 25 years' use of DDT to provide us with reliable data as to DDT's injurious characteristics.

The point is often made that more is known about the effects of ionizing radiation than the effects of any other noxious agent which man has introduced into his environment.[46] A companion point is

45. 35 Fed. Reg. 5414 (1970). The amendment became effective Dec. 28, 1970. 10 C.F.R. § 20.1(c) (1971).

46. *See e.g.*, *Summary Reports from a Study by the National Academy of Sciences,* Report of the Committee on Pathologic Effects, in Staff of the Joint Comm. on Atomic Energy, *Selected Materials on Radiation Protection Criteria and Standards: Their Basis and Use,* 86th Cong., 2d Sess. 1205 (1960); L. Taylor, *supra* note 38, at 139.

that unlike these other noxious agents which were introduced without regulation, in the case of radiation, its hazards have been appreciated from the outset and its use has been heavily regulated to control exposure of the population.[47] These points involve a curious logic when it is recognized that *any* exposure to radiation involves known or assumed risks; while in the case of other noxious agents they came into use in total ignorance of their hazardous potential.

The fact that radiation involves real risks, even though the risks are of uncertain magnitude, does not mean that radiation-producing technologies should not be used. It may well be that public policy considerations lead to the conclusion that even the maximum possible risks are worth assuming in order to avail ourselves of the benefits. But this leads to the questions of how and by whom this risk-benefit calculus should be performed.

At the present time, the AEC's regulatory and licensing program is bottomed on the assumption that most peaceful applications of atomic energy, particularly nuclear power, are beneficial and that, therefore, assumption of the risks implicit in Part 20 of the AEC's regulations are warranted. Thus, in licensing nuclear power plants the principal inquiry is whether the plants will operate in such a manner as not to create conditions which will violate Part 20. If it is concluded that they will not, the plants are *ipso facto* acceptable and are licensed. The public is told that discharge and disposal of radioactive wastes will be in accordance with Part 20 standards; in effect the public is invited to assume that such discharges and disposals are without risks. The fact that the standards themselves reflect a calculated risk based on incomplete knowledge is carefully hidden from public view. Moreover, the basic risk-benefit judgments embodied in the radiation protection standards are made primarily by scientific experts in radiation effects who have little competence to assess benefits, to determine what benefits the public wants, or to know what risks the public is willing to accept for what benefits. Indeed, as Lauriston Taylor, Chairman of the NCRP, has stated, the setting of radiation standards is not "basically a scientific problem. . . . It is more a matter of philosophy, of morality, and of sheer wisdom."[48] The standards in turn are applied in particular cases by the AEC, which is a promotional as well as a regulatory agency.[49]

47. *See* Statement of AEC Comm'r James T. Ramey, *1969 Hearings, supra* note 26, at 131-41.

48. L. Taylor, *Radiation Exposure as a Reasonable Calculated Risk, Hearings on Employee Radiation Hazards and Workmen's Compensation Before the Subcomm. on Research and Development of the Joint Comm. on Atomic Energy,* 86th Cong., 1st Sess. 21 (1959).

49. It is clear that the standards adopted by AEC are accepted, virtually uncritically, from the NCRP. *See Hearings on Reorganization Plan No. 3 of 1970 Before a Subcomm. of the House Comm. on Gov't Operations,* 91st Cong., 2d Sess. 48-56, 130-48 (1970). The NCRP is composed entirely of scientists, engineers, and other technically trained personnel

It is not suggested that the atomic energy program is going forward in callous disregard of the risks attributable to radioactive wastes. Rather, those government officials responsible for the licensing and regulation of atomic energy activities, as well as those scientists who develop the radiation protection standards, sincerely believe that the risks are trivial and far out-balanced by the benefits. Nevertheless, at the same time that radioactive wastes are being discharged and disposed of in ever-increasing quantities, research is going forward to learn more about the effects of radiation on life.[50] More importantly, at the same time that this research is going forward, new and larger nuclear power plants are under construction with a concomitant multiplication of the radioactive wastes which will have to be absorbed by our environment. For example, in the northeastern part of the United States alone (*i.e.*, New England, New York, Pennsylvania, and New Jersey), there are now operating or under construction or on order more than 30 nuclear power plants, each one of which will contribute radioactive waste to the environment.[51] The great danger is that if we learn 10, 20, or 50 years from now, as a result of research or experience, that low levels of radiation are not as innocuous as we presently believe, irreversible injury may by then have resulted, and vested interests in radioactive pollution will have come into being, making it difficult to take adequate and prompt corrective action.

In the past, we have countenanced and permitted our waters and our air to become receptacles for all manner of noxious substances. Generally, when such practices originated the substances dumped in the environment were not recognized as harmful, and the quantities involved were small. By the time the hazards were recognized, the quantities were immense, and the practices had become inherent in our way of life. The case of radioactive waste is somewhat different because we know that radiation is harmful. An instructive analogy can be found in an unrelated but comparable area. In December, 1969, the Commission appointed by the Secretary of Health, Education and Welfare to study pesticides and their relationship to environmental health commented on "the absurdity of a situation in which

with no members from "soft" disciplines. Although it is undoubtedly exceptionally well qualified to determine risks incident to radiation exposure, it is by no means clear that its members have any special competence to appraise benefits or to determine what numerical standards should result from weighing benefits against risks. Indeed, it is by no means clear that the NCRP is endowed with qualifications which make it the appropriate body to consider problems which lie in the realm of "philosophy, of morality, and of sheer wisdom." *See* text at note 48 *supra*.

50. For a description of current research, see Statement of AEC Comm'r Clarence E. Larson, *1969 Hearings, supra* note 26, at 238-76.

51. AEC Press Release No. N-57 (April 10, 1970).

200 million Americans are undergoing life-long exposures, yet our knowledge of what is happening to them is at best fragmentary and for the most part indirect and inferential. While there is little ground for forebodings of disaster, there is even less for complacency."[52]

Just as there is little ground for forebodings of disaster in the case of DDT, there is no basis for predicting that disastrous or even undesirable consequences will flow from discharge and disposal of radioactive waste in the biosphere. Nor is there any basis for complacency, because we simply do not know enough about the effects of radiation on life and the ecological chain to warrant that even minute quantities of radioactive waste are harmless. The strong pressures for rapid introduction and expansion of nuclear power technology, largely sponsored and promoted by the federal government itself, will inevitably lead to ever-expanding quantities of radioactive waste to be disposed of in the environment. The great danger, or as the Commission on Pesticides put it, the absurdity, is that irreversible forces may be set in motion before we know whether or not we can in fact tolerate an environment into which these small quantities of radioactive waste are injected.

52. U.S. Dept. of Health, Education, and Welfare, Rep. of the Secretary's Comm'n on Pesticides and Their Relationship to Environmental Health 37 (1969).