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ATOMIC ENERGY COMMISSION

DISPOSAL OF RADIOACTIVE WASTES

Note by the Secretary

The General Manager has requested that the attached report submitted by the Director of Reactor Development be circulated for the information of the Commission.

W. B. McCOOL

Secretary

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DISPOSAL OF RADIOACTIVE WASTES

Disposal of radioactive wastes is under control at all AEC installations. Costs are relatively high because disposal practices have been conservative.

Problems in cost and public relations may be expected to arise as the industry under private management advances toward populous areas. They have been common to other industries but are accentuated because of the unique characteristics of radioactive wastes. Anticipating this, research and development programs have been carried out to aid the industry and to provide helpful information to responsible public officials.

Low level radioactive wastes present no serious hazards. They must, however, be kept under limited control. Cost for their disposal have been lowered substantially by making use of dilution factors in nature.

High level radioactive liquid wastes presently associated with chemical processing of spent nuclear fuels and specifically long lived radioisotopes such as Sr^{90} and Cs^{137} constitute the hard core of the disposal problem.

Storage of high level wastes in underground tanks is expensive ($.35 to $2.00 per gallon). It is not an ultimate solution if long lived wastes are involved.

Less expensive methods of ultimate disposal are being sought through intensive research and development. These include: (1) removal of Sr^{90} and Cs^{137} - (possibly for use as radioactive sources) in order to permit disposal of the remaining wastes to the ground in selected areas, (2) fixation (to prevent leaching) of radioactivity on selected media which could be disposed of economically by burial, (3) direct discharge to deep selected geologic formations such as dissolved cavities in large deposits of salt or to deep basins under conditions which would not jeopardize other natural resources, and (4) direct disposal in prepared pits under conditions which would permit fixation in situ.

Changes in technology affecting nuclear fuels and assemblies could have a profound effect on chemical processing methods and on the character of wastes to be disposed of. Separating fission products from spent fuels by other than wet chemical processes could also affect the problem of waste disposal.

Regulation and control of waste disposal practices through existing and traditional state, interstate and local channels where feasible are desirable.

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The public relations problems in disposal of radioactive wastes to the environment are very important if the industry is to avoid punitive controls. Relations with public regulatory agencies are excellent.

Continued co-operation with these agencies is important and is contemplated.

A detailed staff report on the subject of disposal of radioactive wastes is attached.

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DISPOSAL OF RADIOACTIVE WASTES

A. E. Gorman and J. A. Lieberman
FEBRUARY 3, 1956

STATUS OF PROBLEM

The handling and disposal of radioactive wastes is a problem whose thread runs through the entire fabric of nuclear energy operation. Wastes in either gaseous, liquid or solid form are evolved in mining of ore, feed material production, reactor operation and chemical processing of reactor fuels. Because of the nature and characteristics of the radioactivity involved, including its long half-life, its ability to cause damage to humans and its potential danger as an environmental contaminant, the safe handling and final disposal of wastes from the nuclear energy industry is most important.

The highly radioactive liquid wastes associated with the chemical processing of reactor fuels presently constitute the major portion of the over-all problem.

Gaseous of air borne particulate wastes vary in concentration of activity depending on the type of operation from which they originate. At one time the particulate material emanating from fuel element failure in the air-cooled X-10 reactor, the particles and iodine originating in the Hanford 200-area plants and particles from plutonium fabrication facilities presented a serious problem. With a concerted attack by operating areas, intensive development efforts and the assistance of such groups as the Stack Gas Problem Working Group and U. S. Weather Bureau the sources of contamination were determined and the effect of their release on and offsite were evaluated. Equipment and facilities for removal of contaminants such as special high-efficiency filters, deep bed sand and fiber filters, and iodine and rare gas removal units were developed and built. In addition, the capacity and limitations of the atmosphere to receive safely radioactivity were established to the extent that this particular phase of the problem was brought under control.

Although there are some points which require further technical work, for example high-efficiency filtration at temperatures above 1000°F (ANP Program) and improved iodine removal if short time cooled fuels are processed, it can be generally stated that handling and disposal of gaseous wastes, whether from fuel fabrication plants reactors or chemical processing facilities, has been solved. An economic review of existing air cleaning operations is highly desirable.

Solid radioactive wastes, such as machine turnings, useless contaminated equipment and contaminated trash which are generated in all operations, at no time have constituted a serious technical problem. The levels of activity associated with solid wastes may vary from a few times background to those requiring shielding or remote handling. To date burial of such wastes under known, controlled conditions and, in specific instances

(Brookhaven National and University of California Radiation Laboratories), disposal at sea have successfully handled the problem. Relatively small quantities of radioactivity (estimated in the range of hundreds of curies, with bulk coming from UCRL and BNL) have been disposed of at sea through arrangements with the Navy.

Established burial grounds exist only at our large production and research sites (Oak Ridge, Savannah River, Idaho, Los Alamos, and Hanford). Up until 1954 some facilities of the Lake Ontario Storage Area were used to store wastes originating from certain AEC installations in the Northeastern United States. Solid wastes, however, originate at all locations where radioactive materials are used. At areas other than those noted above, such as KAPL, WAPD, ANL and many others which usually encompass comparatively small areas and are near or in densely populated sections, it is the general, and we believe sound, policy not to dispose of solid wastes on site, but to ship them off site for final disposition.

The problem here is to locate suitable burial grounds to facilitate and reduce the cost of handling and disposal of these solid wastes. This problem is particularly acute in Northeastern United States where, at present, the only available receivers for these wastes are Oak Ridge and the Atlantic Ocean. These two receivers presently service such widespread points as NAL, KAPL and Bettis Field. In view of shipping and sea disposal costs, it is obvious that a more centralized burial facility is required. There is also every indication that future operations both in and out of AEC will greatly accentuate this need.

Liquid radioactive wastes also originate in essentially all nuclear energy operations from laboratory research to full scale production. It is important to distinguish, however, between a "high-volume-low-level" waste such as a contaminated laundry waste which may contain say a few microcuries of radioactivity per gallon and a "low-volume,-high-level" waste resulting from chemical processing of reactor fuels and which may contain up to 1500 curies per gallon.

Low-level liquid wastes are assocaited with laboratory operations where relatively small quantities of radioactive materials are handled, contaminated laundry operations and the normal operation of essentially all reactors, particularly water-cooled types. They are, under proper environmental conditions, susceptible to either direct disposal or to disposal following minimum treatment. Because of their high volume (on the order of millions of gallons per day) total costs for treatment tend to be high. Therefore, to the extent that it is absolutely safe, maximum possible use is made of dilution factors that are available in nature and that can be quantitatively assessed. In this connection the importance of proper site-selection of nuclear facilities must be emphasized.

High-level liquid wastes presently associated with chemical processing are, as previously noted, the core of the waste disposal problem. Such wastes may, in the future, also be associated with certain types of homogeneous reactors to the extent that continuous fuel processing right at the reactor is contemplated. It should be pointed out, however, that usually such high level wastes do not come directly from the normally

operating reactors themselves. Under conditions of reactor malfunction, some high-level wastes may result.

The quantity of high-level wastes generated depends on the characteristics of the fuel being processing and the chemical process utilized. It may vary from 0.5 gal. to 5.0 gal. per gram U processed. To date accurate figures on the total quantity of such wastes from major production areas have not been available. It is estimated that the production rate of such wastes is in the order of a few tens of millions of gallons per year.

The term "disposal" currently used in connection with highly radioactive liquid wastes is perhaps misnomer. With the exception of a limited, specialized operation at Hanford these wastes are not disposed of but are simply stored in tanks. The cost of such tank storage varies from about $.30 to roughly $2.00 per gallon of capacity, depending on the waste characteristics. Since the effective life of the fission product mixture making up the waste is measured in hundreds of years it is apparent that storage in tanks is not a final answer, although waste practices to date have been safe and adequate.

Because of the large amounts of radioactivity involved, it is also apparent that insufficient dilution is available in nature for any practical, continuing dispersal of these materials into the environment, i.e., the "dilute and disperse" approach does not appear feasible. (From a technical standpoint disposal at sea may be somewhat of an exception).

Listed below are promising approaches, with their salient features, to ultimate, safe disposal of high-level wastes. Work on these approaches is being carried out by a number of AEC installations and contractors and is more fully described under research and development.

1. Fixation in inert media.

The objective is to fix the radioactive waste material, i.e., the actual fission products, in an inert solid carrier so that the possibility of migration of the radioactivity into the environment is eliminated or reduced to acceptable limits. The carrier containing the radioactive material could then be permanently stored or buried in selected locations without deleterious effect on the environment.

2. Special separation of specific isotopes.

Because of the particular radiotoxicity and long half life of Sr^{90} (25 years) and Cs^{137} (33 years) the removal and fixation of these two isotopes would substantially reduce the effective life of the remaining material and facilitate its disposal. With Cs and Sr removed the possibilities of safe disposal into the environment under controlled conditions are greatly increased.

3. Direct discharge to selected surface or underground geologic formations.

Preliminary evaluations indicate the possible technical feasibility of direct disposal of highly radioactive liquids into the ground following somewhat similar practices in other industries but taking into account the unique characteristics of radioactive wastes. Following are places into which it may be practical to dispose of the wastes underground, in some cases without any treatment:

a. Spaces prepared by dissolution in salt beds or salt domes.

b. Deep basins (5,000' - 15,000' in depth) containing connate brines and with no geologic connection to potable waters or other natural resources.

c. Special excavations in selected shale formations.

d. Surface excavations in selected locations where control of contamination of the environment can be assured.

4. Disposal at sea.

"Packaged" or pre- or untreated wastes may be dumped in ocean volumes that are known to be stagnant over long periods of time or where active deposition is taking place. Because of lack of knowledge of pertinent oceanographic factors and complex technical problems and costs involved in preparing, handling and transporting high-level wastes for sea disposal this approach is judged to be a secondary possibility at this time.

Sufficient laboratory and pilot plant work has been done to warrant continued effort on approaches 1 and 2. Under certain circumstances (for example, where plant can be located right at suitable disposal site) approach 3 has sufficient possible advantage to warrant vigorous investigation of the feasibility.

The possibility of economic utilization of the fission products contained in these wastes is a consideration which must not be overlooked. Although utilization per se would not solve the disposal problem it has potential value on two counts; first, it derives a value from materials that otherwise would be discarded; second, it might help to defray costs of ultimate disposal that must be met in any case.

Delineation of any single optimum solution to the problem of ultimate disposal of highly radioactive liquid wastes is difficult. When one takes into account, however, such considerations as possible use of fission products, difficulties in handling and transporting these materials and the continuing control required it appears likely that approaches 1 or 2 above or combinations or modifications thereof represent the best chances for success in the immediate future.

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WASTE DISPOSAL RESEARCH AND DEVELOPMENT

The major objectives of the waste disposal research and development program in the Division of Reactor Development are to:

1. Develop better and cheaper ways for safe handling and disposal of gaseous, liquid and solid wastes from nuclear energy operations, particularly those wastes resulting from the operation of reactors and chemical processing plants.

2. Evaluate quantitatively dilution and/or concentration factors in nature in order to determine the degree of treatment actually required prior to release of effluents to the ground, atmosphere or surface waterways, thus taking a proper economic advantage of these dilution or concentration factors.

3. Obtain increased knowledge of the fundamental phenomena and processes involved in disposal of radioactive and toxic wastes so that more efficient and more economical methods may be devised.

4. Aid in integrating the nationwide efforts of other federal agencies in dealing with waste disposal and environmental problems of American industries with the newer and unique operations of the nuclear energy industry so that full advantage may be taken of the specialized experience and compentency of experts in these agencies.

5. Assist state and local officials concerned with waste disposal and environmental problems within areas of their jurisdiction in a better understanding of related problems in the nuclear energy industry so that they may have a better knowledge of the industry in these fields of public responsibility and concern.

The initial phase of the research and development program was primarily concerned with the handling and disposal of high-volume, low-level liquid wastes, the air-borne particulate wastes and assessment of the effect of relatively low levels of radioactivity in these wastes on public sewage treatment and water supply facilities. Research contracts in these fields were made with Arthur D. Little, Harvard, Massachusetts Institute of Technology, Johns Hopkins, New York University, Universities of Illinois, Texas and California. Related work was also carried out at ORNL and other AEC areas. Early accomplishments were determination of the feasibility of using biologic sewage treatment processes for low-level wastes, the determination of the efficiency of standard water treatment methods in removing radioactivity, the development and commercial production of high efficiency air filters and the publication of Handbooks on Aerosols and Air Cleaning.

At the same time, in accordance with the objectives, extensive meteorologic, geologic and hydrologic programs were initiated under contracts with the Weather Bureau and the Geological Survey to define and assess important environmental

parameters involved in the location, design, construction and operation of nuclear plants and facilities. Examples of accomplishments from this work include detailed geologic, hydrologic and meteorologic reports on all major AEC operating areas, a quantitative evaluation of dilution factors in the Mohawk River which enabled the elimination of treatment of low-level wastes at KAPL and their safe discharge directly to the river; and a compendium of pertinent meteorologic information published as a report "Meteorology and Atomic Energy."

The more recent research and development activities have been concerned primarily with problems of disposal of high-level wastes. A brief listing of current projects serves to indicate the scope and nature of this later waste disposal research and development effort.

1. Fixation of radioactive materials — Brookhaven National Lab. Johns Hopkins University

   At BNL a pilot plant in which radioactivity is fixed on montmorillonite clay has been successfully operated. Currently work is being done on conversion of waste materials to oxides for fixation purposes. At Johns Hopkins University laboratory work is being done on the fixation of Sr and Cs in synthetic feldspar.

2. Disposal of high-level wastes into surface pits — Oak Ridge National Lab.

   Field studies are being conducted on pits actually being used for disposal of area wastes. Related work on heat associated with high-level wastes is also being carried on. Investigations on selective removal of Sr and Cs are in progress.

3. Evaluation of geologic and hydrologic problems involved in disposal at or near the earth's surface — Geological Survey

   Such studies are in progress at various AEC installations and they include determination of the adsorption capacity of natural earth materials for radioactivity.

4. Appraisal of environmental and operational aspects of ultimate disposal systems — Johns Hopkins Univ.

   Through active cooperation of such organizations as the Woods Hole Oceanographic Institute and the Earth Sciences Division of the

National Research Council, progress has been made in delineating and assessing problems associated with sea disposal and land burial or storage of high-level wastes.

5. Assessment of geophysical problems connected with disposal of high-level wastes to various geologic formations — National Academy of Sciences, Earth Sciences Division

Preliminary feasibility studies are being made on the use of salt formations, deep geologic basins, special excavations and other geologic strata for receiving high-level wastes.

6. Investigation of hydraulic and chemical phenomena involved in disposal of liquid wastes into reverse wells — University of Calif.

The nature of the ion-exchange and flow of radioactive liquids in permeable media is being investigated.

7. Quantitative evaluation of dilution factors in surface waterways — Harvard University, Northwestern Univ.

The capacity of surface waterways to receive safely radioactive materials is under study. Harvard is investigating the basic phenomena involved. Northwestern is making a specific study of a pilot stream preliminary to a more comprehensive evaluation of the Des Plaines River in relation to wastes from ANL operations.

8. Investigation of meteorologic factors in disposal of gaseous wastes — U.S. Weather Bureau

The capacity and limitations of the atmosphere to receive safely radioactive materials are being studied.

9. Air cleaning research and development — Harvard University

Developments seeking to improve air cleaning systems have been in progress for about five years. Assistance is received in evaluating air cleaning operations and

problems at various AEC installations.

10. Aerosol investigations — University of Illinois

Properties and behavior of aerosols (particulates) as they relate to air and gas cleaning operations are under study.

11. Relation of fallout to water supplies — Massachusetts Institute of Technology

The ability of municipal water treatment systems to remove fallout activity has been studied.

12. Radioactive waste incinerator development — U.S. Bureau of Mines

Based on pilot plant tests, design and specifications for 30 lb/hr and 100 lb/hr units for handling contaminated combustible wastes are in preparation.

13. Treatment of low-level wastes by algae concentration — University of Texas

The feasibility of utilizing radioactivity concentrating ability of algae for handling low-level liquid wastes has been determined.

The last three projects are now being completed.

The cost of this program in FY 1956 is about $950,000. The total costs of the sanitary engineering research and development program since its inception in 1950 and including FY 1956 is about $5,000,000.

Related work done at other AEC sites is not included in the above listing. Of particular note are investigations being carried out at Hanford on ground disposal of radioactive wastes and Cs and Sr removal, fixation studies at Los Alamos, Argonne and Idaho and ground disposal operations proposed at Savannah River.

The major objective of future research and development activities in the field of disposal of high level wastes is to bring to engineering reality ultimate disposal systems which have been established as being technically and economically feasible. Actual work in the future program will fall into two main categories. First, the extrapolation of laboratory studies which have already indicated practical ultimate disposal systems. Examples include activities in fixation of radioactive materials and Sr and Cs removal. Second, the initiation of laboratory and field investigations on ultimate disposal systems that preliminary

evaluation shows to be promising. The outstanding example of high priority work in this category is the general area of disposal into various geologic formation. Specific problems in this area include those of control of radioactive decay heat, evaluation of chemical and physical reactions between wastes and vatious earth materials, development of suitable environmental control systems, and investigation of problems involved in the physical handling and transporation of highly radioactive materials. To some extent work related to evaluation of sea disposal may also be desirable.

The nature of the future activities noted above makes it apparent that the rate of expenditure of research and development funds will be substantially greater than in the past. Whereas past efforts have been primarily laboratory and small scale, future work will require actual field investigations with associated geophysical exploration, drilling and instrumentation. The FY 1957 budget request of about $1.5 million compared to the FY 1956 expenditure of $950,000 is an indication of the increased expenditures required to give adequate support to this important program.

With such support of an aggressive research and development program we are confident that practical, safe ultimate disposal systems will be developed.

WASTE DISPOSAL POLICY CONSIDERATIONS

The changing technology of the industry in nuclear fuels and fuel elements and chemical processing of them profoundly affects the characteristics of wastes. Many parameters for evaluating the effect of release of radioactive wastes to the environment have not as yet been established. It is, therefore, necessary to be conservative in matters of policy in waste disposal until such time as operating experience and results of research permit relaxation with safety. The economic aspects of waste disposal are also important to the industry. They justify expenditures for continued research and development looking forward to establishing better and safer methods at reduced costs.

Disposal of Wastes by dumping at sea has important policy consideration. To date radioactive wastes disposed of by this method have been in relatively small amounts and mostly in the range of low to intermediate levels of activity.

Although the oceans offer great possibilities for dilution, the disposal of high level long lived radioactive wastes by dumping at sea could present real problems of policy as well as of economics. Important is the fact that wastes so disposed of would no longer be under control. The fate of high level wastes disposed of in this manner and their ultimate distribution in the environment of the oceans of concern to man has not been ascertained adequately.

Of special concern are the effect on biological food chains. The Geneva conference brought out indications of international interest in ocean disposal of radioactive wastes.

The possibility that increasing the radioactivity of the oceans might at some future period have an unfavorable influence on sensitive instruments used in marine service is a matter of special interest.

Land burial of atomic wastes presents problems of policy. It is apparent that as the industry grows there will be a substantial demand in the northeastern section for a burial area to serve AEC and privately owned plants which requires less haul than to ORNL. The feasibility of establishing burial areas at the Lake Ontario Storage Area near Lewiston, New York or at some other suitable area where distance for transport would be favorable is under study. It is possible that under AEC stimulation a private company could be found which would be interested in operating a burial area to serve AEC and other governmental agencies and their contractors as well as competetive industry and research institutions.

A policy item of substance for federal and state consideration is whether or not areas for burial or storage of radioactive wastes should be limited in number or be permitted wherever economic circumstances dictate. In the case of long lived isotopes in wastes a burial area could present a hazard for many decades so decisions made now have serious and important future implications.

Regulatory responsibilities for disposal of radioactive wastes at AEC installations have not been too well defined. Contractors have in general followed conservative practices and have for the most part sought to comply with standards set by their own staff usually after consultation with AEC. These standards were based on limiting exposures of employees on-site to maximum permissible limits recommended in handbooks of the National Committee on Radiation Protection; and of persons living off-site to lesser degrees of exposures by factors of one tenth or one hundredth.

Prior to passage of the AEC Act of 1954 a draft of a GM bulletin dealing with policy regulations for disposal of radioactive wastes at AEC installations was prepared by staff of Divisions of Biology and Medicine and Reactor Development with assistance from staff of various AEC operations and area offices and their contractors. In the spring of 1955 the Division of Civilian Application in co-operation with other AEC Divisions prepared and published in the Federal Register Health and Safety Regulations with which licensees under this new Act must comply. Currently these regulations in revised form are in preparation for review by state officials.

Close working relationships with the state and other agencies should be established and maintained in connection with the administration of these regulations.

Relations with state, interstate and local agencies in fields of public health, safety and conservation of natural resources by staff of AEC and its contractors have been most cordial and co-operative in matters of waste disposal and environmental sanitation. Such co-operation should be continued and encouraged.

Since passage of the 1954 Act there has been evidence of the desire of state agencies to adopt their own regulations. In addition, state agencies show a sincere desire to evaluate for themselves problems in waste disposal which might arise as a result of operations of new plants using atomic energy.

There has been an encouraging effort on the part of responsible state officials to train key members of their staff in the nuclear sciences in order that they might be in a better position to serve new users of atomic energy in their states as they have other industries over many decades. The Public Health Service has done outstanding work in training staff of state and local governments.

The sanitary engineers of AEC have worked closely with their counter parts in other federal, state and local agencies who usually carry technical responsibility for waste disposal and environmental sanitation. They have assisted these officials in acquiring specialized knowledge and a better perspective in evaluating problems of the atomic energy industry. This has involved intimate and continuing working relationships with such federal agencies as the Public Health Service, the Geological Survey, the Weather Bureau and the Bureau of Mines. These are agencies with which state regulatory bodies and industry have worked traditionally. Staff of these agencies are currently familiar with the waste disposal problems of the industry in relation to areas of their special interest. They should be encouraged to serve new comers in the atomic energy industry as they have other industries.

Public relations is an especially important consideration in the atomic energy. A new industry should be prepared to evaluate the impact of its operations and the release of its wastes to the environment, especially if release is near an established community, other industries or important natural resources.

The war operations of the government sponsored atomic energy industry were definitely unorthodox. Plants were located in reasonably remote areas; operations were under strict security control and there was self-auditing of waste disposal practices. Such operations while justifiable had the effect nevertheless, of stimulating the interest and concern of public officials as to environmental hazards associated with practices of the industry. The unique characteristics of radioactive wastes and the general lack of information by public officials concerning the new industry, its technology, its standards and its wastes also may have served to accentuate this situation.

A marked lessening in concern of public regulatory officials over release of wastes from atomic energy plants has taken places - especially during the past five years. To a substantial degree this has been the result of a program of inviting public officials to visit AEC plants, and to serve on advisory committees. Additional factors have been wide distribution of carefully prepared technical papers and manuals and participation by staff of AEC and its contractors in industry sponsored technical seminars and meetings of state and national professional societies.

Expansion of the industry authorized under the AEC Act of 1954 has and will continue to intensify the public relations problems in waste disposal, because it is obvious that competetive industry will want to build and operate plants in or near populated areas where markets for its products exist.

The essence of maintaining good relations with public officials and new users of atomic energy rests in ability and willingness to serve them in resolving technical problems especially those involving waste disposal. The bases for technical service in the field of waste disposal are "know how" and understanding of the traditional relationship and responsibility of public officials toward industry. They rest on information derived from sound research and development programs integrated with knowledge and appreciation of the experiences of industries and communities in satisfactorily resolving their joint environmental problems.

The program of the Sanitary Engineering group in the Division of Reactor Development has been to work with staff of other divisions, area offices, operating contractors and state and local agencies in connection with problems in waste disposal within the industry. It has included assistance in co-ordinating research and development between areas, and initiating research and development in fields of sanitary engineering and environmental sanitation. This has been an "across-the-boards" operation which has been helpful both within and outside the atomic energy industry.

Looking to the future it is clear that when nuclear fuels are used in this country and throughout the world as sources of energy in the amounts which have been forcast, the quantities and levels of radioactivity of fission products which will be formed will present significant problems unless they are anticipated and adequate and reasonably economical means of disposal of wastes are provided. These problems are associated both with nuclear reactors and plants for chemical processing of spent fuel elements.

Risks in the future can be minimized by care in selecting plant sites, by proper location of structures on-site and by careful planning of facilities. These precautions are emphasized because they are fundamental considerations which are influenced by the changing technology in use of atomic energy especially to serve the power and transport industries including related military applications. They have been major items in the waste disposal program of the Division of Reactor Development and will continue to be so.

Demonstration of the feasibility of recovery of Sr^{90} and Cs^{137} from wastes streams and their use for industrial applications could have a profound effect on the emphasis and the economics of the waste disposal program and would materially lessen problems associated with release of the bulk of the wastes to the environment. It is important, however, that removal of these significant long lived isotopes from wastes be complete. So long as waste streams carry such hazardous isotopes, processing for ultimate disposal must be carried to the point of immobilizing them in some solid media. Also should these isotopes be used as radiation sources control over them on a long term basis would be required if public hazards are to be avoided.

Future development of methods of separating fission products from spent fuels by other than the wet chemical processes is a possibility. It could have the value of lessening volumes of wastes to be handled and at the same time may assist in fixing these dangerous sources of radiation against the contingency of future release to the environment.

The rate of progress in the technology of fuel development and fabrication has been rapid and is accelerating. The make up of the reactor fuel assembly has an important effect on the process used for separating unburned fuel from the fission products which in turn affects the character and volume of wastes to be disposed of. In the future a closer working relationship between nuclear, chemical and sanitary engineers would be an important factor in research and development of fuel assemblies for reactors.

Problems of transport of radioactive fuel elements from reactors to the chemical processing plant are many. They could increase markedly in the future, especially when route of shipment is through populous areas or over drainage areas serving public water supplies. In addition, transport of high level radioactive materials other than fuel elements presents problems of control which require evaluation. A special AEC committee is now working on this problem.

CONCLUSIONS AND RECOMMENDATIONS

It is concluded that:

1. The safe handling and ultimate disposal of radioactive wastes is an important technical, economic and administrative aspect of the nuclear energy industry and waste operations must be thoroughly integrated with all other phases of nuclear energy operations.

2. From a technological standpoint the highly radioactive wastes resulting from the processing of reactor fuels constitute the bulk of the problem.

3. Wastes resulting from normal reactor operations are an important consideration, but technically represent a lesser problem for which solutions are generally available.

4. Research and development has indicated feasible systems for ultimate disposal of highly radioactive wastes, but considerably more work is required to bring these systems to the point of economic operating reality.

5. Major <u>technical</u> considerations underlying the waste problem are:

   a. Characteristics of nuclear fuels and chemical (or other) processing associated with them.

   b. Separation of specific isotopes from the wastes and use of these materials to economic advantage.

c. The proper selection of the site for nuclear facilities - especially reactor and fuel processing plants.

d. The detailed quantitative evaluation of the environment in order to assess its capacity to receive radioactive materials.

e. Systems for the physical handling and transporation of highly radioactive materials.

6. Major policy and administrative consideration underlying the waste problem are:

a. The establishment, preferably through private enterprise, of suitable waste disposal services.

b. The regulation and control of waste disposal practices through existing and traditional state, interstate and local channels where feasible.

c. Continuation and strengthening of established practices in relations with the public and its agencies.

It is recommended that:

1. A vigorous research and development program be supported within AEC with the objective of developing safe and practical ultimate waste disposal systems.

2. As soon as technical support information is available, proposals be solicited for a waste burial ground operation to service Northeastern United States.

3. Present practices of cooperating with other federal, state and local agencies in connection with both the technical and administrative aspects of disposal of wastes be continued and strengthened. The formation of a representative advisory or cooperating groups may be helpful in this regard.