NATIONAL RADIATION PROTECTION PROGRAM

APPENDIX C - PROBLEM AREAS

OFFICE OF RADIATION PROGRAMS
ENVIRONMENTAL PROTECTION AGENCY

OCTOBER 1972

APPENDIX C

PROBLEM AREAS

TABLE OF CONTENTS

APPENDIX C

TABLE OF CONTENTS
(Continued)

APPENDIX C

TABLE OF CONTENTS
(Continued)

APPENDIX C

TABLE OF CONTENTS
(Continued)

APPENDIX C

TABLE OF CONTENTS
(Continued)

APPENDIX C

TABLE OF CONTENTS
(Continued)

NOTICE

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The documents are serially numbered for accountability and to insure that recipients receive changes as they are issued.

Recommended changes or corrections should be submitted to the Office of Radiation Programs.

W. D. Rowe
Deputy Assistant Administrator
for Radiation Programs

October 27, 1972

APPENDIX C

TABLE OF CONTENTS
(Continued)

APPENDIX C

TABLE OF CONTENTS
(Continued)

APPENDIX C

TABLE OF CONTENTS
(Continued)

LIST OF TABLES

APPENDIX C

LIST OF TABLES (Continued)

APPENDIX C

LIST OF TABLES (Continued)

APPENDIX C

LIST OF TABLES (Continued)

APPENDIX C

LIST OF TABLES (Continued)

GLOSSARY

Acronyms

AEC	Atomic Energy Commission
ANSI	American National Standards Institute
AQCS	Analytic Quality Control System
BRH	Bureau of Radiological Health, DHEW
BWR	Boiling Water Reactor
CAB	Civil Aeronautics Board
CEQ	Council on Environmental Quality
CRF	Code of Federal Regulations
CIA	Central Intelligence Agency
COMM	U. S. Department of Commerce
CSD	Criteria and Standards Division, ORP
CW	Continuous Wave
CZ	Canal Zone, Panama
DCPA	Defense Civil Preparedness Agency
DEPA	Defense Electric Power Administration
DHEW	Department of Health, Education, and Welfare
DNA	Defense Nuclear Agency, (DOD)
DOD	Department of Defense
DOL	Department of Labor
DOT	Department of Transportation
ECAC	Electromagnetic Compatability Analysis Center
EERL	Eastern Environmental Research Laboratory
EIS	Environmental Impact Statement
ELF	Extremely Low Frequency
EPA	Environmental Protection Agency
ER	Environmental Report
ERAB	Electromagnetic Radiation Analysis Branch, ORP
ERMAC	Electromagnetic Radiation Management Advisory Council
FAA.	Federal Aviation Agency
FCC	Federal Communications Commission
FDA	Food and Drug Administration, DHEW
FFTF	Fast Flux Test Facility
FOD	Field Operations Division, ORP
FP	Fission Products
FPC	Federal Power Commission
FRC	Federal Radiation Council
FTP	Full-time Permanent
GCBR	Gas Cooled Breeder Reactor
GSD	Genetically Significant Dose
HASL	Health and Safety Laboratory
HTGR	High Temperature Gas-cooled Reactor
HUD	Department of Housing and Urban Development
ICRA	Interagency Committee on Radiological Assistance
ICRP	International Commission on Radiological Protection
IGSY	International Geophysical Study Year
IRAC	Interdepartment Radio Advisory Committee
IRAP	Interagency Radiological Assistance Emergency Plan

Acronyms

ITDSN	Institutional Total Diet Sampling Network, ORP
ITS	Institute of Telecommunication Sciences
JCAE	Joint Committee on Atomic Energy
LMFBR	Liquid Metal Fast Breeder Reactor
LORAN	Long Range Navigation
LWR	Light Water Reactor
LV	Las Vegas, Nevada
MLON	Medical Liaison Office Network
MPC	Maximum Permissible Concentration
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NBS	National Bureau of Standards, COMM
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NERC	National Environmental Research Center
NEXT	National Evaluation of X-ray Trends
NGS	Natural Gas Stimulation
NIOSH	National Institute for Occupational Safety and Health, DHEW
NOAA	National Oceanic and Atmospheric Administration, COMM
NRDS	Nuclear Rocket Development Station
NSF	National Science Foundation
NTS	Nevada Test Site
OAP	Office of Air Programs, EPA
OCP	Office of Categorical Programs, EPA
OEGC	Office of Enforcement and General Counsel
OEP	Office of Emergency Preparedness
OFA	Office of Federal Activities, EPA
OGC	Office of General Counsel, EPA
OMB	Office of Management and Budget
OPE	Office of Planning and Evaluation, EPA
OPM	Office of Research and Monitoring, EPA
ORNL	Oak Ridge National Laboratory
ORP	Office of Radiation Programs, EPA
OSHA	Occupational Safety and Health Administration, DOL
OSW	Office of Solid Wastes, EPA
OT	Office of Telecommunications
OTM	Office of Training and Manpower, EPA
OTP	Office of Telecommunications Policy
OWP	Office of Water Programs, EPA
PAG	Protective Action Guidance
PAHO	Pan American Health Organization
PMN	Pasteurized Milk Network, ORP
PWR	Pressurized Water Reactor
RAN	Radiation Alert Network, ORP
RCB	Risk/Cost/Benefit
RPG	Radiation Protection Guide
RF	Radio Frequency

GLOSSARY (Concluded)

Acronyms

SAR	Safety Analysis Report
SID	Surveillance and Inspection Division, ORP
SNAP	Systems for Nuclear Auxilliary Power
STORET	Storage and Retrieval of Water Quality and Hydrologic Data
TAD	Technology Assessment Division, ORP
TLD	Thermo-luminescent Dosimeter
TNP	Thermonuclear Power
TSS	Tritium Surveillance Survey
USBM	U. S. Bureau of Mines
USDI	U. S. Department of the Interior
USGS	U. S. Geological Survey
USIA	U. S. Information Agency
USPHS	U. S. Public Health Service, DHEW
WERL	Western Environmental Research Laboratory
WHO	World Health Organization
WLM	Working Level Month

APPENDIX C

PROBLEM AREAS

ACCIDENTS

PROBLEM DESCRIPTION

Introduction

The potential impact on the environment from accidents associated with the fission fuel cycle is of particular concern to EPA's Office of Radiation Programs because of the extreme toxicity of the radioactive by-products produced during the fission process. The problem is intensified since the toxicity of these by-products would not be significantly reduced through natural processes once introduced into the biosphere. While the amount of radioactivity would decrease with time, as a consequence of the natural radioactive decay process, a significant amount of the radioactivity could remain for many years.

It is the potential for uncontrolled, accidental releases of biologically hazardous radionuclides to the environment which dictates special emphasis on the probability and consequences of accidents associated with fission fuels. The remainder of this problem area description will focus on the question of accidents in nuclear reactors, since the potential risks from these facilities are higher than those associated with other portions of the fission fuel cycle. Similar methodology, however, will be applied to accidents associated with other aspects of the fission fuel cycle (e.g., waste disposal, fuel reprocessing, and spent fuel transportation, etc.). Accordingly, much of the work described herein will contribute to resolving accident-related issues of the facilities, systems, and processes associated with other problem areas.

Component Problems

Accidents and subsequent release of radioactive material from nuclear facilities are important considerations for environmental radiation protection because they represent a finite potential and a significant risk to the public health and the environment if they should occur. The AEC has the authority and responsibility for assuring that nuclear plants are designed, constructed, and operated so as to prevent accidents and mitigate their consequences. Under the National Environmental Policy Act of 1969, the AEC must describe the environmental consequences of its licensing actions, including the risks from accidents.

The output from the program for this problem area to meet the responsibilities of the EPA consists of the following:

Development of criteria and standards relating to risks and consequences from radiation accidents.

Development of methods for the quantitative evaluation of accident risks suitable for use in environmental statements and environmental statement reviews.

Accident risks evaluated for risk/cost/benefit analyses.

Review of Reactor Siting Criteria, and, if needed, issuance of guidance for development of improved criteria.

Development and refinement of protective measures, including the evaluation of experience on evacuation from natural disasters.

Development and refinement of Protective Action Guides.

Establishment of Emergency Monitoring Systems.

Assistance to state and local officials in the area of radiological emergency preparedness.

Background

The potential significant consequences of hypothesized reactor accidents were realized at the inception of the development of reactors. Major efforts were employed at the outset to help assure reactor safety by factoring safety into the reactor design process and by setting up a stringent licensing process to help assure that reactor operation would result in no undue risks to public health and safety. As might be expected, the approach and criteria on which reactor safety and siting judgments are based have evolved over the years as new information was developed, plant designs improved, and operating experience obtained.

The initial concept was to design reactors to assure that even the worst possible accident that could happen would not result in doses to the offsite population greater than prescribed levels. In essence this concept attempted to avoid the requirement of establishing the probability of accidents in a quantitative way. This was to be accomplished by the "safety-in-depth" approach, in which fuel (and fission products which are produced during operation) is contained in a pressure tube (fuel pin cladding), the fuel pins were contained in reactor primary system (pressure vessel and associated piping designed and built to the highest standards available), and the primary system housed in a very low-leakage high strength building (containment building).

In addition, redundant and emergency systems were incorporated into the reactor, to minimize the potential of a single failure in any critical component (e.g., the nuclear control system) from initiating an accident.

By 1962, sufficient advances were made so that a Technical Information Document was issued by the AEC (TID-14844 "Calculation of Distance Factors for Power Test Reactors") which is referenced in the AEC's regulations. TID-14844 provided a sample calculation which could be used as a guide to help assess the suitability of a given site for a power reactor in terms of distance from a populated area. In essence, it embodied the ideas noted above in great detail. The TID-14844 Guide focused on the concept of the "maximum credible accident" (MCA) which is defined as a nuclear accident "which would result in a potential hazard that would not be exceeded by any other accident considered credible during the lifetime of the facility". TID-14844 went on to detail a potential maximum credible accident for pressurized light-water reactors, namely the loss-of-coolant accident (LOCA) initiated by an instantaneous double-ended (i.e., complete offset) rupture of a main coolant line. One of the basic assumptions in TID-14844 was that the LOCA resulted in the release from the fuel elements of 100% of the noble gases, 50% of the halogens, (including iodine) and 1% of the solids fission product inventory in the core. Such an extensive release would be consistent with an accident involving a major meltdown of the core. In addition, it was assumed that half of the iodine (which generally controls the overall hazard for hypothesized large accidents in light-water reactors) plated out instantaneously on surfaces inside the reactor and containment building, making 25% of the iodine inventory in the core available for release from the containment building. While not included in the calculational example, TID-14844 indicated that engineered safeguards such as washdown features (e.g., containment sprays and filtering networks) could provide additional reduction factors of 10-1000.

In the mid and late 1960's the utilities started ordering reactors at an accelerated rate. At the same time significant reactor safety R&D results began to elucidate the behavior which might be expected in LOCA for a light-water reactor. These results indicated that the increased power and hence heat output for the larger plants now being built was such that one of the key required safeguards, namely active emergency heat removal systems, would be required in the event of a LOCA not only to preclude core meltdown, but also to preclude a high potential for reactor vessel melt-through and a possible failing of the containment structure. Thus, while one may initially have correctly presumed that radioactivity releases associated with initiating events even "worse" than the maximum credible accident (such as a catastrophic pressure vessel rupture) would be contained, this might not be the case for the large reactors now being sited. Initially, the probability portion of the potential risk equation appears to have been adequately circumvented by assuming what was essentially an "upper-limit" consequence case and by assuring that these consequences were tolerable; however, it is not clear that this concept is optimum for making judgments concerning the environmental risks associated with potential accidents in the large plants of today.

The preceding discussion has dealt largely with the framework by which reactor accidents are judged; it should be noted, however, that during the last few years the AEC has been placing an ever increasing emphasis on quality assurance in the design, construction, maintenance, and operation of nuclear reactors. This extremely encouraging development stems from the rationale that the objective of safe, economic nuclear power cannot be met unless the reactor systems are reliable. Proponents of this concept suggest that safety stems from an excellence of engineering and that safety is better assured by precluding accidents or stopping them early rather than attempting to accommodate severe accidents late in the accident sequence. Others argue, on the other hand, that errors or natural disasters will still occur and that insufficient knowlege of potential accident chains exist. This thought suggests use of an "envelope" approach with an emphasis on assuring safety by use of consequence mitigating engineered safeguards which are suitable for a variety of accidents. Both approaches have merits and drawbacks, and while not mutually exclusive, do, at times, conflict with each other. (Unfortunately, it appears that the methodology necessary to make objective, cost-effective judgments concerning the optimum mix of engineered safeguards, quality assurance programs, and operating limits (Technical Specifications) has not yet been developed.) All of the approaches employed have directed effort toward reducing the risk of accidents. Little has been done to quantitatively evaluate the risk because of the difficulties involved in determination of the very small probabilities involved with accidents which have severe consequences.

However, the August, 1972 "Comment Issue" of the "Guide to the Preparation of Environmental Reports for Nuclear Power Plants notes that "In the consideration of the environmental risks associated with postulated accidents, the probabilities of their occurrence and their consequences must both be taken into account." It is most encouraging that the AEC is moving in the direction of more quantitatively assessing accident probabilities and consequences. A new AEC program to assess the environmental risk of reactor accidents (accident probabilities and consequences) is underway.

Efforts to date in the area of developing a capability for responding to emergencies as the result of reactor accidents have been somewhat fragmentary, with various state organizations, and Federal agencies (including federally-controlled laboratories) all involved. Improvements in this situation should be forthcoming as the result of agreements reached among participating organizations under the overall coordination of OEP. These efforts will include the development and issuing of improved Protective Action Guides, protective measures, Emergency Monitoring Systems, Emergency Plans and emergency response capabilities, and as such form another major element of the proposed program.

Scope of Problem

In the nuclear power industry, there are about 27 operational plants, about 180 plants operating, being built, planned or on order, and about 1000 plants expected by the year 2000. Facilities for the remainder of the fuel cycle must be expanded accordingly. The expected potential for accidents is such that, while a catastrophic event may never occur, minor accidental releases may increase to a frequency of one or more per year.

Because of the great similarity of reactor components and subsystems among different plants, a number of plants have similar possible chains of failure leading to radioactivity releases and therefore assessment of accidents can be largely generic in nature. Unique plant designs will have both common and unique possibilities for accidents and thus will require more effort in accident assessment. Further, specifics associated with each reactor site must also be factored in. For example, the probability of an accident initiated by an earthquake will vary from site to site, and the consequences of an accident on a site with a larger nearby population would be more severe than one which is well removed from high population areas. Therefore, a treatment of accidents will require not only generic assessments but will have to acccount for site variables. The probability of a given accident being initiated is, of course, a function of many variables. For example, accident initiation could result from some combination of design error, faulty construction, operator error, poor maintenance and natural disaster. Similarly the consequences of the spectrum of possible accidents varies from nil to catastrophic depending on such variables as the event which initiates the accident, reactor size and location, efficacy of engineered safeguards which are intended to control the accident or minimize consequences, the weather and the action of reactors operators, of disaster team specialists, and of public officials subsequent to the accident.

LEGISLATIVE STATUS

EPA and other Federal agencies have sufficient authority to carry out the program proposed herein. Some of the existing legislation, however, requires that interfaces be appropriately defined by participating agencies if the total program is to be performed in a timely and efficient manner.

The statutory authority of EPA to advise the President on radiation matters affecting public health is derived through the transferred authority from the former Federal Radiation Council (FRC) [42 U.S. Code 2021(h)]. Reorganization Plan No. 3 of 1970 gives EPA the responsibilities for setting generally applicable environmental standards, which were formerly held by the Division of Radiation Protection Standards of the Atomic Energy Commission. Authority to protect the public health is derived by EPA from the Public Health Service Act.

The National Environmental Policy Act of 1969 requires that EPA review Environmental Impact Statements, to assess the adequacy of environmental protection associated with major Federal actions. Additional authority for EPA activities in this area can be derived through implementation of the Clean Air Act and the Federal Water Pollution Control Act Amendments of 1972.

While no additional legislation appears necessary at this time, it is possible that proposed legislation such as "The Administration Siting Bill" could relieve any potential misunderstandings as to responsibilities and authority in matters related to this problem area.

COORDINATION

Interagency

The coordination required to assure success in the resolution of this problem area is extensive and complex. Furthermore, the plan envisions that a major portion of the program will be performed by others (largely the AEC). In general, the approach calls for AEC efforts to concentrate on the reactor aspect of reactor accidents and EPA to concentrate on the environmental and health implications of those accidents. As such, a major near-term goal is to set up the appropriate coordinating links and to assess whether the degree and timing of effort contemplated for others is achievable. This section will summarize general responsibilities, and efforts of various organizations from which coordination links can be inferred.

In general, the AEC will be responsible for all activities which relate to implementation and enforcement of policies to assure adequate environmental protection from nuclear power plant accidents including the efforts which relate to the detailed assessment of the adequacy of the engineering, design, construction, maintenance and operation of the reactor plant safety systems and for the development of methods needed to quantitatively assess risks from such reactor accidents. EPA will provide comments to the AEC for use in its enforcement role through the EIS review process. In general, (the proposed program contemplates EPA activities concentrating on the development of standards and criteria which will provide a basis for judgment concerning accident risks to be used in the EIS review process.) The EPA will also develop and refine methods for assessing the environmental and health impact of potential accident induced radiation pollution needed to a) better define potential protective measures which can be taken in the event of an accident, and b) provide additional information needed to assess the need for refinement of the AEC Reactor Siting Criteria. All of the above EPA-developed information will be inputs to the AEC enforcement procedures and Siting Criteria. The latter must also be coordinated with the Federal Power Commission. Major efforts by both AEC and EPA are contemplated in the area of radiological emergency preparedness. In addition to the work on protective measures noted above, EPA will prepare and refine Protective Action Guides (PAGs) and, jointly with AEC, assure the establishment of emergency monitoring systems. [EPA Regions will utilize the PAGs and an AEC-issued Guide for the Preparation of Radiological Emergency Plans to assist regional compacts, and state and local officials in their emergency preparedness efforts. Input to the AEC's Guide for the Preparation of Radiological Emergency Plans will be provided by DCPA, EPA, HEW, and OEP.]

In addition, coordination may be required with the insurance industry and the JCAE in connection with Price-Anderson indemnification legislation.

Intragency

Coordination of the accident problem area with other problem areas within EPA-ORP is also required. Specifically, the accident area addresses the question of reactor accidents. The overall approach, however, will be utilized for addressing accidents in other areas of the fission fuel cycle (e.g. fuel reprocessing and fabrication plants, transportation, waste disposal, and uranium mining). For example, much of the input developed for assuring appropriate emergency response capability, such as Protection Action Guides, will be used directly in other problem areas.

Additional coordination with other EPA offices such as ORM will be required to initiate specific research programs related to the accident area.

ALTERNATIVE APPROACHES

There are many possible alternative approaches to a program for this problem area, each satisfying the requirements and providing benefits to a different degree.

Each suggested alternative is understood to include the effort to develop adequate emergency response capabilities, as has already been agreed to among Federal agencies.

Alternative 1: To leave discretion with regard to accidents to the AEC by

1. Deferring to their judgment on the subject of accidents and their environmental consequences, or
2. Refusing to become involved in the issue due to EPA lack of expertise and resources.

Alternative 2: To develop a comprehensive ORP program independent of the AEC to arrive at independent judgments. This would include efforts related to quantitatively defining the risk of accidents (accident probabilities and consequences), to set standards and criteria including model siting criteria to assure that the risk level from accidents is consistent with general societal values, and to develop methods for application in EIS reviews to assure further reduction of risk on a cost-effective basis.

Alternative 3: To develop an ORP program which recognizes on-going and potential AEC activities, but which (at least initially) can be performed largely independently of the AEC. The ORP efforts would include sufficient independent effort in the areas where comprehensive AEC efforts are anticipated or underway so that a meaningful assessment of the AEC results could be performed in the EIS review process. Such relatively small, independent efforts would also provide ORP with the leverage needed to help assure that the AEC efforts are adequately performed in a timely manner. In essence, the AEC would provide the detailed methods for a) quantitative risk determination (accident probabilities and consequences), and b) application of the cost-effective principle to reduce the risk of accidents, as well as the development of improved Reactor Siting Criteria. The ORP program would develop a sufficient capability to assess the AEC results to provide a basis for independent judgment needed in EIS reviews. In addition, a comprehensive effort to assess the accident risk level which is consistent with general societal values would be undertaken by EPA to provide an independent basis for reaching judgments concerning risks. Further, ORP efforts in the area of assessing the environmental and public health impact of accidents would be performed to provide a partial basis for EPA input to Reactor Siting Criteria.

<u>Alternative 4</u>: To develop a cooperative (i.e. non-independent) program with the AEC in the area of quantitative risk determination, risk assessment, and the development of improved Siting Criteria. This alternative would call for the AEC to provide a definition of the possible radioactivity source terms along with the probabilities of such releases. ORP would calculate the environmental and public health impact of such releases. ORP and AEC would work jointly in developing methods for risk reduction using a cost-effective principle and in an assessment of what risk level is consistent with general societal values. Finally, ORP would provide input to AEC on improved Reactor Siting Criteria based on the above information.

The proposed program on which this plan is based is consistent with Alternative 3. The rationale used in its selection is as follows: Alternative 1 would not allow EPA to discharge its responsibility in this area as currently defined. Alternative 2 would not be a cost-effective program in that it would duplicate major efforts being performed by the AEC. In addition, the manpower and resources required for Alternative 2 significantly exceed those available to ORP. Alternative 4 appears undesirable since it would not likely provide EPA with the capability to make independent judgments. Further it is possible that failure of the AEC to meet ORP expectations in quality or timing could impair ORP efforts. It is also possible that untoward events affecting the performance of ORP (e.g. funding limitations, hiring freezes) could place EPA in a position of hindering another agency through faulty performance. Alternative 3, however, appears to be consistent with projected EPA resources and with meeting EPA responsibilities in the accident area. It also would provide the technical basis for applying leverage on the AEC to help assure that the requisite level of environmental protection will be achieved.

RECOMMENDED OPTIMUM PROGRAM

No recommended optimum program will be described in detail here since the elements would be similar to that of the proposed program. However, the recommended optimum program can be readily inferred from the section "Impact of Proposed Program Compared to Optimum".

Proposed Program Scope

It should be emphasized that the scope of the program noted herein requires major efforts on the part of EPA, AEC, and state and local governments.

The general goal is to assure adequate environmental protection from potential reactor accidents. This goal requires:

1. Determination of the environmental risk of accidents (accident consequences as a function of accident probability).

2. Development and application of criteria for judgments concerning risks in terms of costs, benefits and general societal values.

3. Assessment of adequacy of Reactor Siting Criteria and providing guidance for improvements, if needed, (based on 1 and 2 above).

4. Adequate emergency preparedness to help minimize the environmental and health consequences of reactor accidents, if they should occur.

While initial work in each of these areas can proceed on an essentially independent basis, some iteration and feedback among these areas will be required to assure optimum results. Definitive objectives include the development of improved Protective Action Guides, Emergency Monitoring Systems, State Emergency Plans, and guidance for improved Siting Criteria, and the development of objective methods for factoring the environmental risk of accidents into the decision making process based on a risk/cost/benefit rationale.

1. Quantitative Risk Determination

The methodology for defining the expected risk requires a quantification of the probability of reaching various damage levels for the complete spectrum of accidents, including those which may result in more severe consequences than the currently defined maximum credible accident. Since sufficient statistical data may not be available to allow a straightforward probability assessment for all possible accidents, a variety of approaches will be required to assess the probabilities of both initiating events and the possible responses of the plant, operators, and public officials. Since an estimate of the true environmental risk is required, the developed methods should predict realistic rather than conservative damage levels.

The AEC is required under the National Environmental Policy Act of 1969 to describe in its environmental statements the risk of accidents imposed by its licensing action. The EPA has requested that this include information on the probabilities of accident occurrences, the probable consequences, and other risk, cost, and benefit information. This plan assumes that the needed methods and information will be made available by the AEC in a timely manner. However, the plan calls for ORP to assess the suitability of the methods employed. This effort will include an assessment of the adequacy of the data base, assumptions, judgments, and completeness of the methods, along with an assessment of the adequacy of the accuracy and confidence limits of the results.

2. Development of Methods for Reaching Judgments Concerning Risks

In the preparation of environmental statements under the National Environmental Policy Act of 1969, any agency of the Federal Government (e.g., the AEC), is required to articulate the reasons for altering the environment by its actions (including imposing accident risks on society such as the licensing of nuclear power plants). Thus a major input relating to the problem area is the development of a methodology for reaching objective judgments on what risk due to radiation accidents may be considered acceptable by society. It should be emphasized that there is no absolute "justifiable risk" in a technical sense good for all time and place. Indeed a decision on what constitutes a justifiable risk is basically a societal - political decision since it involves value judgments on which people would be expected to differ. Thus, while this problem is difficult in that there is no "answer" which will satisfy everyone, it is clear that a more objective basis for reaching judgments than currently available can and shall be developed.) In essence, it requires a method for reaching an a priori decision on what risk/cost/benefit balance society would ultimately select if all subsequent information (e.g., reactor risks and risks of alternatives) were available to it. Three complementary risk/cost/benefit approaches will be utilized to develop justifiable risk criteria:

1) comparison of risks associated with the fission fuel cycle (including the risks of reactor accidents) with the risks of not obtaining the additional power.

2) comparison of risks of the fission fuel cycle with the risks of other fuel cycles (including the risks of accidents)

3) comparison of risks of the fission fuel cycle with other "acceptable" non-voluntary risks (e.g., some forms of travel).

While the "risk" term has been emphasized in the above description for clarity, the actual purpose will be to derive "socially acceptable" (i.e., justifiable) cost/risk/benefit balances. The first and second approaches are internal to the energy production framework and will therefore lead to a cost-effective approach to reducing environmental and public-health risks associated with the production of electricity; the latter effort will examine general societal values to enable decisions to be made on whether other alternatives (not previously considered seriously, such as underground siting of nuclear plants) should be considered.

Once the total justifiable risk is defined, a portion of that risk will be considered justifiable for the power plant itself. Using this level of risk for a nominal plant, one may then look at each reactor individually to determine how it's expected risk over the life of the plant (including the risk of accidents) compares to the justifiable level. Within the overall envelope of justifiable risk for the reactor plant, the risk level should be further optimized on a cost-effective basis. In essence, a balance should be made of the cost of combinations of various engineered safeguards, quality assurance programs, and operating limits (technical specifications) and the expected cost saving of preventing accident consequences. Such cost-effectiveness optimizations for individual reactors should be possible once the methods for quantitative risk determination are completed.

It should be recognized that definition of an overall justifiable risk will require significant development efforts and public debate, and as such, will not be finalized in the near term. The plan calls for major efforts by both EPA/ORP and EPA/ORM in this area.

In the near-term (through early fiscal year 1974) ORP will develop a preliminary quantitative assessment of the benefits of the uranium fuel cycle (under the risk/cost/benefit generic area), and develop the mathematical framework for application of the risk justification efforts. The latter efforts will allow parametric studies of health effects (including both acute and chronic mortality), accident consequences, and accident probabilities. In essence, the probability of occurrence of the various classes of accidents required to produce a fixed number of health effects will be determined. Based on this near-term effort, the maximum justifiable probability for each class of accidents will be readily calculable once the overall risk justification is determined.

3. Improved Siting Criteria

The knowledge gained from the quantitative risk determination and the basis developed for judgments concerning risks may ultimately lead to issuing guidance for improved Reactor Siting Criteria. As a first step, a comparison of the relative risks of all existing and firmly planned reactors will be prepared by ORP, assuming an arbitrary but equal probability of accidents resulting in various levels of radioactivity release. Developing such comparisons requires the development of individual risk estimates for each plant on the basis of the local meteorological (and perhaps hydrological) conditions, biological toxicity of the individual radionuclides, and local population patterns. Once the transport analyses define the information on concentrations and locations of the various isotopes involves, the resultant risk to the public health and environment will be calculated to give a true picture of the relative risk of actual sites. Such information will provide a firm base for subsequent rapid assessments when actual accident probabilities are defined.

Therefore, the quantitative determination of the probabilities of various release levels, transport models, and health-effects and land damage models are all required before one can determine the risk of each individual reactor. It is only then that one can determine whether these risks and the judged benefits as weighed against the existing Siting Criteria result in an adequate situation or whether improved Siting Criteria and/or improved nuclear plant safety are required.

It should also be noted that the Siting Criteria will have to reflect multi-station sites, regional siting patterns, and the differences among various types of reactors (BWRs, HTGRs, LMFBRs, and PWRs).

4. Emergency Response Capability

In addition to assessing the risks with regard to acceptability and deciding how to reduce risks if necessary through improved Siting Criteria and/or cost-effective improvements in plant safety, it is necessary to prepare for effective response to emergencies, in order to reduce the consequences of accidents should they occur. Preparedness for such emergencies involves considerable planning, coordination, and the development of response capability, and should be done on a cost-effective basis, consistent with the expected risk and consequences. The effort involved is large, involving several Federal organizations and many lower-level governments. The responsibilities of the EPA involve issuing Protective Action Guides, and assisting other organizations in emergency planning, development and assessment of protective measures, and cooperation in the establishment of radiation detection and emergency monitoring systems. These efforts will be applied not only to radiological emergencies arising from reactor accidents but all other radiological emergencies arising from the insertion of radioactive materials to the biosphere.

An example of one Protective Action Guide (PAG) which requires near-term effort is related to the development of guidance which would weigh the risks due to the evacuation of various population groups and costs of action prescribed against reductions in exposure. There is a real need for guidance to the states on anticipated risks due to evacuations. Through the coöperation of OEP, AEC, and DCPA, ORP will develop a report on the history of the risk due to evacuation. Considered in such a study will be the various population groups and different weather conditions in different parts of the country. ORP will then issue a PAG which indicates at what expected reduction in radiation exposure evacuation of various population groups would be warranted. As a very practical matter, it will take several months to gather this information. Continuing from that point on, ORP, with the cooperation of the other Federal agencies, will develop guidance to the states for the evacuation and/or alternate remedial action in the event of an anticipated exposure, such as the benefit of shelter.

It should be noted that additional PAGs for radionuclides not now considered may be desirable, depending on the outcome of studies of the realistic probabilities and consequences of accidents of current systems, and upon the large-scale introduction of other reactor types (HTGRs, LMFBRs).

With regard to emergency radiological monitoring, agreements among AEC, OEP, DCPA, HEW, and EPA call for the establishment of radiation detection and measurement systems by EPA in cooperation with AEC. It appears that the major effort required in this area is not the invention of basic new monitoring techniques but rather the identification and development of practical systems suitable for emergency use in the field including consideration of existing national radiation monitoring networks. Both AEC and EPA work in this area is contemplated, although the detailed coordination required to assure an optimum effort has yet to be carried out. A major input required to adequately define emergency monitoring systems is a better definition of the potential consequences and probabilities of accidents. Such definition will be provided by the quantitative risk determination study as noted above.

Finally, EPA-Regions will provide assistance to regional compacts, and state and local officials in developing a sufficient emergency preparedness capability. The major effort will be aid to lower level governments in developing Emergency Plans, consistent with an AEC-issued Guide. ORP input to this Guide is planned. The EPA-Regions will utilize information developed by this program (e.g., PAGs) in their efforts and will be aided by EPA laboratories in promoting the training of emergency teams and testing of the Emergency Plans.

In order to meet the schedule for the proposed program as shown in the Milestone Charts, the near-term ORP manpower, contract funding and ORM support levels are estimated to be:

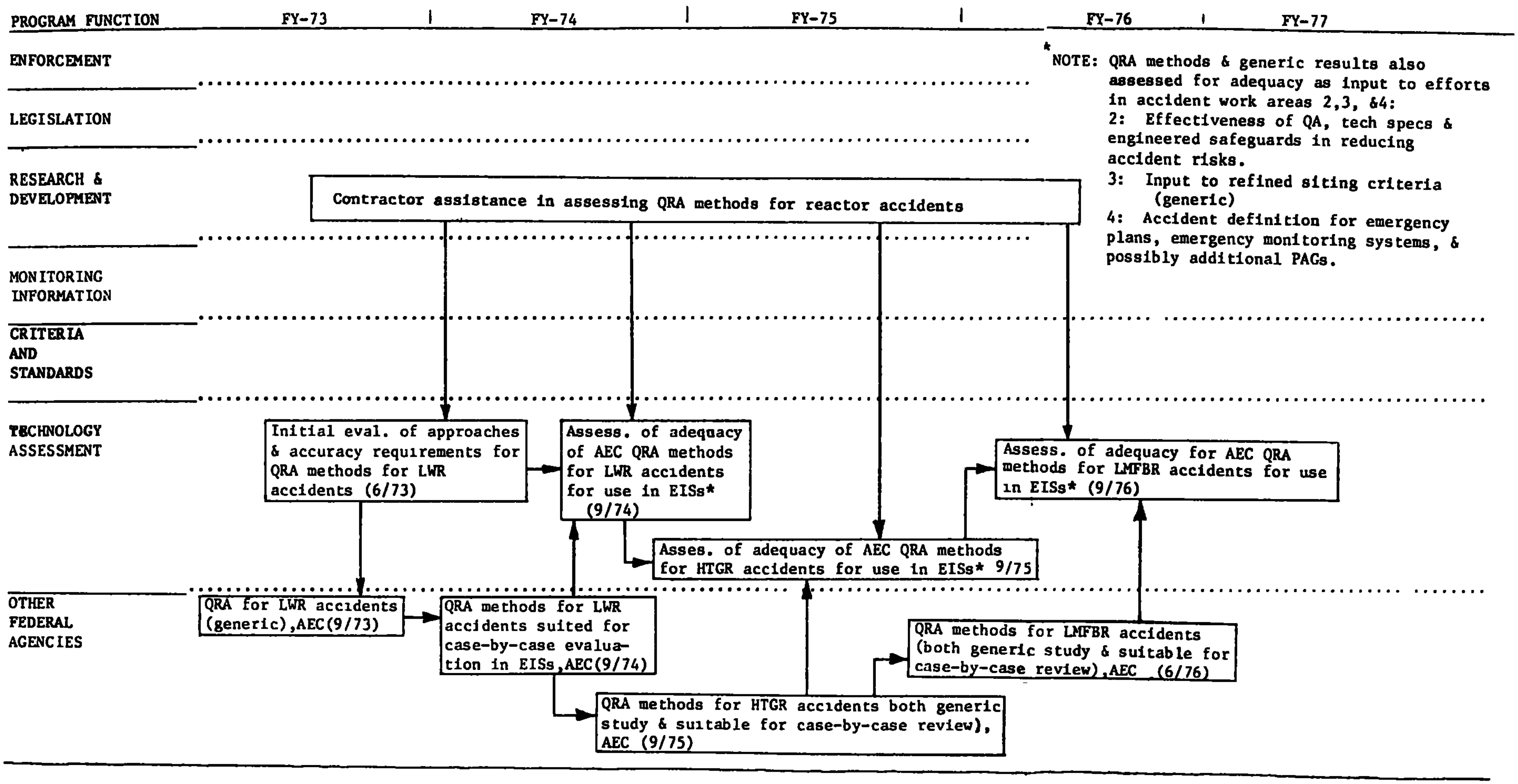
1.	Quantitative Risk Assessment:	2 MY + $15K from 3/73 to 6/73
		2.5 MY + $60K from 6/73 to 6/74
2.	Basis for Judgment:	1.0 MY from 3/73 to 6/73 + equiv. of 2 MY from ORM
		3.0 MY + $65K from 6/73 to 6/74 + equiv. of 6 MY from ORM

3.	Improved Siting Criteria:	2.0 MY from 3/73 to 6/73
		4.0 MY + $50K from 6/73 to 6/74
4.	Emergency Preparedness	5.5 MY from 3/73 to 6/73
		7.5 MY + $100K from 6/73 to 6/74
Total		10.5 MY + $15K from 3/73 to 6/73
		17.0 MY + $275K from 6/73 to 6/74

It is difficult to estimate manpower and contract funding requirements accurately beyond fiscal year 1974. While efforts related to defining a basis for judgment could likely be decreased in FY 1974, efforts in other areas would increase [e.g. quantitative risk assessment of HTGRs and PAGs for other radionuclides (e.g. plutonium)]. It is roughly estimated that 20 technical man years and $300K for contracts will be required each year from fiscal years 1975 and 1976.

The schedules noted in the Milestone Charts are based on the projected manpower levels noted above and were developed on the basis of assigning highest priority to BWRs and PWRs, second priority to HTGRs, and third priority to LMFBRs. This priority rating is based on the relative numbers of such plants which are anticipated in the near term.

REVISION MARCH 1973



MILESTONE CHART FOR ACCIDENT WORK AREA 1, QUANTITATIVE RISK ASSESSMENT (QRA) OF REACTOR ACCIDENTS

FIGURE C-1

REVISION March 1973

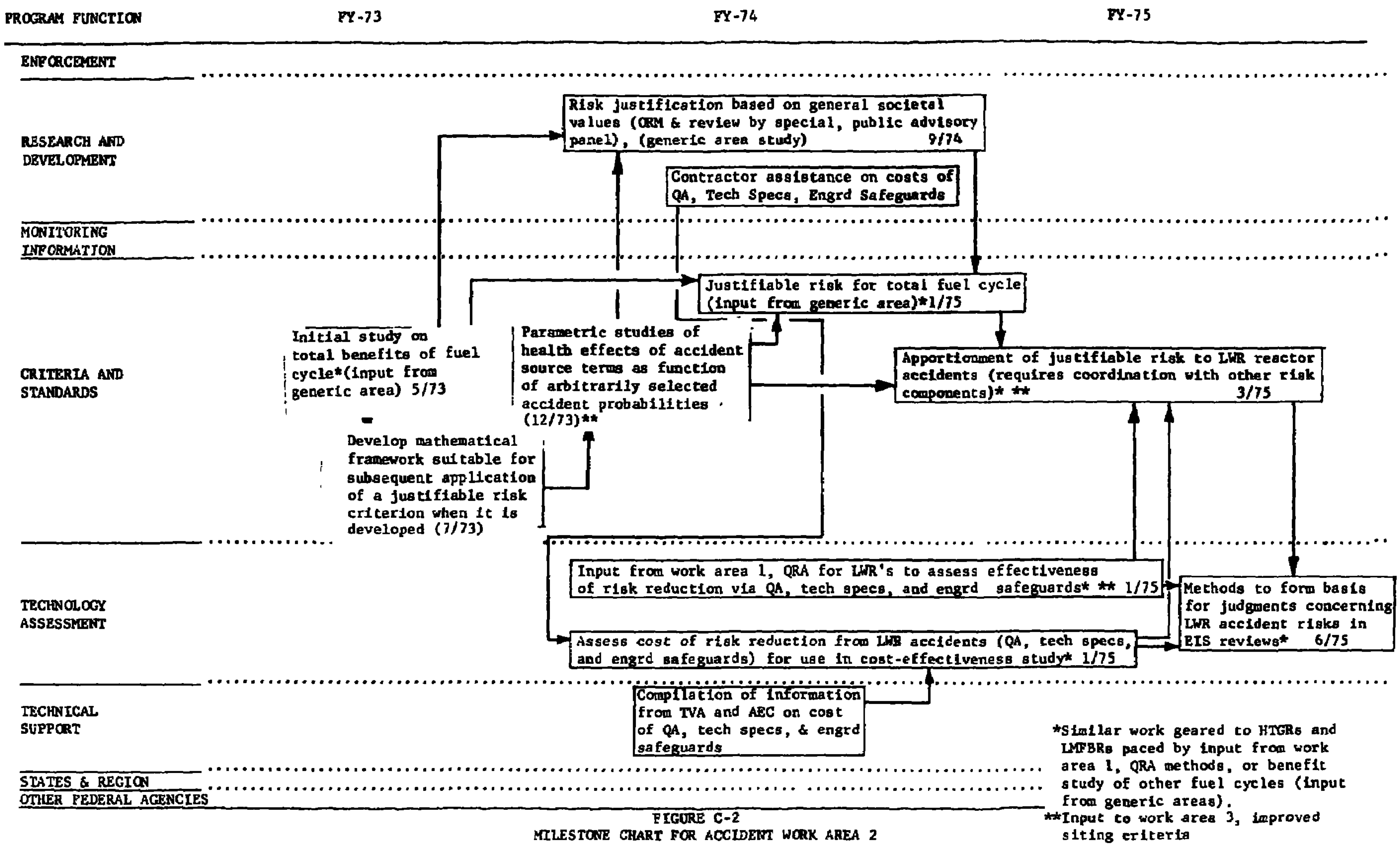
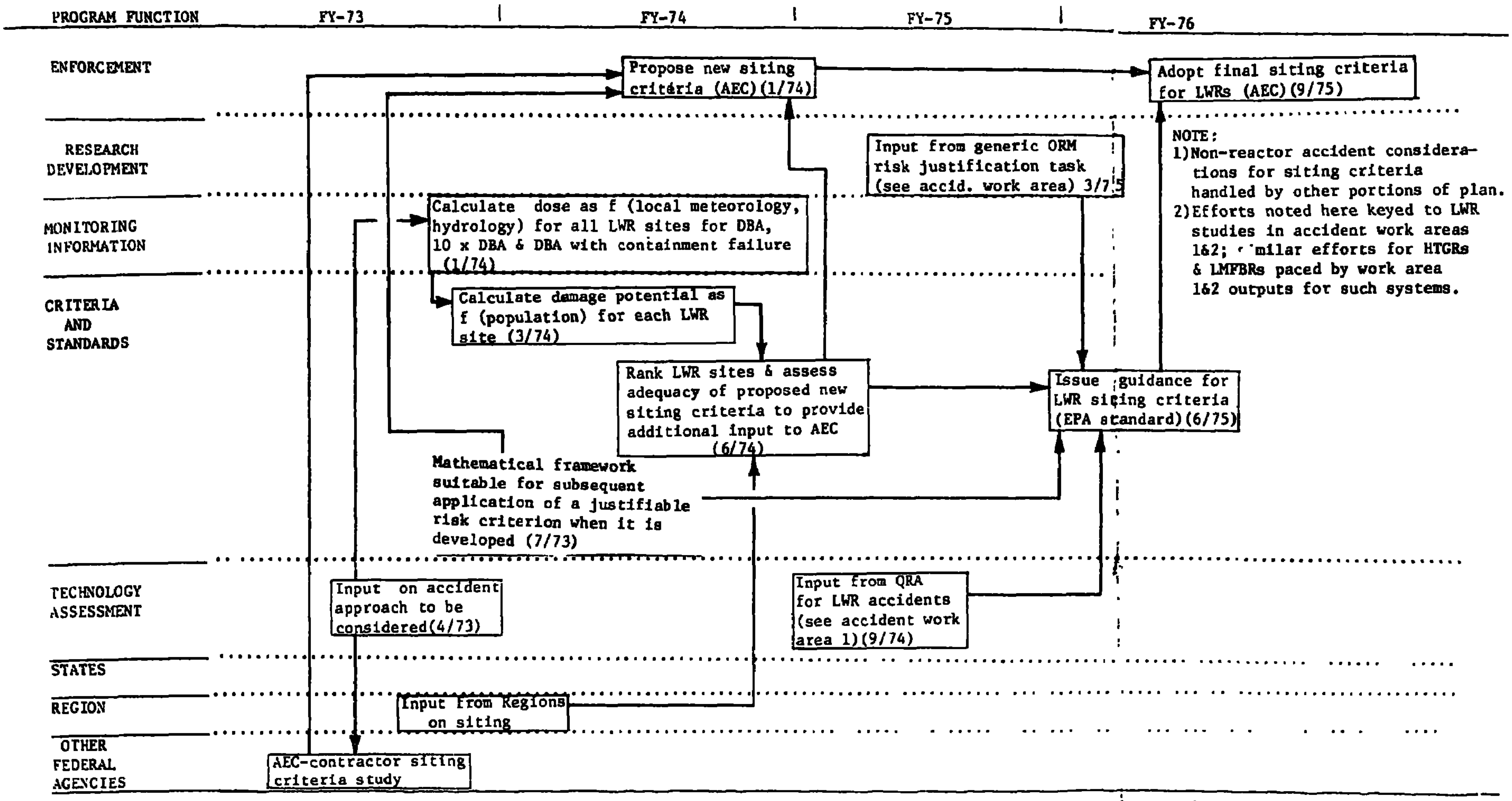


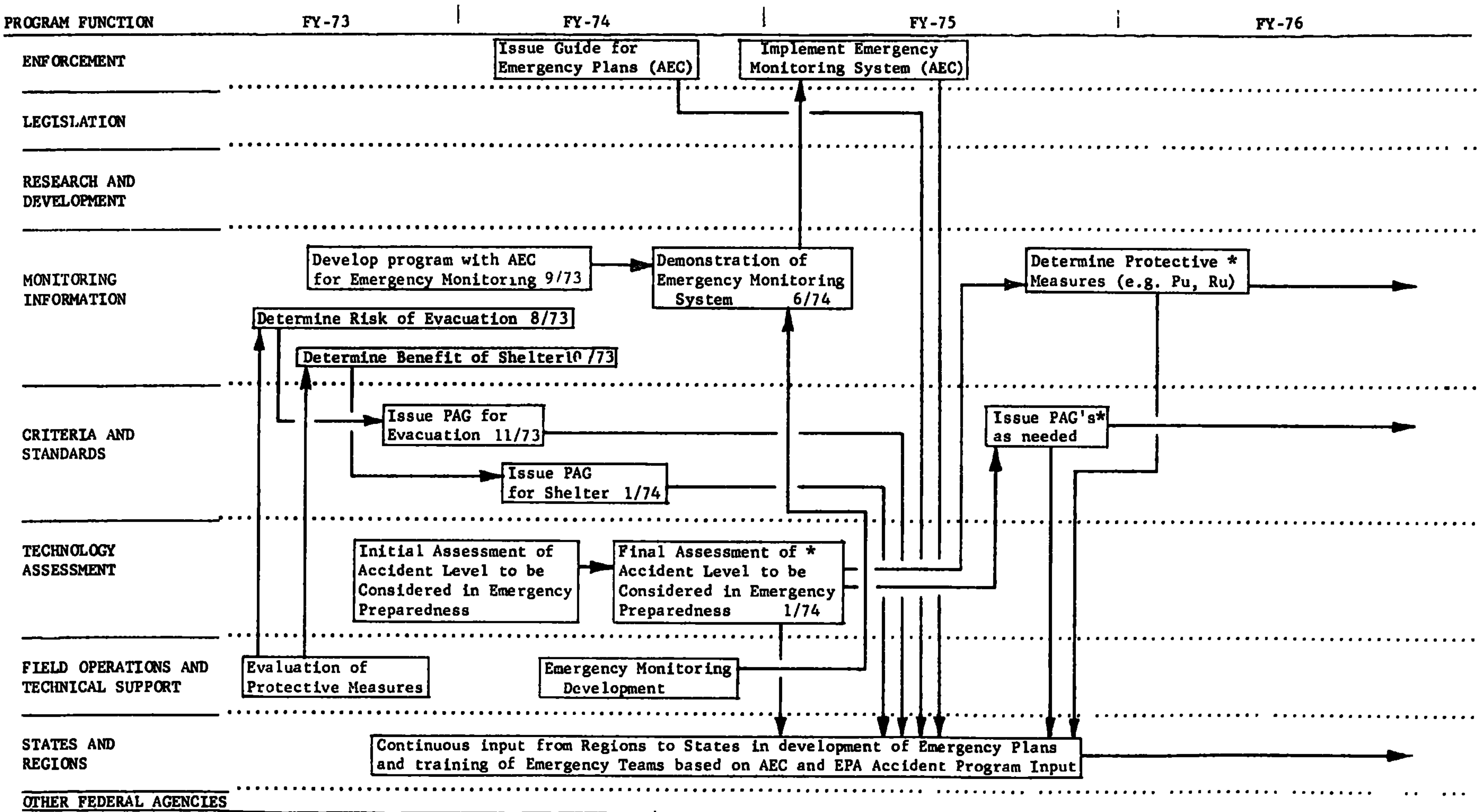
FIGURE C-2
MILESTONE CHART FOR ACCIDENT WORK AREA 2
BASIS FOR JUDGMENT CONCERNING RADIOLOGICAL RISKS FROM ACCIDENTS



MILESTONE CHART FOR ACCIDENT WORK AREA 3, INPUT TO IMPROVED SITING CRITERIA (ACCIDENT CONSIDERATIONS)

FIGURE C-3

REVISION MARC H 1973



*Similar work geared to HTGR's and LMFBR's paced by input from Work Area 1, QRA Methods

FIGURE C-4

MILESTONE CHART FOR ACCIDENT WORK AREA 4: EMERGENCY PREPAREDNESS

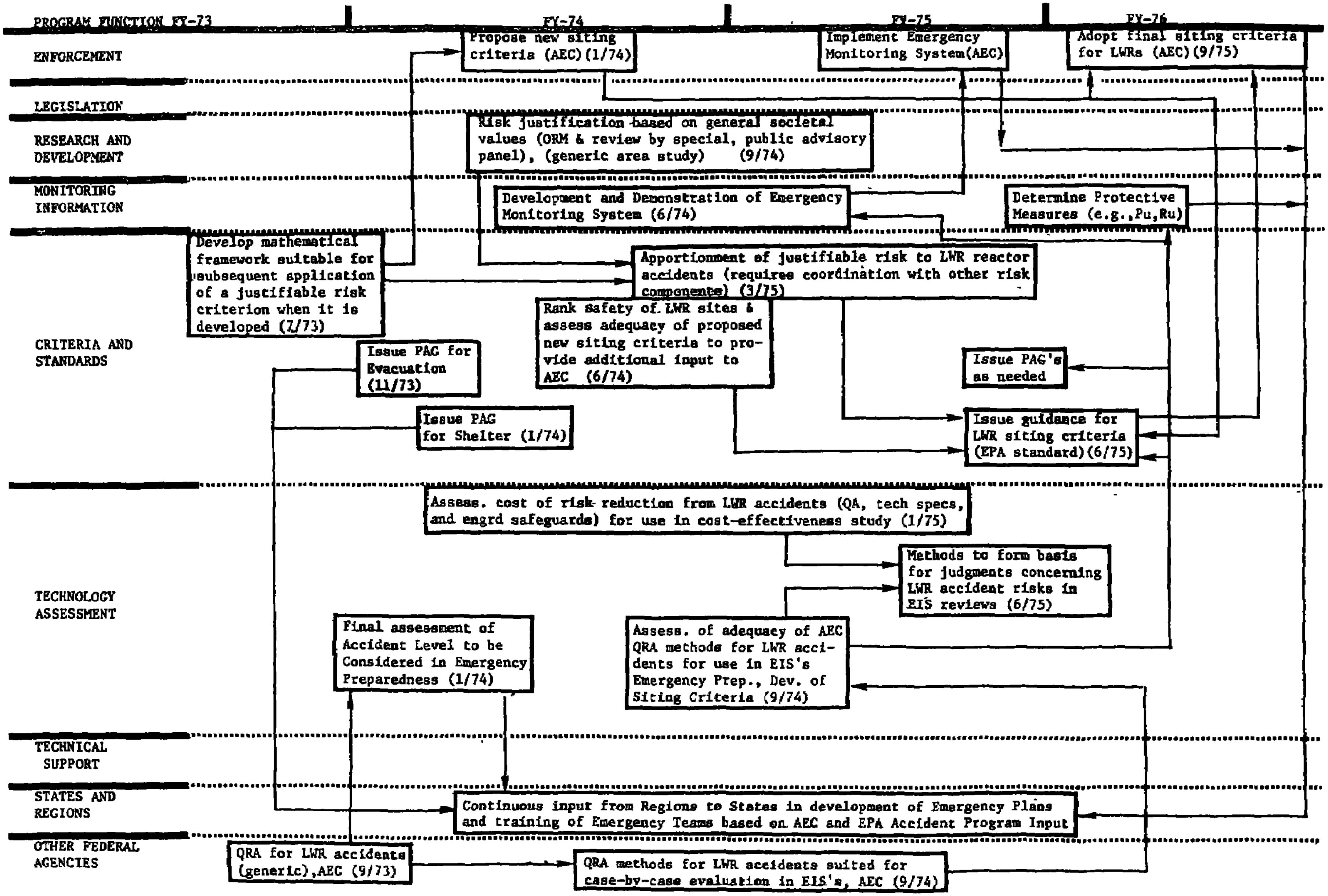


FIGURE C-5 SUMMARY MILESTONE CHART FOR LWR ACCIDENTS

IMPACT OF PROPOSED PROGRAM COMPARED TO OPTIMUM

The optimum program would be similar to that of the proposed program except for two factors. First, the optimum program would apply significantly greater manpower (by a factor of $\sim$1.5) in order to speed up the program. Hence the optimum program would allow review of the safety of reactors on a risk/cost/benefit basis at an earlier time. In view of the many plants to be licensed over the next few years and the fact that each plant has an expected operating life of 30 years, a more rapid completion of the program could have a major impact on environmental protection if it turns out that currently designed systems are not adequate. If, on the other hand, quantitative risk assessment indicates that the current protective features used are unduely restrictive, presumably major cost savings could be provided by reducing conservatism in design. Of particular concern are the relatively late dates for developing methods for assessing HTGRs which are beginning to be introduced in a rapid manner in the U.S. In addition, the optimum program would speed up the efforts related to the adequacy of reactor siting criteria. In view of the long lead times required for site selection, increased near term efforts would be expected to influence the siting of plants which would be operating well into the next century. In addition, the increased effort would result in a significantly more rapid upgrading of radiological emergency response capability. In view of the current state of response capability and the rapid increase in the number of reactors and related facilities which is taking place, such upgrading is urgently needed.

Second, the optimum program would apply yet another factor of 1.5 in manpower (or equivalent in contract help) to assess the validity of AEC efforts noted in the proposed program. In addition such manpower could provide ORP with information for those areas in which AEC efforts are not as timely or complete as desired.

EXPECTED ACCOMPLISHMENT AND MEASUREMENT OF THESE GOAL ATTAINMENTS

The ultimate goal of this area is to preclude any accidental radionuclide release which would adversely affect the public, and to assure adequate emergency preparedness in the event of such an accident. As such, ultimate "success" will be difficult to measure, while "failure" will be obvious. Since some accidents or incidents will happen, however, limiting the extent of radioactivity releases to the environment and significantly reducing the impact of any major release would provide some indication of a successful program.

A more visible measure of program accomplishment will be to assess the degree to which the schedules noted on the milestone charts are met, and the degree to which ORP philosophy and impact are utilized in enforcement actions by the AEC. The program accomplishment can be "measured" by assessing the reduction in public health and environmental risks from reactor accidents (i.e. by quantifying the reduction of reactor accident probabilities and associated consequences) resulting from the program. It should be recognized, however, that since the major portion of the program is "preventive" rather than "cleanup" in nature, the risk reductions will be calculated averages rather than physically measured values.

RADIOACTIVE-WASTE DISPOSAL

PROBLEM DESCRIPTION

Component Problems

The disposal of radioactive wastes is common to every aspect of nuclear energy use. Areas of concern for the Environmental Protection Agency include (1) the projected amounts of wastes that will be produced from operations of light-water and fast-breeder power reactors, and the high-level and low-level wastes that will be produced from fabricating and reprocessing fuels for these reactors; (2) the commercially produced low-level wastes from reactor operations, research, medical, and other sources that are currently being disposed in State-licensed commercial burial grounds; (3) the AEC-generated low-level solid, liquid, and gaseous wastes currently being disposed at AEC facilities and laboratories; and (4) the AEC-generated high-level and transuranic-contaminated wastes currently being stored at AEC facilities and laboratories. These areas of concern constitute the four sub-activities of the proposed radioactive-waste disposal program of the Office of Radiation Programs. (See Figure C-10).

Background

Radioactive wastes are currently being produced in a bewildering variety of solid, liquid, and gaseous forms, are being treated in complex ways, and are currently being stored or are disposed by a variety of methods to ground, air, and water. Decisions related to disposal and storage of these wastes are complex because of the great ranges in concentrations of various radionuclides in various wastes and

PAGE NOT

AVAILABLE

DIGITALLY

the consequent ranges of their biological hazard potentials. The decisions are complicated further by the long-lived hazards of the highly concentrated constituents of some of the wastes, that range from a few years from some fission products, to as much as 200 years for potential future concentrations of tritium, hundreds to a thousand years for strontium-90 and cesium-137, and more than 100,000 years for plutonium and iodine-129.

The general nature of radioactive waste management and disposal problems can be viewed in present-day terms as related to public-health, technologic, and economic decisions concerning:

- the shallow land burial and the release to the environment of large volumes of low-level solid, liquid, and gaseous wastes versus segregation and concentration of these wastes for storage or for disposal in earth materials isolated from the biosphere; and
- the surface and near-surface storage in retrievable form of relatively small volumes of concentrated, high-level solid or liquid wastes versus the storage or ultimate disposal of these wastes in earth materials isolated from the biosphere.

Decisions on all aspects of radioactive-waste disposal should be based on an orderly assessment of the public-health, technologic, and economic factors of present practices and future conceptual methods. Without such assessments it will not be possible for formulate criteria, standards, and regulations that are appropriately conservative in radiologic terms, but are not unnecessarily restrictive in economic terms. The responsibilities of the Office of Radiation Programs relevant to radioactive-waste disposal are immediate because of the necessity for technically based decisions on the radiological-health aspects of Environmental Impact Statements, the responsibility for assessing technology related to radiation matters, the responsibility for developing radiological-health criteria and standards, and the necessity for providing technical assistance and consultation to State agencies.

The field and scope of problems of radioactive-waste management and disposal are such that the Office of Radiation Programs cannot embark on an overall program of research and development, which seems to be the responsibility of the nuclear industry and the Atomic Energy Commission. Nevertheless, a comprehensive program of evaluational and conceptual studies is necessary to provide the data base and back-up for EPA decisions, to identify and sponsor topical research in neglected areas, and to provide a consistent national approach to public-health and safety concerns related to management and disposal of radioactive wastes. Such a program, properly coordinated with AEC and other Federal agencies, State agencies, and industry, would provide EPA leadership to the currently fragmented and inconsistent approaches to disposal practices for existing wastes. The program would also address the longer ranging EPA responsibilities related to the development of nuclear energy and would provide the basis for developing and substantiating adequate criteria, standards, and regulations for commercial power-reactor wastes and for determining the ultimate fate of the storage or disposal sites for these wastes.

LEGISLATIVE STATUS

The Resource Recovery Act of 1970 (P.L. 91-512) specified, in Sec. 212, that the Secretary of the Department of Health, Education, and Welfare will supply to Congress a comprehensive report and plan for the creation of a system of national disposal sites for the storage and disposal of hazardous wastes, including radioactive wastes, which may endanger public health or welfare. The authority for this work has been transferred to EPA, with the Office of Solid Wastes as the lead organization. The problems of radioactive wastes require specialized technical competence and are critical to the mission and ongoing work of the Office of Radiation Programs; therefore, it is desirable that ORP assume the lead for the portions of P.L. 91-512 that apply to radiation matters.

From the wording of P.L. 91-512, the intent of Congress seems clear that the Federal responsibility for the disposal of hazardous wastes, specifically including radioactive wastes, will reside with the Environmental Protection Agency. This is consistent with the more limited authority of the Atomic Energy Commission which exercises control only on those who actually possess radioactive materials. This authority and its accompanying regulations apply to radioactive materials on the ground surface at disposal sites. However, according to prevailing philosophy of the Regulatory portion of AEC concerning commercial waste-disposal facilities, when the radioactive materials are buried in the ground, and thereby are no longer in the possession of the user, AEC licensing is no longer required. The responsibility for the buried wastes is then transferred by legal agreements to the States which issue licenses and establish regulations for the sites.

The transfer of the functions of the Federal Radiation Council to the Office of Radiation Programs provides the general authroity to issue Federal guidance in radiation matters. Further, there is an implied responsibility, in terms of those responsibilities transferred to ORP from AEC, to assure that the controls exercised over the licensees possessing radioactive materials will include proper disposal procedures.

COORDINATION

Intra-Agency

The Office of Solid Wastes is currently proceeding with general contract studies covering the management and disposal of all hazardous wastes, as required by the Resource Recovery Act of 1970. A comprehensive report to Congress on these studies is required by the law in mid 1973. Liaison between ORP and OSW has been established, but additional consultation and cooperation will be required to assure a coordinated EPA approach to the portion of the OSW effort devoted to radioactive-waste disposal.

The Office of Radiation Programs is the lead organization in EPA for radiation aspects of environmental protection including reactor operations, nuclear fuel fabrication and reprocessing, and disposal of radioactive wastes. Therefore, the ORP needs are immediate for comprehensive and detailed data and analysis on critical aspects of radioactive-waste disposal. The ongoing activities of ORP provide the basis for the continuing development of this program. The ORP program will be coordinated to provide evaluations and policy guidance on radioactive-waste disposal which will augment the general OSW studies of hazardous wastes.

ORP has established a coordinated team effort with NERC-WERL to operate with appropriate EPA Regional offices in review of radiation aspects of AEC operations and disposal practices. Continuing coordination will be necessary for 2 to 3 years.

Inter-Agency

A considerable Federal effort, including work in other parts of EPA, the AEC, the Department of Interior, and the Department of Defense, is underway on the overall field of waste disposal. Therefore, it will be necessary to establish liaison and coordination between ORP and these agencies to keep abreast of current developments. It will be desirable to solicit consultation and advice from other agencies by establishment of an inter-agency task force or working group.

EPA-State

Under ORP sponsorsorship the Conference of State Radiation Control Program Directors has established a Task Force on Radioactive Waste Disposal which will be advisory to ORP.

ORP is currently providing financial assistance to States having commercial waste-disposal sites for the purposes of inventorying and analyzing the existing commercial wastes. ORP anticipates continuing technical assistance and coordination as part of the on-going State programs.

EPA-Industry

It will be desirable to continue EPA-Industry liaison through appropriate committees of the American National Standards Institute, and to establish consultation through the Atomic Industrial Forum and other groups.

ALTERNATIVE APPROACHES

Several alternative approaches to radioactive waste disposal problems are possible for ORP. Briefly, these are as follows:

1. Maintain general cognizance sufficient for review of Environmental Impact Statements. Maintain general liaison with other parts of EPA and provide advice and consultation as requested.
2. Develop the recommended optimum 4-year ORP program on the four areas of concern (described below) that will accommodate the overall needs and mission of EPA, and also will permit EPA leadership in a timely and nationally consistent program of radioactive-waste management and disposal related to the development of nuclear power.
3. Develop an alternative ORP program (described below) to provide a data base adequate for defining problem areas and potential environmental hazards. Develop conservative radiation-health

criteria and, ultimately, conservative general policy, criteria, and standards for storage and disposal of radioactive wastes to provide guidance for other EPA activities and state consultation. The program would involve some cooperation between ORP, Regions, NERC, and AEC in acquisition and analysis of the data base.

OPTIMUM PROGRAM

An optimum ORP program would address the four component problem areas, or subactivities (above), in sufficient depth to accomplish the ORP missions connected with Environmental Impact Statements, radiological-health criteria and standards, assistance and consultation to States, and the Resource Recovery Act of 1970. The program would provide a consistent national approach to the immediate public-health and safety concerns related to existing AEC and commercial radio-active wastes. Additionally, the program would comprehensively utilize the remaining lead time (about 5 years) before the fuel-reprocessing and reactor-operational wastes from the nuclear-power industry will begin to require major decisions concerning storage and disposal.

The program would consist mainly of conceptual and evaluational studies, augmented by Federal-State-Industry consultation, to assess current knowledge, technology, operational experience, and planning. Gaps in knowledge will be identified for research or will be treated in appropriate manner during development of the criteria, standards, and regulations which would be the major goals of the program. EPA-Industry consultation is vital on all phases of technologic assessment, economic and geographic evaluations, and in the development of regulations. This can be accomplished through liaison and participation with the American National Standards Institute, the Atomic Industrial Forum, and by other means such as Government-Industry advisory task forces.

The Optimum Program would consist of three phases and would extend from FY 1973 to FY 1976, with a possible extension through FY 1979. (See milestone chart for Optimum Program.) The phases would consist of (1) establishing a comprehensive data base, (2) analyzing and evaluating existing disposal practices and conceptual methods to develop EPA radiation-health criteria and interim positions, and (3) developing EPA general policy, criteria, standards, regulations, and overall recommendations to Congress which would lead, potentially, to establishment of carefully selected, evaluated, and regulated national repositories for various kinds of radioactive wastes.

External Needs

Parts of the needed information for beginning the program are being obtained from existing literature and documents as part of current ORP activities. Because of manpower limitations within ORP it will be necessary to obtain other information, state-of-the-art assessments, and needed research through contracts with consultants, industrial firms, and other Federal agencies in specific technical fields. ORP-State program elements underway include obtaining inventories of wastes and reviewing management practices at existing commercial burial grounds. Additional efforts in reviewing hydrogeology and other environmental factors, monitoring procedures, needed additional site investigations, and applied research will require a continuing joint ORP-State program. Acquisition of similar information about AEC sites will require cooperative action with AEC. Reviews of sites and operations will require ORP coordination of teams from NERC-WERL that will include representatives from various Regional Offices. ORP sponsorship will be required for the Task Force on Radioactive-Waste Disposal of the Conference of State Radiation Control Program Directors and Federal interagency Task Forces (yet to be established).

Internal Needs

Much of the necessary administrative, supervisory, and technical competence, as well as the necessary overview for the Optimum program currently resides in ORP. The full-time assignment of 5 professional personnel will be necessary to manage and coordinate activities, to sponsor and monitor research, to analyze data and prepare reports, and to provide liaison and coordination with other Federal, State, and Industry organizations. An additional 5 professional personnel will be required for topical investigations and preparation of reports in specific areas of competence.

PROPOSED PROGRAM

The Proposed Program also would address the four component problem areas (subactivities) in sufficient depth to accomplish the ORP missions connected with Environmental Impact Statements, radiological-health criteria, assistance and consultation to States, and the Resource

Recovery Act of 1970. The main objectives would be completed in FY 1973-1976. (See milestone chart for Proposed Program.)

The Proposed Program would consist of establishing essentially the same data base (Phase I) as the optimum program. However, the scope of evaluational studies (Phase II) would be reduced considerably in the Proposed Program. In connection with existing wastes at commercial burial grounds and AEC sites, the Proposed Program would concentrate mainly on determining and defining potential problem areas and developing EPA positions and recommendations concerning the problem areas. In connection with future commercial fuel-cycle wastes, the Proposed Program would concentrate mainly on developing radiation-health criteria for disposition of various radionuclides; on assessment of proposed conceptual methods such as engineered surface storage or subsurface disposal in optimum earth materials; and on development of EPA general policy, criteria, standards, and regulations concerning these methods. Potentially, the alternative program also would lead to the establishment of national repositories for radioactive wastes.

External Needs

As with the optimum program, parts of the needed information for beginning the program and establishing the data base (Phase I) will be obtained from existing literature and documents, through existing State programs, through ORP-NERC-Region teams, and through cooperative action with AEC. ORP sponsorship will be required for the State Task Force on Radioactive Waste Disposal and for Federal interagency task forces.

Because of the lesser scope of the Proposed Program, the Phase II contractual needs for research, state-of-the-art assessments, and site investigations by private, State, or Federal organizations outside ORP would be minimal.

Internal Needs

The Proposed Program will require the assignment of 5 professional personnel in ORP to manage and coordinate activities, to analyze data and prepare reports, and to provide liaison and coordination with other parts of EPA and other Federal, State, and industry organizations. An additional 5 personnel will be required for about half-time efforts for topical investigations and preparation of reports in specific areas of competence.

Comparison of Optimum and Proposed Programs

The recommended Optimum Program and the Proposed Program would both consist of conceptual and evaluational studies to provide the data base and essentially the same preliminary definitions of potential problem areas and environmental or radiation hazards.

In Phase II the general approaches and depths of consideration of the two programs diverge. The Optimum Program would develop and apply EPA radiation-health criteria to assessments of actual situations associated with current methods of disposal of commercial and AEC-generated wastes to determine environmental limits of current practices and sites, and also would apply the criteria to various conceptual methods for disposal and storage of various projected nuclear power wastes. This would assure effective assistance to States, authoritative recommendations concerning AEC wastes, and positive, well-founded radiation-health leadership in the waste-disposal aspects of nuclear-power development. As further steps, the Optimum Program would assess the technologic feasibility of various methods of storage and disposal and the economic, geogrpahic, and geologic-hydrologic aspects of waste-disposal siting in order to assure a practical approach, consistent with public-health, to the development of general EPA policy, criteria, and regulations.

Phase II of the alternative program would concentrate mainly on applying radiation-health criteria to analyses of the defined problem areas and potential hazards of existing wastes and making recommendations to States and AEC toward solving these problems. In connection with future wastes from the development of nuclear power, the alternative program would concentrate on developing necessarily conservative general EPA policy, criteria, standards, and regulations concerned with public-health aspects of ideal or optimum methods of storage and disposal.

With the alternative program the general mission and responsibilities of EPA can be accomplished in terms of critical review, problem identification, and development of guidance, criteria, standards, and regulations. However, the alternative program will not permit the EPA to exert strong leadership in developing radiologically safe and economically practicable management and disposal practices.

MEASURES OF GOAL ATTAINMENT

Fiscal Year 1973

- Complete evaluations of Federal and State criteria and regulations for radioactive-waste disposal.

Fiscal Year 1974

- Complete inventories of existing waste-disposal facilities.
- Complete definitions of potential problems and hazards of existing sites.
- Complete EPA radiation-health criteria for various radionuclides.

Fiscal Year 1975

- Complete evaluations of the necessity for continuing interim storage for radioactive wastes.
- Develop EPA positions and recommendations for disposal at existing commercial sites and storage and disposal at AEC sites.

Fiscal Year 1976

- Complete EPA general policy, criteria, standards, and regulations concerning storage and disposal of radioactive wastes.
- Complete overall summary report and recommendations to Congress.

Fiscal Years 1977-1979

- Complete national repositories and determine ultimate fates of wastes and repositories.

NUCLEAR FUEL REPROCESSING

PROBLEM DESCRIPTION

The objective of this program is to fulfill the obligations of ORP/EPA set forth in Public Law 91-190 that is: (1) to mitigate the impact of the environmental radiation challenge by consideration of environmental, ecological, and social costs associated with nuclear fuel reprocessing plants; (2) to assist decision makers by indication of the costs and benefits of the various alternatives available for controlling any projected adverse impact associated with such plants.

Background

Uranium-235 is the only fissile material found in nature in sufficient quantities to be of practicable use. Naturally occurring uranium contains about 0.7% U-235 and approximately 99.2% U-238, a fertile material. Under neutron irradiation U-238 is transmuted to U-239 which subsequently decays by beta emission to Pu-239, a fissionable material. A second fertile material which is readily converted to a fissile material by neutron irradiation and beta decay is Th-232 from which U-233 is obtained.

A typical light water reactor is loaded with about 100 tonnes (long ton) of slightly enriched (2 to 4%) UO_2. Subsequent to long-term reactor operations, fissile materials are intimately mixed with the fission products; and must be chemically separated before they can be recycled. This separation process is known as fuel reprocessing.

Both U-233 and Pu-239 are candidates for breeder reactor fuels. Since they are not found naturally (their half-lives are relatively short compared to U-235), they must be produced by transmutation. Because they also fission under neutron irradiation, the reprocessing of spent nuclear fuel (or blanket material) is a necessary step in a breeder program.

A variety of processes were used in the past most of which performed satisfactorily for plutonium recovery. However, the fission product wastes were often left in a state unsuitable for solidification or other processing to facilitate waste management. The Purex process is currently used at all operating AEC and commercial facilities. The high level wastes are left in an acid solution and thus are amendable to solidification.

Three processing plants are currently operated by contractors for the AEC at Hanford, Idaho, and Savannah River. The commercial plant owned by Nuclear Fuel Services has operated since 1966. The Midwest Plant owned by G.E. and located near the Dresden nuclear power site is essentially completed and is in the final stages of the licensing process. A large commercial plant is under construction in Barnwell County, S.C. adjacent to the Savannah River Plant. A fourth commercial facility was originally planned for South Carolina and preliminary designs were completed. However, this plant was canceled due to lack of contracts with utilities. On the basis of projections of power requirements (nuclear-electric), it appears that the three commercial facilities in use or under construction will provide sufficient capacity for the next ten years.

Development work for reprocessing nuclear fuels is being conducted primarily at ORNL. Most of this work is oriented to the development of methods for High Temperature Gas Reactor (i.e., U-Th cycle) fuels. Idaho is also participating in this developmental work. Preliminary investigations for LMFBR spent fuel characteristics are also being conducted at ORNL. It appears that the LMFBR fuel can be processed using the same technology as is used in processing LWR fuels. The three fuel cycles have differing criticality problems, however, which mitigates against using identical processing operations and facilities.

Component Problems

The development and implementation of a publically acceptable administrative method for controlling any projected adverse impact associated with nuclear fuel reprocessing plants (present and future) constitutes a major problem to be solved by EPA.

Much public concern exists regarding the use of nuclear energy for public in general and opponents of nuclear power in particular, to believe any pronouncements of the AEC relative to the adequacy of their regulatory activities to prevent adverse environmental impacts. Since nuclear fuel reprocessing represents a major component of this endeavor, any policy which can provide control that will alleviate the concern will in turn contribute to avoidance of the projected energy shortage.

Fuel reprocessing plants are the main source of waste which comes from the nuclear industry. The quantity of radioactivity in the waste material represents 99.9% of the fission products which were in the spent fuel. Approximately 1 - 1/5% of the plutonium produced is found in the waste stream also, although it is expected that this level will be reduced to 0.5%. An example of the specific activities of the main fission products in LWR spent fuel elements for 90 and 150 days is presented in Table C-2.

Individual fuel reprocessing plants are being designed to process as much as 1500 metric tons/year with a total capacity of 1200, 3100 and 6700 metric tons per year projected as being required for the years 1975, 1980 and 1985 respectively.

This quantity of radioactivity greatly exceeds the total in the waste produced from all other sources. In view of these considerations and the relatively few number of plants that have been projected as being required to provide reprocessing capability, special waste management techniques are mandatory for such facilities in order to avoid adverse environmental impacts.

The radioactive pollutants that can be released from nuclear fuel reprocessing plants can be distributed both locally and worldwide. Although the worldwide health impact may be small relative to background; permitting the worldwide distribution of radioactive material can have impact on our foreign policy -- in much the same manner as atmospheric testing of nuclear explosives. This problem is compounded by the fact that the benefits associated with any planned releases accrue directly to the local and national population groups and only indirectly (or possibly not at all) to the worldwide population group.

The problem defined must be resolved for establishment of policy regarding siting, normal operation, and decommissioning. The parameters requiring consideration include the following:

TABLE C-2

PRODUCTION RATES OF THE MAIN FISSION PRODUCTS IN A LWR*

Isotope	Half-life	Radioactivity 90 days after discharge from LWR curies per tonne of fuel	Radioactivity 150 days after discharge from LWR curies per tonne of fuel
Tritium	12.3 years	6.98×10^{2}	6.92×10^{2}
Krypton 85	10.76 years	1.13×10^{4}	1.12×10^{4}
Strontium 89	51 days	2.14×10^{5}	9.6×10^{4}
Strontium 90	28 years	7.69×10^{4}	7.66×10^{4}
Yttrium 90	2.60 days	7.69×10^{4}	-
Zirconium 95	65 days	5.24×10^{5}	2.76×10^{5}
Niobium 95	35 dyas	8.69×10^{5}	5.18×10^{5}
Ruthenium 103	40 days	2.55×10^{5}	8.9×10^{4}
Ruthenium 106	1 year	4.59×10^{5}	4.1×10^{5}
Antimony 125	2 years	8.48×10^{3}	8.1×10^{3}
Iodine 131	8 days	3.81×10^{2}	2.1
Xenon 133	5.2 days	-	-
Caesium 136	13 days	5.10×10^{2}	2.08×10^{1}
Caesium 137	30 years	1.07×10^{5}	1.06×10^{5}
Barium 140	12.8 days	1.11×10^{4}	3.23×10^{2}
Lanthanum 140	1.6 days	1.28×10^{4}	-
Cerium 141	32.5 days	2.05×10^{5}	5.67×10^{4}
Cerium 144	285 days	8.92×10^{5}	7.7×10^{5}
Promethium 147	2.6 years	1.04×10^{5}	9.9×10^{4}

*LWR of about 1100 MWe; fuel 90 tonnes of enrichdd uranium; Burn-up 33,000 Mwd/t; specific power 30 Megawatts per tonne.

Accidents

Disposal

Occupational

Transportation

With the advent of the LMFBR and associated "energy parks," additional problem areas will include:

Fabrication - Plutonium

Operation - Plutonium

Operation - Uranium

Should the "energy park" concept be applied to LWR and HRGR fuel cycles, additional problem areas will include:

Fabrication - Uranium (includes Thorium cycle)

Scope

Present. The present situation may be described as one of slow but deliberate growth with a transfer of technology from the government to the private sector. The technology base is extensive and the documentation prolific, the latter peaking recently with the publication of ORNL-4451 (Siting of Fuel Reprocessing Plants and Waste Management Facilities) which address virtually all associated problem areas, but essentially begs the basic question of need for reprocessing in an absolute sense.

To date, only one commercial fuel reprocessing plant has been in operation and its experience has been limited to reprocessing of highly decayed spent fuel.

Based upon operating experience to date, two major categories may be delineated - effluents and facility operations. Regarding effluents the following is the norm at present:

- Uncontrolled release of long half-lived Kr-85 and H-3.
- Controlled release of long half-lived Co-60, Cs-134, Cs-137, and Sr-90, short half-lived Ru-106, and very long half-lived I-129 and actinides.
- Controlled release of other isotopes in virtually negligible amounts by comparison.

Because of the long cooling times of spent LWR fuel reprocessed commercially to date, little experience with relatively short half-lived I-131 effluent has been attained commercially. Thus, I-129 control technology has also suffered.

The major facility problems are associated with waste storage (not significant to date), accidents (none serious to date) and transportation (some significatn operational experience has been gained).

Future. Projections of the extent of future problems are weighted heavily by the LMFBR program. The LWR spent fuel reprocessing load is expected to peak throughout the 1990's, with a rapid decay after the introduction of the LMFBR. Many projections, however, appear to have underestimated the growth being experienced by the HTGR (U-Th cycle), the impetus for which comes primarily from private industry. Thorium processing poses somewhat different operational requirements and problems. An estimate of the total quantity requiring processing for the various cycles is presented in Figure C-11.

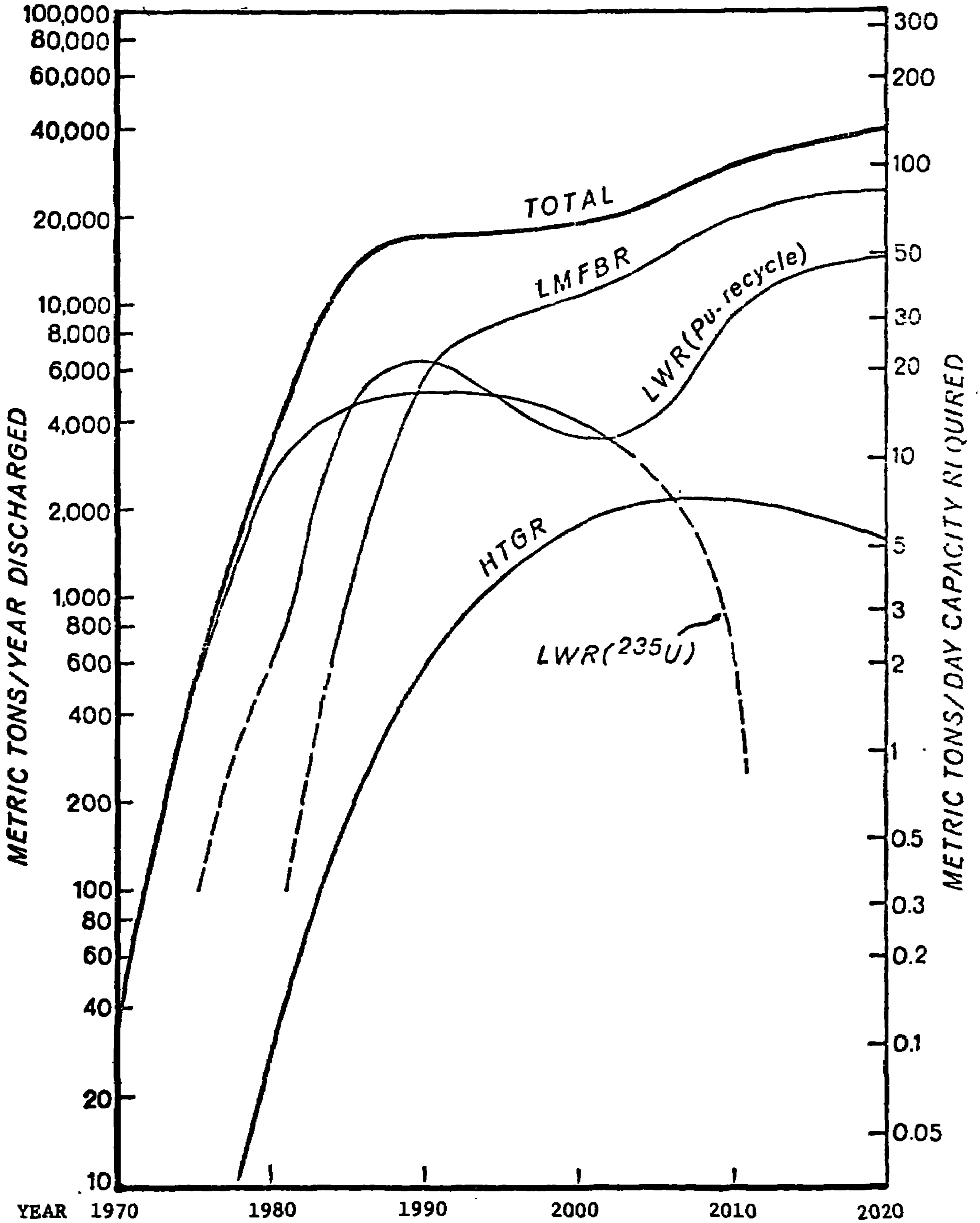


FIGURE C-11

U.S. FUEL DISCHARGES BY FUEL TYPE

In their proper time frame, then LWR (U) reprocessing problems will be most significant during the 1980-1995 period, HTGR (Th-U) during 1983-2000 and LMFBR (Pu) beginning in 1990 and continuing indefinitely.

Because of the 30 day recycling period projected (by economic considerations) for the Pu cycle, with higher burn-up fuel, the advent of the "energy park" will impose a several order of magnitude increase in all problems associated with this problem area. In particular, gaseous holdup tanks, presently the norm at PWR facilities, will be required in energy parks; the amount of radioactivity contained therein (about 1,000 times greater than at present) requiring underground tanks and posing a potential accident problem.

Certain general predictions regarding management of hazardous waste can be made as follows:

- In general, by 1985 the off-site "disperse and dilute" disposal method will be virtually obsolete and on-site "contain and control" will reign.
- Solid and liquid wastes will probably be stored above ground, awaiting a solution to the problem of ultimate disposal.
- Decontamination factors for iodine will still not be quite satisfactory to purists (10^{-8} is rather small).
- Energy parks, "criticality," fire, siting, transportation, fuel cycle (Pu, Th, fusion, solar) tradeoffs, off-shore reprocessing and deep-sea burial, and "accidents" will reign as the major problems.

LEGISLATIVE STATUS

EPA has authority primarily to provide guidance, or set standards, but not enforcement authority. The statutory authority of EPA to advise the President on radiation matters affecting public health is derived through the transferred authority from the former Federal Radiation Council (FRC) (42 U.S. Code 2021h). In addition, the Reorganization Plan No. 3 of 1970 provided for EPA to assume the responsibilities for setting generally applicable environmental standards, which were formerly held by the Division of Radiation Protection Standards of the Atomic Energy Commission. Authority to protect the public health is derived by EPA from the Public Health Service Act. Possible authority to regulate radioactive materials may be derived through the implementation of the Clean Air Act or the Federal Water Pollution Control Act, although the legislative history of these acts casts some doubt upon the applicability of them to AEC regulated licensees and materials. Although EPA has no specific authority to set uranium mining radon daughter limits, the setting of these standards on the request of the Department of the Interior (Bureau of Mines) is an example of the general EPA policy of advising other Federal agencies with regard to radiation safety.

COORDINATION

Interagency

Since all fuel reprocessing plants, commercial and governmental, are regulated by the AEC, a majority of interagency activity will be with that particular agency. It is anticipated that interactions with other governmental agencies will be required to a lesser extent with regard to specific topics as follows:

- Federal Power Commission - Energy Requirements and Projections.
- Department of Commerce - Fuel Cycle and Waste Control Economics, industrial standards, etc.
- Department of Labor - Occupational Safety.
- Department of Defense - Safeguards and security.
- Department of Transportation - Transportation of Hazardous materials.
- Department of State - International implications of Kr and H-3 dispersal.
- Health, Education, and Welfare - Biological risk assessment methodology, demographic data.
- NOAA - Air transport and dispersal mechanisms and meteorological information.
- Department of the Interior - Geological, seismologies and natural resource information.
- CEQ - Environmental Impact Statements.

Intragency

The tasks outlined previously will require intragency interactions as follows:

- ORM - Technique development, model development and data accumulation re-multiobjective decision making procedures, transport and dispersal mechanisms, reduction in uncertainties in risk assessment, compliance assessment instrumentation, determination of value judgment for different target groups.

- OCP/OSW - Hazardous materials disposal sites.
- OPM/OPE - Promulgation of rules, economic analyses guidelines.
- OAW - Constraints for non-radiological pollutants.
- OGC - Legislative authority requirements.

ALTERNATIVE APPROACHES

Two major alternative approaches are available for EPA to achieve its obligations with respect to control of adverse environmental impact from radiation facilities -- specifically in this case from nuclear fuel reprocessing plants.

EPA/ORP may assume a passive role in which its programs in the subject area are dictated essentially by inquiries from governmental agencies, the public, intervenors and other institutions. This approach suffers from the fact that the priorities are essentially established from without the office; the office is continually under pressure to supply answers to inquiries, and there is no overall strategy. This inefficient approach is rejected in favor of the other major approach. This second alternative to generate an overall program, such that those technical and administrative problem which are common elements in the overall list of problems may receive sufficient emphasis to be resolved effectively. In this case the overall program is active, the problems are self-initiated in advance of external inquiry. In this case, priorities can be more easily controlled and resources used more effectively.

OPTIMUM PROGRAM

Any program to resolve the problems associated with nuclear fuel reprocessing is necessarily cyclic in that it must incorporate a method which allows for introduction of technological advances and an updating of management techniques.

The Optimum Program should address the following questions:

- What are the electrical energy (power) requirements for both the short-term and long-term and what fraction of these requirements will be met through nuclear (fission) systems?
- For each of the fuel cycles under consideration, under what conditions can fuel reprocessing be justified when viewed with respect to the overall environmental impact?
- What are the protective action guides (levels and methods) for both normal and abnormal operations for each of the fuel cycles as a function of time?
- What are the appropriate criteria for siting, operation, and decommissioning for each fuel cycle?
- What is the most appropriate control technique and compliance assessment procedure for each fuel cycle?

The program can be divided into the following functional elements:

- Criteria development.
- Procedures (Techniques) development.

- Data accumulation.
- Technology Assessment (Evaluation).
- Multiobjective decision making (Policy).
- Decision Implementation (Rulemaking activity and Compliance assessment).
- Program management (Planning, Interfacing, Reports, etc.).

A program flow logic for the major decisions regarding siting, operations, and decommissioning is displayed in Figure C-12.

External Needs

Legislative Needs

Some form of legislation is required to provide EPA with either the authority to license and regulate specific facilities which may give rise to adverse environmental impacts or the authority to regulate other agencies and institutions which control the specific facilities.

Knowledge Needs

Knowledge, including a mechanism for its timely provision, is required from various agencies external to ORP. The needs include:

- A definitive listing of the independent objectives of EPA and the value functions for each of the stated objectives.
- Power projections for specific nuclear fuel cycles.
- The status of development of new separation technology for LMFBR and HTGR systems.
- The status of the development of new effluent control technology for iodine, volatiles, tritium, and the noble gases.

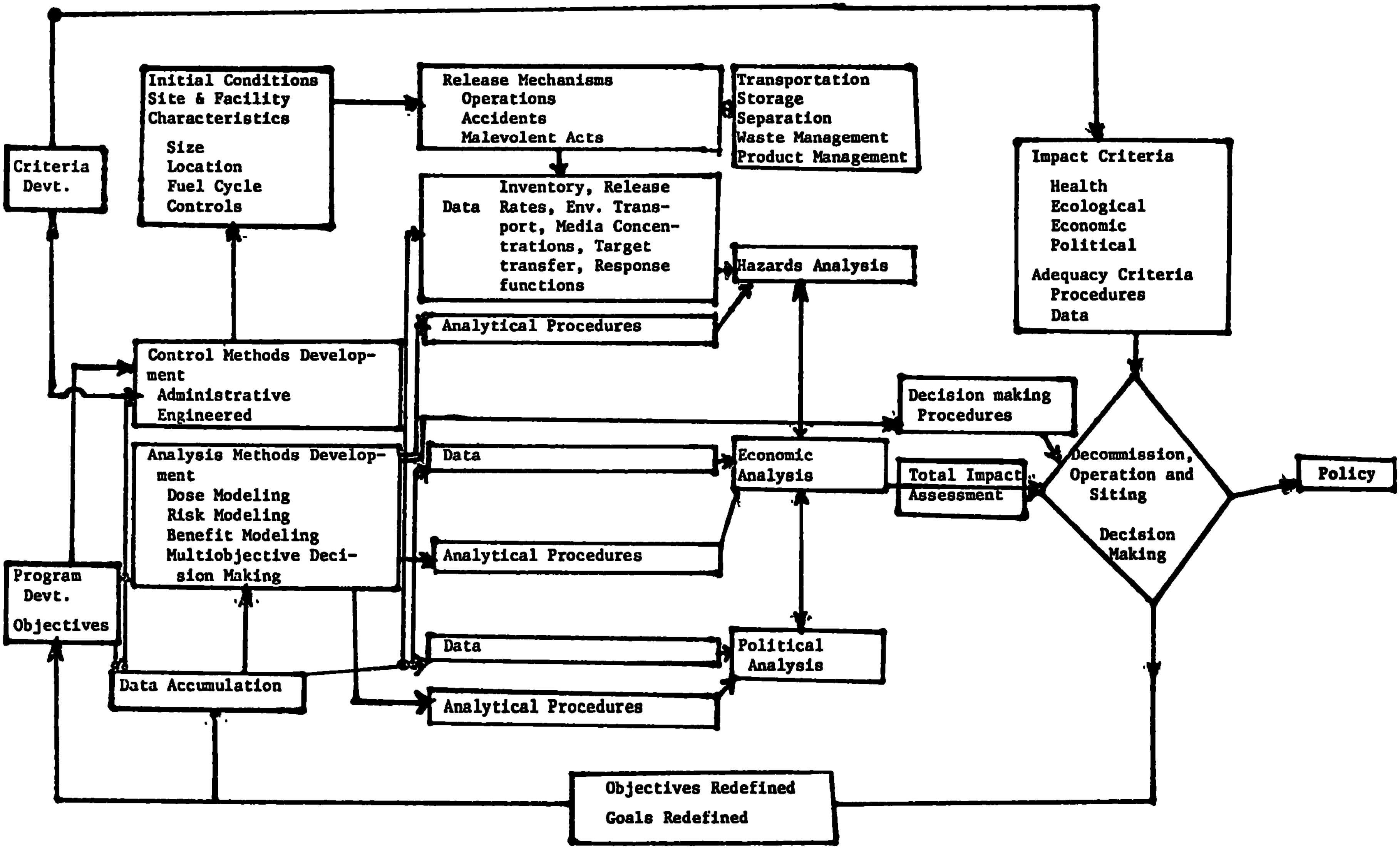


FIGURE C-12

PROGRAM FLOW LOGIC - FUEL REPROCESSING

- The status of the development of waste disposal technology.
- The status of radiological health effects studies specifically for long-term low level exposures.
- Operational characteristics and release rate data for specific facilities of interest (both governmental and commercial).

Research and Development Needs

EPA Research and Development program needs include:

- Development of a decision making methodology (risk/cost/benefit analysis).
- Determination of value judgments regarding public health, ecology, and economics as viewed by public, industrial and governmental population groups to provide basis for impact criteria.
- Development of an understanding of multiple stress health effects.
- Development of environmental transport parameters, media concentration factors, and intake/exposure parameters.

Enforcement Needs

Enforcement needs requires the development of enforcement methodology consistent with authority.

Internal (ORP) Needs

The knowledge methodologies and data required within the office in order to fulfill the objectives of the ideal program include the following:

- Analysis models to assess risks/costs/benefits, i.e., inventories, environmental transport, media-target interactions, target response models.
- Monitoring surveillance methodology.
- Acceptable impact criteria for health, economics, ecology, and policy for populations and individuals.
- Detailed fuel cycle economics.
- Details of engineered controls regarding decontamination factors (release rates), reliability and costs.
- Sensitivity of siting criteria to size, operations, accidents, transportation, configuration (i.e., energy park concept).
- Spent fuel projections and inventories for the various fuel cycles.
- Isotope specific risk indices with emphasis on I, H-3, Kr, alpha emitters and volatiles.
- Site specific demography.
- Influence of ultimate waste disposal strategy and techniques on fuel reprocessing facilities.

Milestone Chart

The milestone chart for the Optimum Program is displayed in Figure C-13. The dates for deliverable items is predicted on the assumption that the siting criteria for facilities which process LMFBR fuel should be available at least 10 years before the facility becomes operational. This assumption presumes that the energy park concept

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will be applied to such facilities. For facilities not utilizing the energy park concept, a 5-year lead time is assumed to be sufficient.

PROPOSED PROGRAM AND COMPARISON WITH OPTIMUM PROGRAM

The Proposed Program differs from the Optimum Program in that the method proposed to administratively control the adverse environmental impact is through: (1) constant review and critique regarding the adequacy of the licensing and regulating agency's specific administrative control methods through FRC authority by comparison to EPA criteria, guidance, and/or standards; (2) the use of the critique of environmental impact statements; and (3) providing technical capability to evaluate objectively a point of contention that may arise between opponents and proponents of a given endeavor.

In this case, there is no longer a need for further legislation nor increase in enforcement capability. The interagency agreements are still required as are all of the knowledge and R&D efforts described previously, however.

MEASURES OF GOAL ATTAINMENT

The anticipated accomplishment is that EPA will influence the control methods (both administrative and engineered) for nuclear fuel reprocessing plants while simultaneously building credibility for objectivity in the view of both the proponents and opponents. Goal attainment can be measured by the frequency and lapse time with which EPA policy recommendations are incorporated into the positions regulating agency and the intervenors.

THERMONUCLEAR

PROBLEM DESCRIPTION

It is possible that towards the end of the 20th century thermonuclear power (TNP) will be in use as a source of electrical energy. The purpose of this program is to develop a system for estimating the environmental impact of TNP so that meaningful decisions can be made regarding its introduction into the energy economy.

The program presented below has two main objectives:

- to establish a time frame for EPA actions in this area of environmental protection responsibility, and
- to establish a means of monitoring present TNP safety and health risk evaluation programs so that potential problem areas can be identified in a timely manner.

Technical Background

A nuclear reaction which combines atoms of low atomic number, such as hydrogen isotopes, to yield atoms of higher atomic number like helium is known as nuclear fusion. Many such reactions have been identified and several are highly exothermic. For various technical reasons the particular process most likely to be used initially for the production of TNP is the deuterium-tritium reaction.

$$^{2}D + {}^{3}T \longrightarrow {}^{4}He \text{ (3.5 MeV)} + {}^{1}n \text{ (14.1) MeV.}$$

Because tritium is needed as fuel, all proposed thermonuclear systems are tritium breeders utilizing 14.1 MeV neutrons; the most promising breeding reaction being

$$^{1}n + {}^{3}T \longrightarrow {}^{4}He + {}^{3}T.$$

Predicted tritium breeding ratios are high (1.3) and fuel doubling times may be as low as one-tenth of a year. Consequently the radiological hazards associated with TNP are centered around accidental and routine losses of the tritium inventory within a large fusion reactor and with the activation products produced in reactor components by the fast neutrons.

Choice of the particular fusion reaction chosen for TNP is limited by plasma density, the temperature and confinement times needed to start an exothermic process; the D – T reaction having the most favorable conditions for initiation. Other possible reactions such as the D – D and the D – ^{3}He reactions are much further from practical application but are of environmental interest in that not only is neutron activation considerably reduced but also most of the energy is available as charged particles. This latter feature could lead to direct conversion to electrical energy at very high thermal efficiencies and a reduction in the thermal load to the environment. It seems likely, however, that if TNP is introduced as an energy source at least one generation of D – T reactors will be built. The problem analysis presented here is directed at the expected environmental impact from first generation plants using a D – T cycle. Other fuel cycles which may be used in the future will occur much later and present lesser problems.

Present Problems

Not only is there no present environmental problem from TNP, it is even conceivable that there never will be. Exothermic steady-state fusion has not been demonstrated and the costs of TNP as a competitive energy resource have not been established. Indeed there is a school of thought that TNP implementation much later than the year 2000 will never be economically feasible because of predicted technological improvements in fission breeders. It is probable, however, that a decision to use TNP will depend in part on environmental considerations. A plan for developing the necessary information on a timely basis if presented below.

Notwithstanding the possibility that fusion power may never be an important energy resource, it would seem prudent for EPA to assume that TNP is a likely option for fulfilling the national energy needs and to prepare plans that will allow the environmental impact to TNP to be explored before final commitments for large scale utilization are made. It is noted that such a before the fact consideration of environmental impact is a rather unique opportunity for EPA. Hopefully, it can also be a prototype problem for developing skills in preventing detrimental environmental impacts rather than cleaning up after them.

Future Problems

The most likely sources of pollution from TNP are very large electrical power plants. (The possibility of distributed sources is less likely and will be considered in a separate section.) Present thinking is that, to be economically viable, a TNP plant would need to produce 2000 MWe in a single unit. The possible impacts considered below are based on a plant of this projected capacity. Such a plant would contain about ten kilograms of tritium of which only a few grams at most would be in the plasma state, the rest would be circulating in the tritium recovery apparatus or be held up in the walls of the various components. Ten kilograms of tritium corresponds to about 10^8 curies. The ORNL is currently predicting (for planning purposes), a tritium inventory loss of one part per million per day (100 Ci/day) but this projection is based on environmental considerations rather than available technology. At heavy water reactors where there is a large economic incentive to conserve D_2O, the inventory losses are about 60 times larger (60×10^{-6} parts per day) but it is best not to put too fine a point on this difference since in actuality, tritium confinement will depend in part on the configuration of fusion reactor and tritium recovery systems not yet invented.

A secondary source of possible radiological hazard from TNP is from the induced radioactivity in reactor components due to 14.1 MeV neutrons. Metallurgical problems due to the anticipated flux of fast neutrons are quite severe and it is anticipated many highly radioactive components will need to be replaced throughout the lifetime of a fusion reactor. Indeed, selection of component materials will probably be determined by their lattice stability under neutron bombardment. In any event, there will be a waste disposal problem associated with reactor parts. The magnitude of this problem will depend on the final selection of reactor materials. Niobium and vanadium are materials presently being considered but these choices are too tentative to warrant a discussion at this time of any specific health implications.

Tritium production figures for a TNP powered world can be pretty impressive since fusion does produce about 2×10^4 more tritium atoms than fission (for an equal energy increment). However, fusion also consumes tritium atoms so that a proper measure or its environmental impact is the amount of tritium liberated into the environment. Long-term storage of high level T_2O need not be a problem because if the breeding ratio of a fusion reactor is reduced to less than 1, the fusion process can be used as a tritium waste disposal mechanism.* It will probably be necessary, at first, to breed tritium in fission reactors to provide the tritium for fusion reactor start up. If an economically viable means of concentrating tritiated wastes can be found, these wastes could be an alternate source of the needed tritium. Any plans for tritium recovery in fission fuel reprocessing should consider the possible economic incentives offered by a future TNP program.

Tritium produced by a fission power plant enters the environment at two locations, near the reactor site and, with presently approved practices, in the vicinity of the furl reprocessing plant. While a PWR plant releases more tritium at the reactor site than a comparable boiling water reactor, in either case most of the tritium is released at the fuel reprocessing site, as shown in Table C-3. Fast fission of plutonium (in breeder reactors) has a higher tritium yield than the thermal fission of uranium as presently used in light-water reactors. Indeed, per Gigawatt-year of energy, fusion and fast fission breeder reactors could release about the same amount of tritium into the environment if

*Because fusion reactors are such a copious source of fast neutrons they have been considered as a means of converting some long half life fission wastes to short half life isotopes by transmutation (ANS Trans. Vol. 15, #1). The projected economic/power costs are rather severe but it is something ORP/EPA could bear in mind.

TABLE C-3

TRITIUM IMPACT FOR ONE GIGAWATT YEAR ELECTRIC

Slow Fission[1]		
PWR	5.0 Ci	at reactor site
LWR	0.5 Ci	at reactor site
Fuel Reprocessing	18.0×10^3 Ci	at reprocessing site
Fast Fission[2]		
LMFBR	----	at reactor site
Fuel Reprocessing	29×10^3 Ci	at reprocessing site
Fusion[2,3]	18×10^3 Ci	at reactor site

---

[1] Assumed thermal efficiency 0.3.

[2] Assumed thermal efficiency 0.4.

[3] Assumed T release fraction 10^6/day

tritium containment in fusion reactors is held to 10^{-6} as predicted by ORNL, Table C-3.

Future power needs on the time scale of interest in a discussion of TNP are not well known and may be subject to more societal control than presently predicted by exponential growth curves. There is some agreement that if TNP is introduced the earliest this could occur is sometime around the year 2000. Taking 2000 as a starting point for a discussion of possible levels of tritium contamination in the Earth's hydrosphere, the total tritium inventory at that time will be about 700 MCi. About 300 MCi of this tritium radioactivity is due to past weapons tests and cosmic ray production and (assuming no tritium recovery in fuel reprocessing) about 400 MCi from fission generated electrical power, (2×10^3 Gwatts per year). If this amount of fission generated electrical power were replaced by TNP the amount of tritium generated and consumed by fusion reactors would be 8×10^5 MCi per year. The tritium inventory in these fusion reactors might be something like 4×10^4 MCi, of which about 150 MCi per year will be added to the environment. Any future growth in generating capacity using TNP will increase environmental tritium inventories by 75 MCi for each 1000 Gwatt years.

Though fusion reactors are usually thought of as some sort of "plasma" machine containing an ionized gas of reacting atoms, there is some discussion of a fusion reactor which depends on a sharply focused laser beam to "ignite" a solid pellet of deuterium and hydrogen. Perfection of such a process might make it possible to reduce the scale of TNP plants by several orders of magnitude if the explosion containment problems are also adequately solved. Laser "fired" fusion plants utilizing such technology might be as small as 20 M Watt; i.e., about one-third the size of a pre-1945 fossil fuel plant. Development of small TNP sources would have both good and bad environmental effects. Though the control problem for tritium release would no doubt be more difficult, the total environmental impact from electrical power generation might be reduced greatly. It is often mistakenly assumed that the thermal pollution problems associated with electrical energy production started with fission. Rather, fission made the introduction of very large scale fission and fossil plants economically advantageous. The net result is we are faced with meeting future energy needs with large point sources of thermal pollution where formerly the thermal impact of "old fashioned" fossil plant was comparatively minor. Introduction of small TNP reactors might allow the heat load on the environment to be spread out. If siting problems can be solved it would also allow on-site production of electrical energy and heat with a resultant saving in energy transmission losses.

Though the possibilities outlined above are intriguing, it would seem advisable to limit (at this time) exploration of the environmental problems from a distributed source power system utilizing small TNP reactors. A first generation of large TNP breeders will be needed to produce the tritium fuel for smaller TNP sources. We can also assume that any early fusion plants will be costly because of developmental and safety costs; and consequently rather large so as to reduce the investment per unit of electrical production. Finally, the widespread application of small TNP units is an improbable development, perhaps two orders of magnitude less likely than TNP per se. In any event, many of the radiological studies for large plants would be directly applicable to small plants as well; only the size of the source term changes.

The predicted tritium inventory and rate of tritium release from possible fusion reactors given above are certainly no better than order ofmagnitude estimates at this early stage of hazard analysis. They do serve, however, to give a scale to the problem which perhaps allows a tentative opinion. The environmental impact from tritium due to an energy economy based on TNP would be of the same order of magnitude as that from one using nuclear fission. Other radiological impacts would, of course, be much less. There would be no fission products. There would be no waste storage problem of plutonium and other long half life biologically important isotopes, such as I-129.

Perhaps most important of all, the catastrophic accident problem is largely removed by the use of TNP. Not only is the potential energy in the amount of the fuel (2 grams) being "burned" at any one time in a fusion reactor rather small, about 10^{12} joules compared to that in an LMFBR (10^{19} joules) but also the physical requirements for fusion to occur are difficult to maintain. Accidents in a fusion reactor which perturb the carefully maintained physical conditions within the plasma will terminate the fusion process. The control problem is not how to shut the thing off but how to keep it going. Fast breeders have a different set of problems.

LEGISLATIVE STATUS

TNP would effect the general environmental levels of radioactivity and therefore are under the general guidance and standard setting responsibilities of EPA. Considering the time frame for TNP implementation it is perhaps unrealistic to discuss any specific legal implications of TNP in terms of the agency's present legislative status. Rather in the program plans presented below, suggestions are offered on how new legislative actions might be coordinated with programmatic requirements.

COORDINATION

Interagency

Interagency requirements for an effective coordination of the proposed TNP hazard evaluation plan are listed in Table C-4. The laser-fusion program is currently budgeted under the AEC weapons development programs and coordination with DOD is indicated. However, the expectation is that if this line of research shows potential for TNP development, part of it will be split out of the weapons program. Currently the proposed AEC budget (FY 1973) for fusion research and development is $39 million for magnetic confinement studies with an additional $20 million in the weapons budget for laser related fusion studies. Direct DOD financing of high powered laser research, an unknown fraction of which is related to fusion problems, was $100 million in FY 1972.

Intragency

Intragency coordination requirements are two-fold. Within ORP, the problem areas associated with Plowshare, fuel reprocessing and to a certain extent waste disposal, are related to the evaluation of possible TNP hazards. The Plowshare evaluation program, where tritium dose models and health risk from environmental tritium must be considered in detail,

TABLE C-4

SHORT RANGE COORDINATION

INTERAGENCY	ORP/EPA INTRAGENCY
AEC HQ	ORP PROBLEM AREAS
DOD LASER TNP	PLOWSHARE - TRITIUM DOSE MODELS AND HEALTH RISK
AEC LABS	
ORNL	WASTE DISPOSAL FUEL REPROCESSING
LIVERMORE	
LOS ALAMOS	EPA
PRINCETON	OFFICE OF RESEARCH AND MONITORING WATER QUALITY OFFICE

is particularly relevant. It is assumed that the various ORP divisions will contribute to an evaluation of TNP environmental studies via the problem area route rather than by means of specific line responsibilities.

Eventually any large TNP operations will have impact on water quality and ORP efforts in preserving water quality will be coordinated with that EPA office. Of more immediate interest are any ORM studies, present and future, that are concerned with tritium distribution in the environment, its possible reconcentration, and health impact. Such studies must be coordinated with TNP requirements as outlined in Table C-4.

ALTERNATIVE APPROACHES

In terms of alternative approaches to potential TNP environmental problems, EPA/ORP has two options. One is to wait five or ten years to see if exothermic fusion is demonstrated in the laboratory. The other is the establishment of a program now that will monitor ongoing health and safety studies of TNP being performed by other agencies and, most important, prepare plans that will allow the timely implementation of EPA directed studies and regulations as TNP research progresses. A plan outlining the second approach is given in the next section. At first glance a "wait and see" policy has at least cheapness to recommend it. However, it is likely that this cost advantage would be wiped out in any rapid start-up of a TNP program by staff personnel not familiar with TNP problems. The approach outlined below will insure that EPA/ORP will have at least some expertise on TNP health implications on call at any time.

A "wait and see" approach also nullifies the impact a study of TNP will have on other problem areas. As pointed out in the section on coordination, study of the potential release of tritium into the environment is common to a number of problem areas.. The information on the health risk from tritium and the devleopment of good tritium pathways and distribution models obtained in this study can be invaluable inputs to a number of identified environmental problems.

It should be noted that no optimum program is proposed. The proposed program is also the optimum program at this early stage of TNP development. The proposed program has built into it a means of reappraising the scope of EPA/ ORP needs as research on TNP progresses.

PROPOSED PROGRAM

A study of environmental TNP problems must be future oriented which leads to the attendent difficulty that technological innovations cannot be predicted with much precision. Therefore, a plan for the study of TNP environmental problems needs a degree of flexibility not typilfied by other ORP problem areas. Rather than just describing work areas and needs in this problem area, a time frame for EPA actions is presented in Table C-5, and then more specific needs are discussed in the context of the milestone charts, Figure C-14.

A time scale for the study of thermonuclear power helps establish priorities for EPA/ORP reactions to this environmental challenge. The dates presented in Table C-5 are neither projections nor speculations of when actual events might occur. Rather they have been postulated to

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TABLE C-5

A HYPOTHETICAL CHRONOLOGY FOR TNP DEVELOPMENT

TIME SCALE (Fiscal Years)	TECHNOLOGICAL EVENTS OCCURRING IN THIS INTERVAL
1973 - 1975	Plasma Confinement Research
1976 - 1980	Laboratory Fusion
1981 - 1985	Fusion Reactor Development
1986 - 1990	Prototype Reactors are Built and Tested
1991 - 1995	First Generation Full Scale Reactors are Planned and Constructed
1996 - 2000	Thermonuclear Electric Power on a Commercial Scale

provide some idea of the sequence of events and what the interval between subsequent events might be. The listed dates should be regarded as gates. When a significant event occurs in TNP technology this will initiate certain actions and activities within EPA/ORP so that progress in the solution of TNP environmental problems will coincide with the implementation of TNP into the national energy economy. The sequence of events shown in Table C-5 represents an "optimistic" chronology in that these events are unlikely to be earlier and may occur as much as 5 to 10 years later. A long-range milestone chart showing how these events trigger EPA/ORP responses is given in Table C-6.

EPA Responses to Progress in TNP Implementation

The responses shown in the milestone chart, Table C-6, are triggered by the events shown in the technology row. Demonstration that sustained fusion is possible will start the development of prototype reactor systems. However, before such a program develops its own momentum, a decision on the applicability of TNP to national needs should be made. It is outside the bounds of this study to define what the national policy on energy regulation will be at that time. There may be a single Federal agency regulating all large energy sources or the multiple control system now used may be in force. Hopefully, some agency or group of agencies will be in a governing postiion to consider whether a TNP program should be initiated at all in view of the national energy needs, types of energy resources available, and the expected environmental impact of alternative energy sources. It can be expected that the "costing" of environmental detriments will be highly developed by the time TNP is

TABLE C-6

TIME SCALE FOR ORP/EPA ACTIONS

	FY 73-75	ENDING FY 80	FY 85	FY 90	FY 95	FY 2000
TECHNOLOGY DEVELOPMENT	PLASMA RESEARCH	FUSION IN LAB	PROTOTYPE REACTOR DEVELOPMENT	PILOT PLANT OPERATIONS	BUILD FIRST GENERATION FULL SCALE REACTORS	THERMONUCLEAR POWER
EPA RESPONSES	SEE TABLE C-7	APPROVAL AS ENERGY SOURCE AFTER COMPARISON WITH ALTERNATIVE SOURCES WRITE ENVIRONMENTAL STANDARDS FOR DEVELOPMENTAL AND LATER REACTOR TYPES ESTABLISH SITING CRITERIA REACTOR SEE IF LEGISLATIVE MANDATE IS NEEDED		SET FINAL 1) CRITERIA FOR SITING 2) REGULATIONS 3) WASTE STORAGE		MONITOR AND INSPECT TNP INSTALLATIONS PLAN FISION PLANT DECONTAMINATION AND DECOMMISSIONING

considered and that such hidden costs will be given full weight in any decision involving a choice between energy sources or the switch from one source of energy to another. It is mandatory that EPA/ORP be in a position to provide the necessary environmental impact information as needed as soon as a successful fusion system has been defined by the engineering community.

Assuming a TNP development program is initiated after due consideration of the EPA/ORP recommendations, it will be necessary to provide environmental standards for prototype TNP reactors. Rather than the piecemeal implementation being followed in the consideration of environmental impacts from LMFBR systems, a more global approach should be used for TNP. This should include setting interim guidelines for all future reactor developments such as permissible tritium losses, waste disposal regulations and siting criteria so that the development of TNP can take place within a framework that minimizes environmental problems. Consideration of legislative problems that may follow such an approach is outlined in a separate section.

After the monitoring of TNP pilot plant operations have established the relationship between predicted and actual releases and any unexpected problems have been recognized and evaluated, final criteria and regulations for TNP environmental effects should be set, as shown in Table C-6. This should occur before the full scale systems are designed and in the construction phase. Finally, EPA/ORP should consider the set of problems associated with the decommissioning of fission plants as they are replaced by TNP units.

A shorter range view of needed ORP/EPA actions is shown in Table C-7. The immediate need is for an information monitoring program to provide inputs into ORP/EPA judgments of the potential environmental effects from TNP. (It is contemplated that other ORP problem areas will be a position to furnish an evalution of fission power when the desirability of using fusion as national energy resource is considered.)

This short range plan has four major areas of effort. The most important at this time is to establish technical liaison with other researchers and safety groups working on TNP problems. Quite frankly it is more practical at this time for ORP to depend on other organizations for information, particularly the AEC, than to expend ORP resources on original research. Not only will such a passive approach economize on ORP resources but it is likely that the best information will come from these groups working directly with people responsible for the technical development of TNP.

Other activities in this time frame (Table C-7) include a review of presently available tritium dose models and biological effects information. Under dose models are included models for predicting the distribution of tritium in the environment from its point of release, pathways for human uptake, physical deposition of energy, and the calculation of total body and organ doses. Timely review of this material will allow ORP to project its research and information needs to ORM by the start of the FY 1974 planning cycle, Jan-Feb 1974.

The identification of problem areas will depend on the results obtained by monitoring other TNP safety programs. Several possible areas

TABLE C-7

TNP REVIEW AND EVALUATION FY 73-FY 75

	FY 73	FY 74	FY 75
Identify Safety Groups and Establish Working Relationship	by Dec. 72		continue
Review Tritium Dose Models[1]	Draft Jan. 73	continuous	update
Review Tritium Bio-Effects	Draft Jan. 73	continuous	update
Suggest Research to ORM	Feb. 73	Jan. 74	Jan. 75
Update Plan and Review Fusion Progress		Aug. 73	Aug. 74 → is plan still valid → Yes
Identify Likely Problems Tritium Leadage in Normal Operations Heat Load to the Environment Component Activation Siting Accidents Fission-Fusion Hybrids	machine dependent		No Review need for study. If needed start new plan based on newer estimates of TNP time frame.

[1]"Dose Models" to include dispersion, possible reconcentration, pathways, uptake models, etc.

have been recognized, Table C-7. The magnitude of all these problems is more machine dependent than generic and it is likely that most of the meaningful safety work in these areas, such as practical countermeasures, will be developed after the demonstration of practical TNP systems.

Included in the plan is a schedule for updating the plan and reviewing fusion research progress so that the "gates" identified in Table C-6 will be implemented as soon as possible.

External Needs

Legislative Needs

Any legislative needs can be deferred until sustained thermonuclear fusion is demonstrated. The suceeding 5 to 10 year interval for fusion reactor development is long enough to consider any new needs, such as regulatory authority in terms of the Agency's legislative mandate in the 1980's.

Information Needs

ORP/EPA needs to establish, in a formal manner, technical liaison with all TNP safety groups so that all copies of relevant reports are forwarded to this office and the problem area leader. Besides formal communication, some direct personal contact between team members and other persons working in this area should be established. The end point of this communications effort is to have ORP/EPA fully aware of new potential problem areas in TNP safety as they devleop, and access to current thinking on how the problems identified in Table C-7 may be solved.

Research & Development Needs

The basic and applied research required for an adequate assessment of the radiological hazards from thermonuclear power relate to the large postulated tritium inventories and the evaluation of potential releases of this radionuclide. The neutron activation products induced in plant construction materials will present a waste disposal problem but, as these products will generally be fixed in the materials and mainly consist of short-lived radionuclides (such as niobium-95), their potential introduction into the general environment has a low probability. Technology to shield against the high energy neutrons emitted by fusion process (D–T reaction) is already developed.

Tritium as a potentially serious environment contaminant is not unique to fusion power sources. It is produced in appreciable quantities by both fast and thermal fission of uranium and plutonium. Many of the general research requirements related to tritium dosimetry and environmental transport will also arise from consideration of nuclear gas stimulation (Plowshare) and fission power (both light-water and fast breeder operation, fuel reprocessing, and waste disposal). Within this framework, the general research needs relative to tritium transport, control technology, and dosimetry are:

- Development of models to predict world-wide mixing of tritium in the atmosphere and oceans, in particular the determination of the dilution capacity (effective mixing depth) of the oceans.
- Determination of the reaction kinetics for the exchange of tritium between the gaseous elemental form (HT), water, and biologically significant molecules.

- Validation of models for predicting the washout of atmospheric tritium (as HT or HTO) into surface waters.
- Development of compartmental models for predicting the intake, turnover, retention, and distribution of tritiated molecules in living organisms with particular reference to humans.
- Determination of applicable concentration factors for tritium uptake by aquatic and marine organisms.
- Determination of unique biological effects resulting from the incorporation of tritium into biologically active molecules such as proteins, carbohydrates and, most importantly, genetic materials such as deoxyribonucleic acid (DNA).
- Development of microdosimetric models to predict the effects of low-energy beta particle emission at cellular level and particularly sub-cellular levels.
- Development of tritium control technologies capable of removing tritium from gaseous hydrogen and from large quantities of water having low tritium concentrations (low specific activity wastes) without excessive economic penalties.
- Development of long-term storage and ultimate disposal techniques which will keep either tritiated gas or water excluded from interaction with the biosphere and concomitant research on ground water transport related to the safety of such methods.

The time scale for the research indicated above will for the most part be determined by needs in other problem areas (Plowshare, etc.). An area which requires further investigation and is not particularly germane to either fission power production or gas stimulation is tritium confinement and retention technology, particularly the diffusion of tritium through metals. Tritium in the gaseous form (HT or T_2) can diffuse quite readily through many metals. Because of the large tritium inventories in fusion reactor plants this phenomenon is of considerable importance. It is questionable whether EPA needs to pursue this research topic now, since it is being investigated by the AEC as part of the TNP development program. The AEC research program should be monitored to determine whether sufficient containment will be insured prior to the construction of any TNP demonstration plants.

Internal Needs

The program as outlined above places only modest requirements on ORP resources. For this very reason care should be taken that administration of the proposed program is delegated at a level high enough to insure that the fusion study is not lost in the press for time and resources to study more immediate problems.

About one man year of professional effort will be required to start the projected study. Effective technical liaison, and not just report collecting, will require 0.2 to 0.3 man-years. Evaluation of dose models, health risks and relevant EPA/ORM research will require an additional 0.5 man years. Some of this effort will of course be applicable to other problem areas such as Plowshare.

At least two and preferably three professionals should share the responsibility for this study. While this may be less efficient than centralizing the effort in one person, it insures that a single personnel transfer will not wipe out ORP capability. Some of this capability may be of more immediate use to EPA than outlined in the milestone charts. Inquiries, Congressional and otherwise, concerning potential TNP environmental problems can be expected at any time. ORP must, of course, be in a position to prepare adequate replies.

Divisional responsibility for this problem area does not present any difficulties. Either CSD or TAD could be the lead organization. More important is the active participation of each of these divisions in the implementation of an approved plan. The Field Operations Division will provide information on the applicability and adequacy of any tritium monitoring operations proposed for TNP assessments.

MEASURES OF GOAL ATTAINMENT

This program will accomplish the following:

- Provide a long range guide for EPA actions as various technological goals in the national TNP program are accomplished as shown in milestone chart - Figure C-14.
- Keep ORP/EPA on top of the progress made by other agencies in the identification and solution of TNP safety and environmental problems.
- Identify EPA research needs for ORM and other research groups.
- Familiarize the ORP/EPA staff with TNP and its related environmental impacts.

Identifiable indicators of goal attainment are of two types. The most important of these in the short run will be how well EPA/ORP will be prepared when the laboratory demonstration of sustained fusion initiates a national debate on the usefulness of rapidly introducing TNP. The environmental consequences of plutonium breeder energy economy are so great EPA should be able to lead such a debate. If it can't, this program has failed.

A more objective measure of goal attainment will be the degree of change in the amount of tritium in the environment if TNP is eventually introduced. It is anticipated that the concentration of tritium in the local environment around TNP installations will be energetically monitored. This will allow an objective evaluation of the effectiveness of equipment and control methods at specific installations. It will also test the adequacy of the models used to predict tritium release rates and transport coefficients. In the final analysis the degree to which environmental tritium problems are controlled will be the final measure of program success.

FABRICATION PLUTONIUM

PROBLEM DESCRIPTION

Component Problems

- Fuel Fabrication - the manufacture of plutonium reactor fuels for the LMFBR and LWR plutonium recycle reactors.
- Radioisotope Generators - the fabrication and use of plutonium radioisotope generators for space and terrestial heat sources.
- Nuclear Weapons and Use - the fabrication of nuclear weapons and their use for war or as nuclear explosives in Plowshare activities.
- Plutonium Recovery - plutonium scrap recovery facilities, waste treatment facilities for reclaiming, or storing plutonium*
- Inventory Control - the identification and inventory of uncontrolled quantities of plutonium in small sources.

Background

Environmental Problems

The fabrication of plutonium fuels for reactors, in addition to operation of Pu fueled reactors and fuel reprocessing plants, is expected to be a potential source of population and environmental radiation exposure. Long-term accumulation in the environment from small, continuous, or accidental releases is the likely source for inhaled, resuspended and inhaled, or ingested plutonium in people. For plutonium and other transuranic elements, the contamination will cause an indefinite commitment for the future because of the long half-life involved. Radiobioeffects

*Use and recovery of plutonium in nuclear fuels are discussed in problem areas Operation-Plutonium and Fuel Reprocessing.

from plutonium inhalation are controversial. The long-term accumulation and incorporation into other living organisms has been sparsely studied with little indication of the environmental insult within an ecosystem. As the uses of plutonium for reactor fuel and radioisotope generator heat source increase, the need for determining long-term health and environmental effects will become critical.

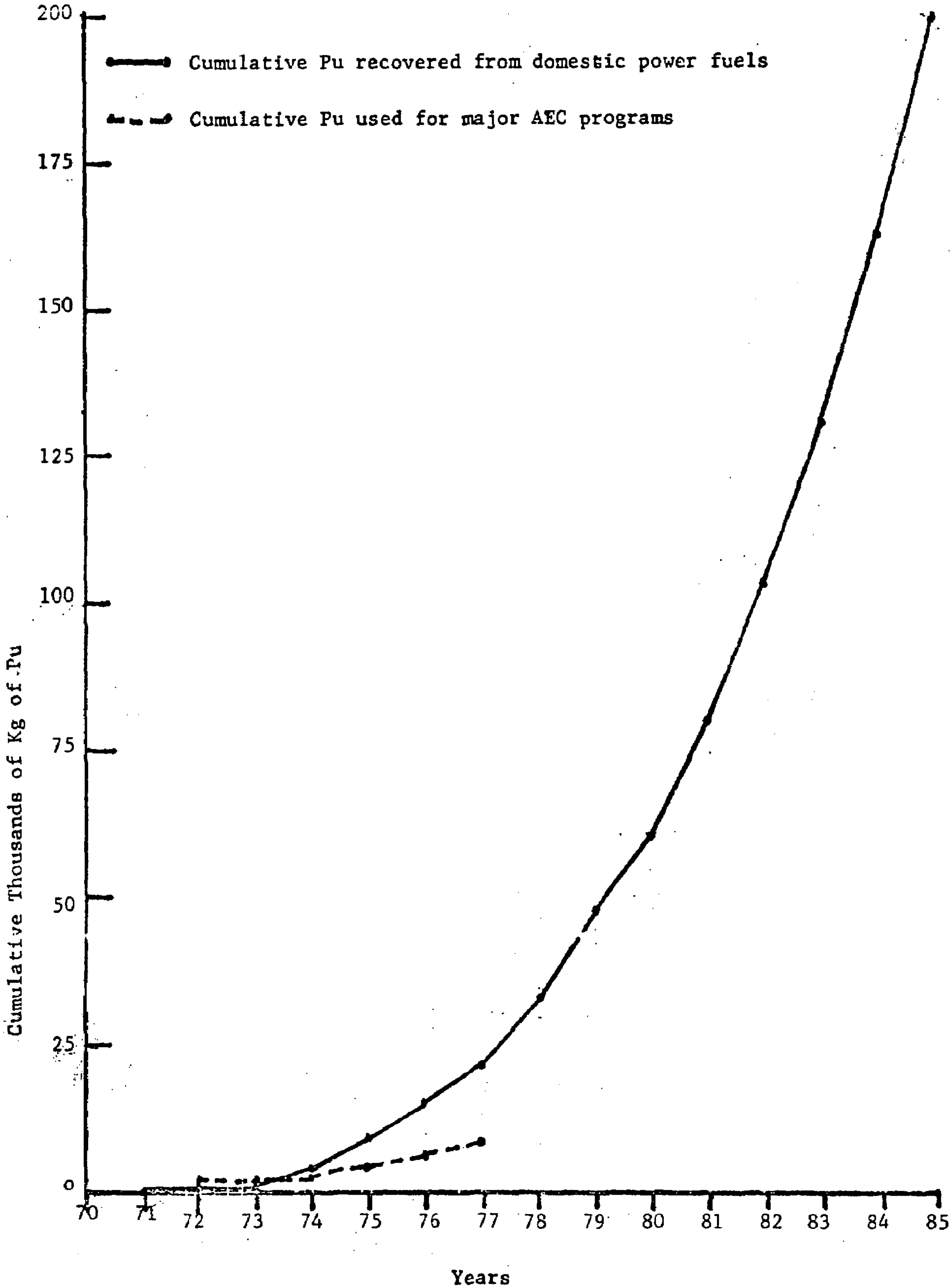
Potential Sources

The increased use of plutonium for reactor fuel will follow the development of Pu recycle in light-water reactors and development of the Liquid Metal Fast Breeder Reactor. The fabrication of plutonium fuels is mixed with fabrication of uranium fuels in most facilities. The source of Pu for the LMFBR and Pu recycle fuels is the conversion of U-238 in present light-water reactors. (See Figure C-15 and C-16). During fuel reprocessing the Pu is recovered along with uranium. The Pu as a nitrate or fluoride is converted to PuO_2, the powder pressed into pellets, sintered, milled, and the pellets loaded into fuel cladding tubes. The total time between discharge of spent fuel and use of the recovered plutonium and uranium in commercial operation of the reactor is estimated as two years.

Other Sources

Other potential sources of plutonium in the environment are plutonium scrap recovery plants, nuclear explosives and weapons manufacture, Pu-238 radioisotope generator fuel fabrication, and application of Pu-238 radioisotope generators as space and terrestial electric sources. The present levels of plutonium in the environment are from

FIGURE C-15
CUMULATIVE PLUTONIUM PRODUCTION WITHOUT Pu RECYCLE



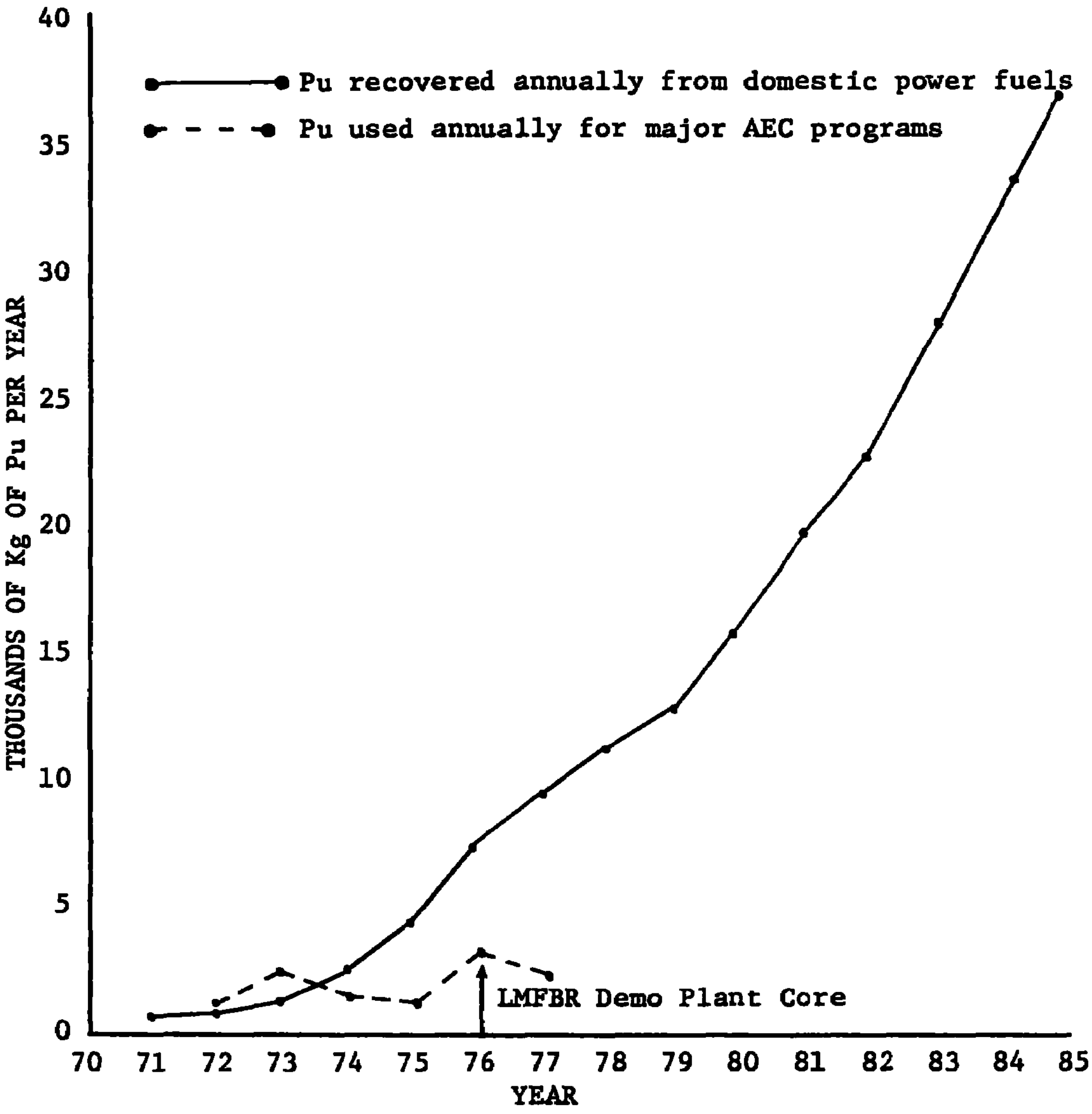


FIGURE C-16

PLUTONIUM PRODUCTION AND USE WITHOUT Pu RECYCLE accidental or routine releases from the above applications rather than from nuclear power plants. Nuclear device testing has deposited Pu-239 as fallout. In addition, an accidental burnup of a Pu-238 radioisotope generator has added Pu-238 to the ambient levels of radioactivity present in the environment. Pu-239 has also been released from the AEC's Rocky Flats Plant. (See Figure C-17.)

Relation to Other Program Areas

Present experience at plutonium facilities indicates accidents are a major source of environmental contamination. Other ORP plutonium problem areas in addition to accidents are waste disposal, fuel reprocessing, operation-plutonium operation-uranium, medical isotope (Pu-238 powered heart pacers), occupational radiation, device testing, fabrication of uranium, and transportation.

Inventory Control

Small sources of plutonium that are sold to AEC and Agreement State licensees and the small quantities that are not recovered in processing materials will be placed in radioactive wastes. A lower limit for handling the wastes as long half-life alpha emitting transuranic elements will be required.

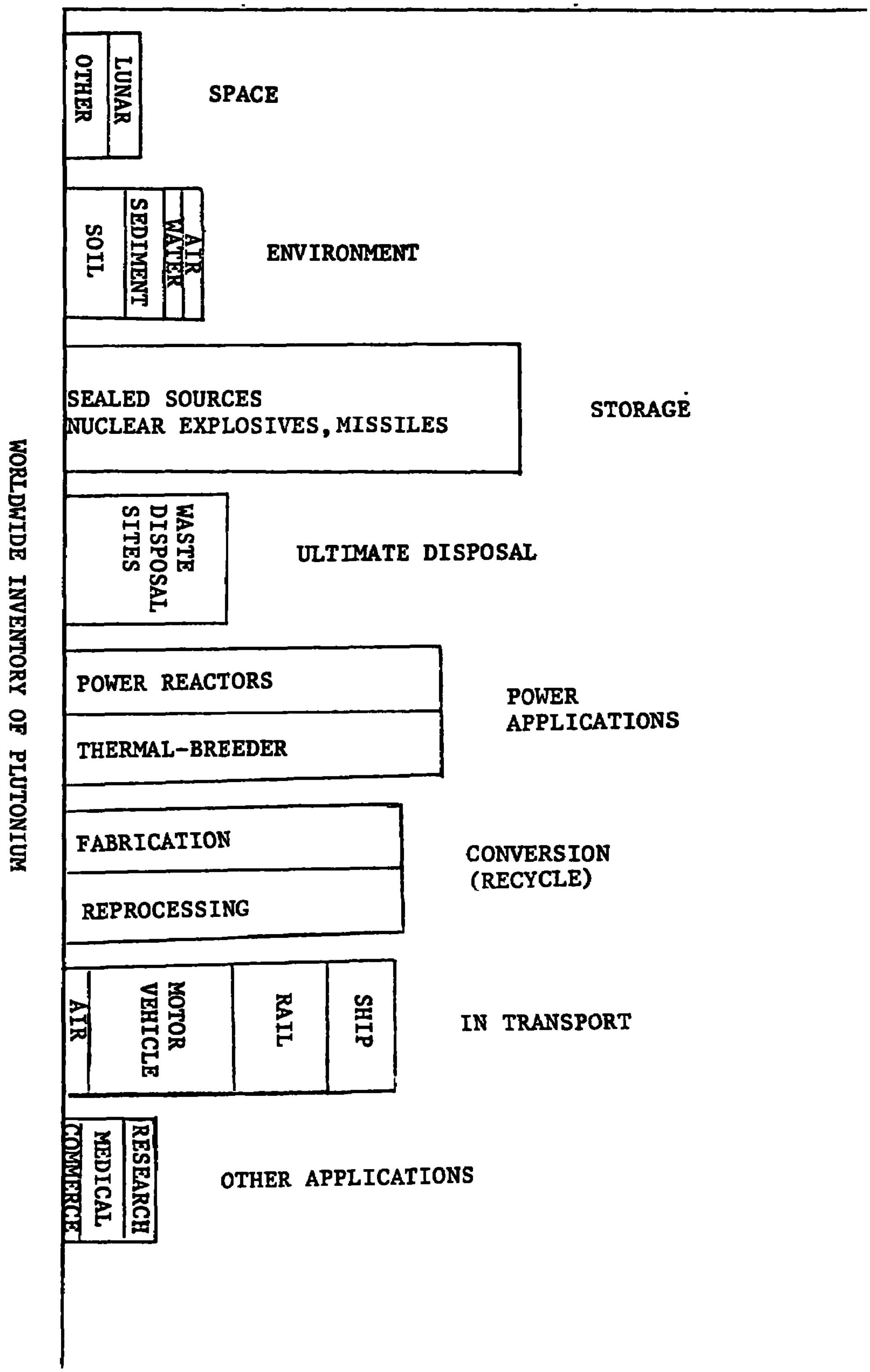
Scope

Present

The following table is a summary of data from The Nuclear Industry 1971 for plutonium reactor fuels capability.

FIGURE C-17

KILOGRAMS OF PLUTONIUM
(NOT COMPLETELY TO SCALE)



U.S. Commercial Capability

Type of Facility	No. of Facilities	EPA Regions
Pu Fuels Fabrication	8	II, III, IV, VI, IX, X
Pu Fuel R&D	9	I, II, III, IV, V, VI, IX, X
Cold Pu Scrap Recovery	3	III, IV, VI

In addition to the above facilities AEC contractor plutonium facilities at National laboratories are involved in handling plutonium for research, device manufacture, and radioisotope generator assembly.

The present level of environmental contamination by plutonium operations at Rocky Flats, Colorado has received a great deal of public attention. Because of disagreement between "experts," assessing the magnitude of the hazard to public health from environmental plutonium is difficult for Rocky Flats or other plutonium facilities.

Future

The future plutonium fabrication facilities in the U.S. would be expected to parallel the growth of the LMFBR and Pu recycle in light-water reactors. Expansion of existing uranium fabrication facilities to handle plutonium fuels and new plutonium facilities will be the means for meeting increased fabrication capacity. The anticipated plutonium requirements for the Fast Flux Test Facility (FFTF) and the first LMFBR are not expected to use the total Pu produced in the light-water reactors. In 1976, the plutonium requirements for the FFTF, LMFBR fuels research, and the LMFBR demonstration plant fuel total 2,450 Kg of plutonium. Without Pu recycle the plutonium recovered from domestic power reactor fuels for 1976 is projected as 6,400 Kg. The remaining plutonium would be expected to be used for Pu recycle in light-water reactors.

Other plutonium facilities for utilization of Pu-238 for radioisotope generators for space and medical applications will be expanded, but will be smaller in number.

LEGISLATIVE STATUS

ORP has no specific legislative authroity at present, but has general authority from transfer of the Federal Radiation Council functions and environmental radiation level standard setting function transferred from the AEC. General functions assumed from DHEW allow research monitoring, data interpretation, data publication, assistance to states, training, and public information activities.

COORDINATION

Interagency

Since all plutonium facilities, commercial and governmental, are regulated by the AEC, a majority of interagency activity will be with that particular agency. It is anticipated that interactions with other governmental agencies will be required to a lesser extent with regard to specific topics as follows:

- Federal Power Commission - Energy Requirements and Projections.
- Department of Commerce - Fuel Cycle and Waste Control Economics, industrial standards, etc.

- Department of Labor - Occupational Safety.
- Department of Defense - Safeguards, Security, and devices. Example: Air Force - Broken Arrow emergency assistance.
- Department of Transportation - Transportation of hazardous materials.
- Department of State - International implications of Pu dispersal from accidents. (device dispersal in plane crash.)
- Health, Education, and Welfare - Biological risk assessment methodology - demographic data.
- National Oceanic and Atmospheric Administration - Air transport and dispersal mechanisms and meteorologial information.
- Department of the Interior - Geological, seismologies, and natural resource information.
- Council on Environmental Quality - Environmental Impact Statements.

<u>Intragency</u>

The tasks outlined previously will require intragency interactions as follows:

- ORM - Technique development, transport and dispersal mechanisms, reduction in uncertainties in risk assessment, environmental radiation assessment instrumentation, determination of value judgment for indifferent target groups.
- OCP/OSW - Hazardous materials disposal sites.
- OCP/OTS - Associated Toxic materials.

- OPM/OPE - Promulgation of rules, economic analyses guidelines.

ALTERNATIVE APPROACHES

Identification of Alternatives

First Alternative

A minimum EPA program which monitors AEC work and suggests additions without active participation except approval.

Second Alternative

A maximum EPA program which is completely independent of AEC.

Third Alternative

A carefully coordinated program in which EPA and AEC work together for optimum information development, exchange and minimize duplication of effort.

The third alternative is the optimum from the standpoint of the development of ORP and EPA expertise and needed information. Since the primary responsibility of the EPA and the AEC differ, the types of information development required do not parallel. However, the overlap between the agencies very easily leads to duplication of effort. Thus, close coordination between EPA and AEC on any aspect of plutonium is necessary.

OPTIMUM PROGRAM

Major emphasis is placed on a research program and ORP paper studies which provide the documentation evidence needed for dose assessment models. Environmental criteria for the maximum safe levels of plutonium are derived from experimental evidence, reducing the uncertainties of radiobiological effects and critical pathways. The Milestone Chart for the Optimum Program is presented in Figure C-18.

External Needs

Legislative Needs

None.

Knowledge and Information

Much of the preliminary knowledge and information needs for the program exist within AEC documents and the open literature. This body of information should be drawn together by data summaries that would be of use to EPA, AEC, its contractors and licensees. AEC plans for present and future research programs should be considered in development of EPA sponsored research protocol.

Some monitoring data presently exists for plutonium in the environment. Analyses of the data are needed to indicate the present levels of plutonium in the environment and serve as baseline data for future assessments of plutonium in the environment.

Research and Development Needs

Research programs to identify the mechanisms and importance of environmental pathways for transport of plutonium are used as a base of information for criteria and standards development. Research is to be defined to provide a data base and parameters for dose assessment models.

A great amount of effort has been expended by the AEC for research in all areas of plutonium technology. Despite the many projects investigating the biological and environmental hazards of plutonium, several

PAGE NOT

AVAILABLE

DIGITALLY

aspects of the hazards associated with the element have not been investigated. Environmental studies presently conducted under AEC or EPA sponsorship are limited to the western U.S. in desert or high plains ecosystems. Long-term accumulation, resuspension, and redistribution is expected to be an important mechanism for transport of plutonium to man. Present planning for the LMFBR and Pu recycle in LWR's indicates the majority of these reactor and an equal number of plutonium fuel service facilities will be in the midwestern or eastern seaboard states. The mechanisms of resuspension and the importance of each should be determined for the midwestern and eastern ecosystem.

Food chain transport of plutonium has been studied on a small scale. Present literature sources only offer small bits of information for plutonium and essentially no information for other transuranic elements. Further research in the area of plant, milk, and meat as media for transport of transuranic elements to the human should be studied. While a given food type may be very small as a source of ingested plutonium, the integrated amount from air, water, and all foods may be important.

A systematic means for integrating all sources of plutonium and other transuranic elements reaching man would be the development of a regional radionuclide transport model. The pathways identified for transport of other radionuclides can serve as the basis for such a model. As information from present and future plutonium research becomes available, the data base and parameters for the exposure pathways can be added to the model.

Enforcement and Control Requirements

Since the AEC and the EPA can regulate through the rule-making activities, enforcement would be through this means. Control would be implemented through the AEC licensing and compliance process.

Interagency Implementation

The major external agency implementation of plutonium criteria and standards would be through the AEC regulation, licensing, and compliance programs.

Internal Needs

ORP requirements to implement the optimum program must be considered with the operations plutonium problem area. Also, the fuel reprocessing problem area is considering the environmental hazards of plutonium and other transuranic elements. Efforts in all three problem areas are thus related. Fabrication-plutonium is unique as a plutonium and transuranic element problem area only because plutonium is present in much larger quantities and without the concurrent large quantities of fission and activation products.

The major internal ORP needs would be addition of personnel needed for monitoring research programs, development of dose assessment models, and adequate computer facilities for model development. Monitoring for plutonium in the environment would require additional laboratory analyses and additional data analyses.

Plutonium as an environmental pollutant fits into many of the modeling efforts for fission products released to the biosphere. The major deficiencies are the lack of identified pathways and associated parameters. These variable are required for development of criteria and acquisition of proper monitoring data that describe the plutonium and transuranic element radiation insult to man and the environment. One would foresee standards and criteria for media (air, water, and soil) as well as worldwide limits.

PROPOSED PROGRAM

The milestone chart for the Proposed Program is presented in Figure C-19.

External Needs

Legislative Needs

None.

Knowledge and Information

The knowledge and information needs for the Proposed Program are the same as the Optimum Program. However, the information is used to write research protocol appropriate to early issuance of provisional radiation protection guides and environmental plutonium criteria.

Research and Development Needs

Research programs would be reduced to short-term laboratory studies with the goal of criteria for plutonium accumulation in the environment being issued the end of FY 1974. A long-term resuspension study would be started to provide the needed data for evaluation of the adequacy of the criteria by FY 1979.

Enforcement and Control

Same as Optimum Program.

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Interagency Implementation

Same as Optimum Program.

Internal Needs

Through summary papers of existing literature and results of AEC sponsored research, the present staff would issue provisional environmental plutonium criteria. Added personnel would be required for follow-on studies needed for evaluation of the provisional criteria and validation by monitoring.

COMPARISON OF OPTIMUM AND PROPOSED PROGRAMS

The proposed program results in early issuance of environmental plutonium criteria based on present knowledge of the behavior and effects of the element in biological systems. Issued as provisional criteria the influence of research findings can be used to change the criteria at a later date. The uncertainties of this program would be off-set by the Optimum Program which relies on sound data from experiments designed for determining parameters needed to predict plutonium movement in the environment. The proposed program would be less costly and set criteria prior to development of siting and effluent standards. The Optimum Program results would be delayed by the long time period required to complete appropriate research projects.

MEASURES OF GOAL ATTAINMENT

The goal of the program is to minimize the health and environmental risks associated with utilization of plutonium. The first measure of this goal would be setting environmental criteria for plutonium and the subsequent use of the criteria for setting siting and effluent criteria for plutonium. The second measure of goal attainment would be decreasing or negligible plutonium detected in the environment after implementing the criteria and standards.

OPERATIONS - PLUTONIUM

PROBLEM DESCRIPTION

Component Problems

This problem area has the problems of assessing the potential radioactive effluents from the routine operations of the proposed liquid-metal-cooled fast breeder reactors (LMFBR's) and the light-water-cooled reactors (LWR's) which employ plutonium fuel, of determining significant exposure pathways and dose to the population, of issuing guidance and/or standards adequate for the protection of the population from these effluents, and of verifying the sufficiency of this procedure by environmental monitoring. The major emphasis of this problem area will be related to the radiation dose to adjacent population groups from the operation of these facilities. In addition, the information developed on effluents will be an input to the overall assessment of the total radiation hazard from all sources.

Background

The development of a LMFBR has been assigned a national priority in President Nixon's Energy Message to Congress on June 4, 1971. The LMFBR can produce more fissile material than it consumes and its development could alleviate the depletion of fossil-fuel (coal, oil, and natural gas), and uranium reserves that would be required to meet projected increased demand for electricity. As a result of this impetus, the AEC has initated an LMFBR Development Program to construct large (500-1,000 Mwe) demonstration plants. If these demonstration plants show that the

LMFBR is both technically and economically feasible, a program for the large-scale commercial utilization of LMFBR's for electrical power generation will commence.

Large quantities of plutonium and other highly toxic alpha-emitting transuranic elements will be generated in LMFBR operations, in addition to production of radionuclides such as tritium, krypton-85, and iodine-129. These radionuclides have the potential for irreversibly contaminating the environment for hundreds or thousands of years with concomitant long-term radiation exposure to succeeding generations. The radionuclides released to the biosphere from the large scale utilization of plutonium-fueled reactors could add to existing radiation exposure from naturally occurring radioactivity, medical X-ray and other health related sources, industrial radiation applications, uranium fueled nuclear reactors and associated operations, and other portions of the plutonium fuel cycle. The total radiation exposure of population groups must be controlled if radiation induced deleterious health effects are to be minimized. These factors indicate that releases of radionuclides from LMFBR operations to the environment should be severely restricted, and, if feasible, guidance should be established to prohibit the release of plutonium and other highly toxic radionuclides to the environment. The estimated accumulated production of the more important long-lived radionuclides are shown in Table C-8 as an indication of the potential magnitude of this aspect of the radiation problem from the increasing utilization of nuclear energy.

TABLE C-8

ESTIMATED PRODUCTION OF LONG-LIVED RADIONUCLIDES
BY NUCLEAR POWER REACTORS

Radionuclide	Half-life (years)	Activity (Curies) Accumulated by* 1970	2000	Percentage Increase (2000/1970)	Activity Remaining in 2100+ Curies	Percent of 1970 Values
H-3 (tritium)	12.3	40,000	90,000,000	225,000	321,250	800
Krypton-85	10.8	60,000	1,200,000,000	2,000,000	1,958,200	3,300
Iodine-129	17,000,000.	2	7,600	380,000	7,600	380,000
Plutonium-238	86.4	700	31,000,000	4,428,000	13,897,800	1,985,400
Plutonium-239	24,400	90	1,300,000	1,444,000	1,296,300	1,440,300
Americium-241	458	9,000	120,000,000	1,333,000	103,146,000	1,146,100
Curium-244	17.6	130,000	260,000,000	200,000	5,065,000	3,900

*Source: USAEC Report ORNL-4451 July 1970 Table 2.1 p 2-9.
+Assuming no production after the year 2000.

The utilization of nuclear power for electrical generation presently provides only a small fraction of the nation's power requirements. In 1970, only 3 gigawatt-years were generated by nuclear reactors compared to a total generation of 205 GWe-years; nuclear generation comprising only one and one-half percent of the total. Only three large U.S. fast reactors presently exist: the commercial 200 MWt Fermi plant, the 20 MWt SEFOR plant, and the 62.5 MWt EBR-II. Although large scale LMFBR plants will not be operable until the late 1980's, they are expected to provide approximately 31% of all electrical power by the year 2000.

The Atomic Energy Commission's proposed fast-reactor development program will incorporate requirements for the use of the latest waste treatment technology to minimize radioactive releases to the environment. Thus, the effluents from these plants should be well below current light-water reactor releases and the population dose commitment from a single plant would consequently be small. Because of the use of these advanced waste treatment systems and the retention of most radioisotopes in sodium, other portions of the fuel cycle, especially spent fuel reprocessing, could represent greater potential radiation than the normal operation of plutonium-fueled reactors. It must be clearly recognized, however, that any long-lived radionuclides which are emitted from these plants will add to releases from other portions of the plutonium fuel cycle and similar releases from the uranium fuel cycle components. These long-lived radionuclides may also accumulate in the environment as a consequence of their slow removal rate due to radioactive decay. Thus, radionuclides discharged from plutonium-fueled reactors, unless strictly controlled or for the most toxic radionuclides prohibited, would have both additive and cumulative impacts on environmental radiation levels.

Scope

The problem area is restricted to the radiation exposures to the public resulting from effluents that may be released during routine operation and those inadvertent minor radioactivity releases resulting from waste treatment system malfunctions, in-plant spills, or operator error. Specifically excluded from consideration in this problem area are potential major accidents in these plants and other portions of the plutonium fuel cycle. The use of plutonium in aerospace or other non-reactor applications is not contained within this area but will be included in the Fabrication-Plutonium problem area.

LEGISLATIVE STATUS

There are no authorities granted to ORP that relate specifically to this problem area. The general authority derived from the Federal Radiation Council function allows EPA to issue general guidance to Federal agencies on all types of radiation exposure including plutonium-fueled reactors. The environmental radiation level standard setting function transferred to EPA from the AEC provides a direct means of limiting radiation exposure from these facilities. EPA comments on plutonium-fueled reactors provide a powerful means of effecting changes in waste treatment system designs, effluent releases, and facility operations. The general functions assumed from DHEW provide EPA authority for research, monitoring, data interpretation and dissemination, standards development support, aid to states and other governmental bodies, training, and public information activities related to environmental radiation exposure. These combined authorities provide an umbrella under which all of the porposed radiation programs can be justified and, therefore, no new legislation for additional authority is required.

COORDINATION

ORP Internal Coordination

The problem area Operations-Plutonium comprises only one component of the total radiation problem and, as such, both the input requirements (information needs) and outputs (radiation hazard evaluations and control requirements) generated within its scope must be combined with those from other problem areas to provide a unified strategy. This unification is accomplished under the generic areas of monitoring, risk-benefit analysis, and strategic studies.

The strategic area sub-element "fuel-cycles" will be of primary importance in developing the ORP policy on plutonium-fueled reactors. The total radiological impact of the plutonium fuel cycle must be the primary consideration in this regard and, therefore, becomes the radiation leverage point for EPA policy formulation. Operations-Plutonium and other ORP problem areas that intersect with the plutonium fuel cycle are depicted in Figure C-20 in order to provide a concise summary of their relationships.

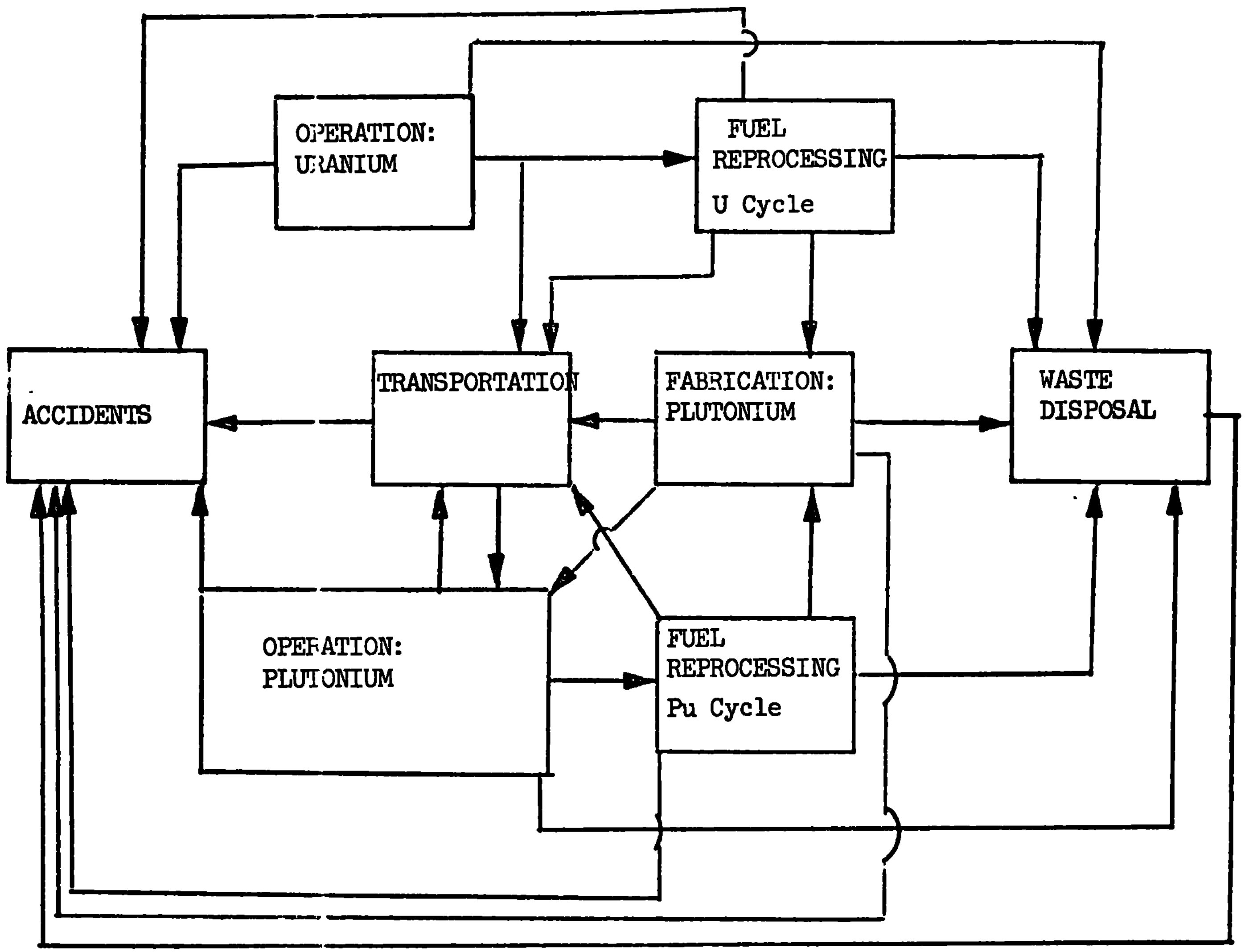

FIGURE C-20

PROBLEM AREA COORDINATION REQUIRED FOR PLUTONIUM FUEL CYCLE

Interagency Coordination

In order to implement the proposed systemic radiation strategy, the ORP will have to draw upon the expertise and capabilities present in the other offices of EPA. The principal scientific areas where coordination is required are related to health effects research, monitoring, environmental system simulation, and pollutant dispersion modeling. In addition to these technical support functions, guidance and administrative support will be required from the Office of Planning and Evaluation (cost-benefit analytical techniques and economic analyses), Office of the General Council (legal guidance), Office of Administration (contract management support), and the Office of Categorical Programs (policy guidance). Thus, coordination with all of the operating offices of EPA will be required to implement the programs described below. Many of the required areas of coordination will generally follow from the systemic strategy and the requirements of this approach. Specific coordination for this problem area will be required in the development and execution of plutonium research programs, the conduct of field studies around LMFBR's and in the development of environmental monitoring programs.

External Coordination

The majority of the research effort on reactor technology, ionizing radiation bioeffects, and the environmental movement of radionuclides will be performed outside of EPA, primarily by the AEC, its National laboratories, and contractors. In order to provide suggestions for further research, to avoid duplicative efforts, and to obtain relevant data, extensive liaison must exist between ORP and AEC components. Several other agencies are also involved in power demand forecasting, environmental system modeling, and radioecological research, and coordination with these agencies must also exist, both nationally and internationally. A third area of EPA coordination is required with national and international bodies which provide guidance on radiation protection so that this guidance may be reflected in EPA radiation protection efforts.

ALTERNATIVE APPROACHES

Description of Alternatives

There are three possible approaches for the conduct of a program for plutonium-fueled reactors.

First Alternative

The minimum functional program for plutonium-fueled reactors is predicated on continuing only those essential radiation functions of EPA which cannot be delegated to the AEC, or the states, or otherwise dispense with. These functions are primarily nationwide monitoring and environmental impact statement response. The milestones for such a program are shown in Figure C-21. This program completely relegates all research to the AEC and minimizes the standard setting and radiation guidance roles which EPA could assume. The problem contains only a small number of support functions required by the monitoring programs and for EIS technical backup. The principal technology assessment functions are required to support the EIS responses which would become the principal promulgation mechanism for EPA's radiation positions.

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Second Alternative

Develop a systematized approach to assess the magnitude of potential health risks and environmental effects from plutonium-fueled reactor operation and formulate radiation standards and environmental criteria to minimize these risks. The development of control technology to meet the EPA requirements would be relegated to the AEC and industry.

Third Alternative

Undertake an active research program in control technology development, in addition to performing the assessment and guidance functions specified above in the second alternative. These three alternative approaches are designated, respectively, the minimum functional, proposed, and optimum programs and are described below.

Compromise Alternatives

Because of the great difference between the proposed and minimum functional programs, there is a wide variety of options which could result in compromises between these two programs. The first paring of the proposed program would be to minimize direct EPA radiation research functions related to plutonium-fueled reactors. Leverage could be exerted on the AEC to perform these research functions by virtue of its substantially greater environmental and radiation bio-effects research budgets. A second reason for cutting the research functions would be the cost-effectiveness of research programs which require long lead times and large fund expenditures before yielding results which can be employed by program offices. The second level of cut-backs would be to eliminate facility-oriented radiation exposure standard development which the AEC could undertake, leaving EPA to develop the environmental criteria for long-lived radionuclides. Thus, ORP could still employ a systemic strategy although much reduced in scope.

OPTIMUM AND PROPOSED PROGRAMS

The Optimum and Proposes Programs are generally similar and major differences occur only in two areas: (1) the conduct of monitoring operations and (2) the degree of involvement with waste treatment system development. Under the Proposed Program, ORP would concentrate on environmental aspects and leave control technology development and a detailed study of in-plant radionuclide transport to the industry and the AEC. Under the Optimum Program, EPA would have an active research input into these areas via the programs shown in Table C-9. Monitoring would be performed directly by EPA labs and coordinated through regional offices in the Optimum Program. The Proposed Program would require a smaller commitment from EPA and a greater involvement of state health and environmental protection agencies and of utility companies in the actual conduct of monitoring operations. EPA would conduct field studies for effluent data verification and pathway model validation. Because of the similarity of the remaining portions of both programs, a common program plan can be developed for both. Differences between the two programs will be indicated where they occur.

External Needs

Legislative Needs

ORP has available suffieient authorities for conducting either the proposed or optimum programs and additional legislation is not required.

TABLE C-9

RESEARCH AND DEVELOPMENT ACTIVITIES CONDUCTED UNDER THE OPTIMUM PROGRAM WHICH ARE NOT IN THE PROPOSED PROGRAM

Period	Task	Method of Performance	Total Resource Requirements		Allocation to Operation Plutonium		
			man-years	$1000's	Fraction	man-years	$ 1000's
FY74-FY82	Long-term Resuspension study from soil to air (interim report FY 78 for plutonium standard development - final report in FY82)	ORM	20	800	1/4	5	200
FY73-FY76	Evaluate Noble Gas Recovery Systems	Contract	3	160	1/4	.75	40
	Evaluate Gas Disposal and Storage Techniques	Contract	3	400	1/8	.4	50
FY75-FY78	Develop tritium removal technique	ORM	16	1600	1/4	4	400
	Evaluate tritium disposal methods	Contract	3	160	1/8	.4	20
		ORM	6	240	1/8	.75	30
FY77-FY80	Evaluate effectiveness of sodium cold-traps	Contract	3	160	1	3	160
FY79-FY82	Evaluate techniques for disposal of contaminated sodium	ORM	9	240	1/2	4.5	120
		Contract	3	160	1/2	1.5	80
	ORP TOTAL		15	1040		6	350
	PROGRAM TOTAL		66	3920		20.3	1100

Knowledge Needs

The development of a systemic radiation strategy for plutonium-fueled reactors requires the following information:

- Estimates of the magnitude and composition of effluents;
- A means for determining radionuclide movement and accumulation in the environment, particularly in the food chains leading to man;
- Techniques for converting environmental radionuclide concentrations into external dose rates;
- Methods for predicting the distribution of and dose rates from radionuclides in the human body;
- Assessment of the potential biological hazard, both genetic and somatic, from the accrued radiation doses;
- Methods for comparing the risks from the plutonium fuel cycle with those from alternate energy sources and from the lack of power;
- Monitoring programs and techniques for forecasting the potential risk magnitudes to insure that excessive risks may be identified within sufficient time to institute control measures.

The majority of the information required to develop the system models will be obtained from extensive review of the past and current technical literature and close monitoring of existing research programs of other agencies, primarily those of the AEC, its National laboratories, and contractors. Specific knowledge needs and the external coordination points required to obtain them are shown in Figure C-22 for EPA offices

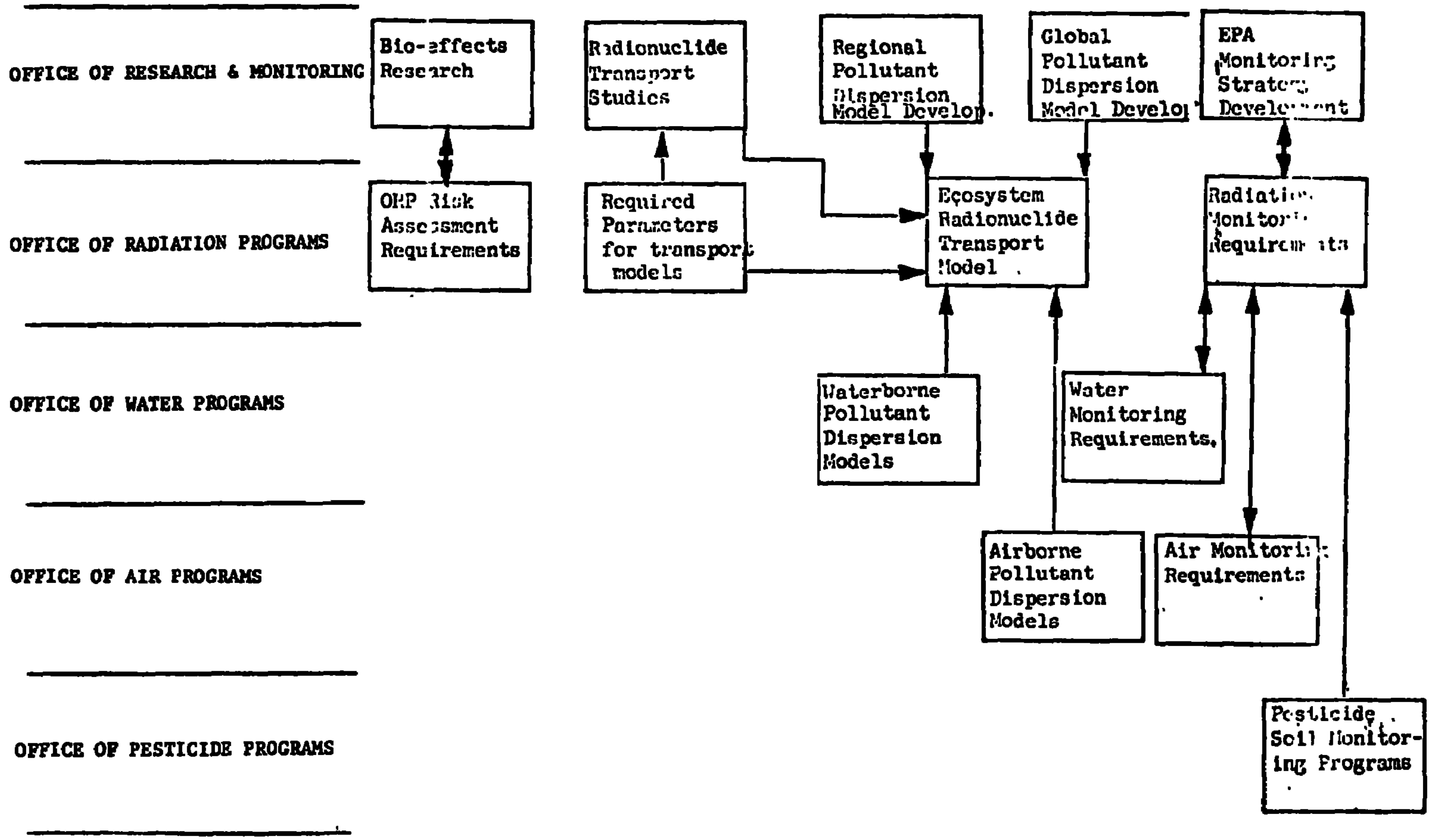

FIGURE C-22

INTRAAGENCY INFORMATION NEEDS

and in Table C-10 for other agencies. This coordination is required on a continuing basis and is not shown on the program milestone charts.

Research and Development Needs

The principal research on plutonium-fueled reactors and their radiation hazards will be conducted by the AEC, its National laboratories, and contractors. EPA research efforts to supplement this research could fall into two areas: (1) evaluating waste treatment systems and radioactive waste disposal techniques; (2) determining the health risks from plutonium and other actinides and the significant food-chain pathways for these elements in man's diet. One of the principal differences between the Proposed and Optimum Programs is the limitation of EPA's reserach efforts under the Proposed Program. Under the Optimum Program, research on the development of improved radioactive waste treatment systems and disposal methods would form a large portion of the total research effort. The Proposed Program would concentrate primarily on the environmental aspects of radionuclide transport and on bio-effects research and leave research on in-plant parameters governing effluents and waste treatment system development to industry and the AEC.

The resuspension in air of plutonium and other long-lived actinides which have been deposited on the ground may be a principal determinant of the long-term hazard from these elements as the usual forms of these elements do not readily enter into food-chains leading to man. The degree to which resuspension can occur over a long duration may determine whether the accumulated ground deposit constitutes a hazard or whether only recent airborne releases contribute significantly to the dose to man.

TABLE C-10

EXTERNAL INFORMATION NEEDS

AGENCY	INFORMATION OR SERVICES PROVIDED	EPA APPLICATION
U. S. Atomic Energy Commission (USAEC)		
Division of Reactor Development and Technology	Breeder Development Program Status	Program Timetable and Planning
	Waste Treatment System Design*	Effluent Estimates
	Sodium Chemistry & Fission-Product Retention*	Effluent Estimates
Division of Biology and Medicine	Radiation Bio-effects Data*	Risk Assessment and Dose-Effect Models
Division of Planning and Analysis	Nuclear Power Growth Forecasts	Problem Magnitude Assessment
Division of Environmental Affairs	Radioecology Research Data*	Radionuclide Transport Models
	Environmental Effect Data*	Environmental Impact Assessment
Division of Compliance	Operating Experience and Effluent Data*	Effluent Estimates
	Field Studies Protocol	Coordination of Efforts
AEC National Laboratories (ORNL, ANL, BNL, PNWL, SRL, and NRTS)	Items Marked (*) Above	See Above
Federal Power Commission	Power Growth Forecasts	Problem Magnitude Assessment
Council on Environmental Quality	Policy	Policy Guidance
National Council on Radiation Protection and Measurements (NCRP)	Radiation Protection Guidance	Standards and Advisory (FRC) Policy Formulation
International Commission on Radiological Protection (ICRP)	Radiation Protection Guidance	Standards and Advisory (FRC) Policy Formulation
International Commission on Radiological Units and Measurements (ICRU)	Radiation Protection Guidance	Standards and Advisory (FRC) Policy Formulation
International Atomic Energy Agency	Foreign Bio-Effects Research Data	Risk Assessment and Dose-Effect Models
	Foreign Reactor Development and Operating Experience	Effluent Estimates and Waste Treatment Technology
Department of Commerce	Economic Data	Risk-Benefit and Cost Effectiveness Analyses
National Oceanic and Atmospheric Administration (NOAA)	Environmental Data	Radionuclide Dispersion Model Inputs
	Commercial Fishing Industry Data	Food Intake Model
	Consultation	Environmental Systems Modeling
Department of Interior		
Fish and Wildlife Service	Radioecological Research Results	Radionuclide Transport Models
Office of Budget and Management	Budget Analyses and Policy Direction	Funding and Policy Formulation
	Standards Review	Standards Development
National Academy of Science	Consultation	Program Guidance
National Academy of Engineering	Consultation	Program Guidance
National Research Council	Consultation	Program Guidance
The Congress of the United States	Budget Review	Program Funding
Government Accounting Office (GAO)	Program Review	Management Guidance
Government Printing Office (GPO)	Printing Services	Public Information
State Health and Environmental Protection Agencies	Monitoring	Monitoring Data

The AEC has research programs to study this phenomenon in desert soils such as the Nevada test site of the Rocky Flats area. Present planning for the LMFBR and Pu recycle in LWR's indicates the majority of these reactor and an equal number of Pu fuel service facilities will be in the midwestern or eastern seaboard states. Thus, the mechanisms of resuspension and their importance should be determined for midwestern and eastern soil types. Under the Optimum Program this research would be performed directly by EPA research facilities, either as part of the ORM research program or partially funded by ORP. Because none of the eastern EPA laboratories currently occupies a large enough site for such a study, additional facilities would be required in an isolated area, adding to the proposed cost. Although this research is on an important environmental factor, the proposed program would use EPA influence to induce the AEC to undertake such a study at one of its National laboratories.

The Optimum Program would provide contract funds for evaluating sodium clean-up (cold-trap) systems and noble gas removal techniques, both of which are important factors in determining LMFBR effluents. A tritium removal technique would also be developed to limit the discharge of this radionuclide to the environment. Both krypton and tritium are also produced in uranium-fueled reactors and the principal release points are the fuel reprocessing plants so that the costs of these programs should be allocated between the problem areas Operations-Plutonium, Operations-Uranium, and Fuel Reprocessing (the assumed allocation of resources for both of these tasks is 1/4, 1/2, respectively).

The Optimum Program would also entail direct EPA participation in the development and evaluation of disposal techniques for tritium, krypton, and contaminated sodium. The costs of the first two programs would be divided between the problem areas Operation Plutonium, Operation Uranium, Fuel Reprocessing, and Waste Disposal as 1/8, 1/8, 1/4, and 1/2. The programs costs for sodium disposal would be shared equally between Operations-Plutonium and Waste Disposal.

Estimates of the total costs of these programs and those costs assignable to Operations-Plutonium are shown in Table C-9. Under the Proposed Program these efforts would be relegated to the AEC with EPA-ORP monitoring their progress and only health-effects research and food-chain transport studies would be conducted. The ORM budgets for these programs are provided in Table C-11.

Interagency Implementation and Enforcement Requirements

The principal external outputs from the proposed program will be environmental radionuclide criteria and a radiation exposure standard for the LMFBR and Pu-recycle LWR's. These differ in their applicability and enforcement requirements.

The criteria would be independent of the facility type and hence not only applicable to plutonium reactors but also to fuel reprocessing, waste disposal, fuel fabrication operations, and the corresponding uranium fuel-cycle operations. These criteria would specify the maximum concentration of each nuclide that could exist in the general environment with special regard to potential long-term buildup from multiple sources

TABLE C-11

RESEARCH PROJECTS UNDER PROPOSED AND OPTIMUM PROGRAMS

Project Title (WERL Project #)		Resource Requirements FY 73	FY 74	FY 75	FY 76	FY 77	FY 78	Project Total
Pulmonary Carcinogenic Effects of Radioactive Particles (21-AMT)	man-years	2.4	2.4	--	--	--	--	9.8
	$1000's	52.8	52.8	--	--	--	--	105.6
Inhalation Health Effects Research OPERATION PLUTONIUM Allocation of above (25%)	man-years	0.6	0.6	--	--	--	--	1.2
	$1000's	13.2	13.2	--	--	--	--	26.4
Transport Processes of Selected Radionuclides in the Environment (21-AMI sub-tasks 17,18,19,20 and 23 only)	man-years	6.5	6	5.5	6.5	7.5	7.5	39.5
	$1000's	143	132	121	143	165	165	869.0
Food-chain Transport Studies OPERATION PLUTONIUM Allocation of above (25%)	man-years	1.6	1.5	1.4	1.6	2	2	10.0
	$1000's	36	33	30.5	36	41.5	41.5	217.5

Total Research Costs	man-years	44.3
	$1000's	974.6
OPERATION PLUTONIUM Allocated costs	man-years	11.3
	$1000's	244.9

and forecasted power demands. In order to meet these criteria, the regulatory agency (AEC) may have to impose effluent limitations (in terms of release rate, not concentration) on each facility type in order that the total nuclear industry release rate (summed over all sources and facility types) would not exceed the criteria. Compliance with these criteria would be demonstrated by calculating the long-term buildup from measured effluents at present power demand growth rates and comparing this with environmental monitoring program data designed to assess long-term buildup trends. At periodic (five or ten year) intervals, or in the event of an extreme upward deviation of power demand forecasts, the EPA guidance and applicable AEC effluent regulations would be reassessed with regard to changes in projected power demands and the observed buildup trend.

The exposure standard would be more conventional, be expressed as the maximum acceptable individual and total population dose rates, and be applicable only to the LMFBR and Pu-recycle reactors. Compliance with the standard could be confirmed by (1) local radiation surveillance programs conducted by state agencies with EPA validation studies in the proposed program and by EPA in the optimum program, and (2) compliance with AEC effluent regulations which were developed to meet the limits specified by the standard.

Enforcement of the exposure standards and applicable AEC effluent regulations would be solely the function of the AEC. Review of the adequacy of the AEC effluent regulations in meeting the exposure standards and the criteria would be an ORP responsibility.

Internal Needs

The systemic approach will require new talents to be added to existing ORP capabilities. A large systems analysis operation involving systems analysts, computer programmers, radioecologists, meteorologists, hydrologists, and geologists would be required in order to model environment radionuclide transport processes. Capabilities in economic analysis, nuclear-chemical engineering, and power systems analysis would be required for cost-effectiveness and risk benefit evaluations. Additional expertise in statistical trend analysis would be required to evaluate monitoring data.

The information inputs to the systemic models require a well-equipped technical library and the development of an information storage and retireval system. A large computer system with adequate data storage capacity and multiple output modes (alpha-numeric, graphic, and graphic display) will also be required.

Few of the necessary tasks are unique to the problem area Operations-Plutonium; considerable overlap will exist with other problem areas concerned with the plutonium fuel cycle. For this reason, it is necessary to allocate manpower and budgetary resources for common tasks between the problem areas involved. For Operations-Plutonium the total ORP effort expended in the next ten-year period (FY 1973 - FY 1982) will be 69 man-years and $2,229,000 for an average of 7 man-years and $223,000 per year. The level of effort is not constant but varies with the proposed program milestone schedule. The maximum efforts are exerted in FY 1977 (9 man-years and $244,000) and FY 1980 (13 man-years and $365,000). Of the total effort, external contracts expenditures would be $132,500 and field support studies would require 23 man-years and $555,000.

The total Proposed Program requirements (including research efforts) would be 80 man-years and $2,474,000. The Optimum Program would require 114 man-years and $4,146,000. Of this, resources directly allotted to ORP's efforts in Operations-Plutonium would be 75 man-years and $2,579,000, the remainder being additional research study support.

Proposed Program Milestones

The program milestones for the Proposed Program are shown in Figure C-23.

Technology Assessment

During FY-1973, preliminary estimates of actinide production will be prepared to aid problem assessment and guide program development. These preliminary estimates will be supplemented by a complete review of actinide production and control technology in FY 1978-FY 1979 prior to the issuance of environmental criteria for plutonium and other alpha-emitting transuranium elements. The second review will also contribute to an assessment of the total radiological impact of the Pu fuel cycle. The latter study will provide the primary basis of EPA's EIS comments on large commercial LMFBR's and the development of an LMFBR radiation exposure standatd. A preliminary review of existing soidum reactor effluents and waste treatment systems will also be undertaken in FY 1973. This will serve to provide background information on sodium-cooled reactors and will be supplemented by a field study performed at the FFTF site and a special study at a large demonstration plant.

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The proposed monitoring program may be subdivided into:

- Network monitoring which determines the status of the environment and provides baseline data .
- Special studies at nuclear installations and in unique environments, to provide data for radionuclide transport modeling.
- Field studies to verify effluent data.

At present monitoring around existing facilities is performed by the operators, and in some cases, by state agencies. Nationwide monitoring for plutonium is limited to analysis of selected air network samples.

A realistic assessment of the impact of radionuclides added to the environment by plutonium-fueled reactors will require, in addition to information from the AEC, facility operators, and state agencies, special studies in the environs of selected facilities such as Fermi #1 and the FFTF to determine effluents.

In order to assess the long-term accumulation of plutonium and other radionuclides, the analysis of additional media such as soils will probably be useful, and may be achievable with a minimum of additional effort through combined monitoring programs with other EPA offices (such as the analysis for plutonium in soil samples acquired by the Office of Pesticide Programs) in the course of ORP monitoring programs. Similar indications for aquatic ecosystems may be provided by the analysis of sediments in regional watersheds. Indication of human exposure to plutonium and other bone-seeking actinides would be provided by a bone sampling and analysis program. Monitroing programs to assess the long-term environmental accumulation of tritium and krypton-85 would also be required. These programs are already in effect on a limited basis and do not appear on the milestone chart as their scheduling would be governed primarily by the fuel reprocessing program requirements.

By the time the first LMFBR demonstration plant has experienced a year of normal operation, i.e., about 1981, the state of the art of evaluating the environmental impact of nuclear operations should be considerably advanced, and a special study of the LMFBR demonstration plant should provide good supporting data for the reassessment of the plutonium-fueled reactor program and review of the large LMFBR EIS which may be expected at that time. This information will also be used in the development of the LMFBR exposure standard and over-all review of the plutonium fuel cycle.

Criteria and Standards Development

In order to provide bases for specific radionuclide criteria and facility exposure standards, the basic ORP philosophy for its radiation protection guidance must be establihsed at an early stage. This should be undertaken in FY 1973 with the issuance of provisional radiation protection guidance for this activity.

At least four environmental concentration criteria would be required for the principal long-lived radionuclides: iodine-129, plutonium, tritium, and krypton-85. The iodine-129 criteria are introduced first because of the need for developing techniques of assessing the hazard from very long-lived radionuclides and the large existing body of information on iodine retention systems and environmental transport pathways for iodine. Krypton-85 criteria are developed secondly because of the relatively simple exposure pathways (it does not enter food-chains to any significant extent), the need for early control because of greater potential dose levels than from tritium, and the growing body of information on noble gas retention technology which will permit control. Tritium criteria development is delayed until FY-1977 in order to permit the development of feasible control techniques which do not presently exist. In addition, this timetable will permit more sophisticated environmental transport models to be employed to predict potential environmental accumulation. The delay of plutonium nad actinide criteria until FY 1978 is not advisible from a programmatic viewpoint as substantial plutonium inventories will be accumulated from light-water reactor operation. However, this delay is necessary to incorporate a complete review of actinide production, the interim results of the long-term resuspension-migration studies, and bio-effects research results.

The LMFBR exposure standard is also delayed beyond a programmatic optimum time frame. This is necessary if large LMFBR plant operating experience, the complete Pu fuel-cycle assessment, and data from special studies around the demonstration plants are to be incorporated. These factors will provide a more informed and factual basis for the standard development.

COMPARISON OF OPTIMUM AND PROPOSED PROGRAMS

A comparison of the major alternative programs is shown in Table C-12. The impact of the Proposed Program is similar to that of the

TABLE C-12

COMPARISON OF OPTIMUM, PROPOSED, AND MINIMUM FUNCTIONAL PROGRAMS

	Optimum Program	Proposed Program	Minimum Functional Program
Systemic Radiation Strategy?	Yes	Yes	No
Enforcement Capability?	No	No	No
Guidance Expression Options?	Yes: Radiation Protection Guides, Radiation Criteria and Standards, and EIS Comments	Yes: Radiation Protection Guides, Radiation Criteria and Standards, and EIS Comments	No EIS Comments Only
Control Technology Development?	Yes	No	No
Active EPA Research Input?	Yes	Yes	No
Permits Risk-Benefit Assessment?	Yes	Yes	No - Risk Assessment Only
Requires Additional Expertise and Staffing to Present Capabilities?	Yes: Economic Analysis, Radiobiology, Nuclear-Chemical Engineering, Radioecology, and Environmental Systems Modeling	Yes: Economic Analysis, Radiobiology, Nuclear-Chemical Engineering, Radioecology, and Environmental Systems Modeling	No Reprogramming of Functions
Degree of EPA Leadership Exercised	Strong	Strong	Weak Primarily Response to AEC Lead
Permits Completely Independent Assessments?	Yes	Yes With Exception of In-plant Parameters	No, Leans Strongly on AEC Supplied Data
Budget Changes	Requires 40-60% Increase	Requires 15-25% Increase	Permits 20-30% Decrease
Change in Support Functions	Require Large Technical Library and Computer Facilities	Require Large Technical Library and Computer Facilities	No
External Visibility	Strong: Technical Reports and Papers Meeting Presentations, and EIS Comments	Strong: Technical Reports and Papers Meeting Presentations, and EIS Comments	Weak: EIS Comments Primarily
Execution of Monitoring Programs	EPA Directly through Labs and Regional Offices	State & utility Co. with EPA validation studies.	States with Financial Assistance
Scope of Monitoring Program	Regional and National, Supplemented by Local Field Studies	Regional and National, Supplemented by Local Field Studies	National and Field Studies Only
Execution of EIS Reviews	By Regions with Policy Guidance and Technical Support by Headquarters	By Regions with Policy Guidance and Technical Support by Headquarters	Principally by Headquarters

Optimum Program except that greater reliance is placed upon the AEC for waste treatment system development and research on in-plant radionuclide transport and upon the states for the conduct of monitoring programs. These changes result in some loss of independence for EPA and a greater need for coordination with other agencies but with a corresponding reduction in the financial and manpower requirements to carry out these programs.

The minimum functional program provides for a response rather than a leadership role for ORP and consequently diminishes the influence which can be applied to the AEC. This program provides only minimal external visibility and does not permit a systemic radiation strategy to be developed. Under the minimum functional program ORP's technical capabilities would be severely limited and there would be little flexibility in the choice of guidance expression options. The ability to react to unforeseen problems (and even to foresee problems) would also be reudced under this extreme option.

MEASURES OF GOAL ATTAINMENT

The principal goal of the Proposed Program described above is to assess and minimize the radiological impact of plutonium-fueled reactors on the environment and on public health. Subsidiary goals are to provide adequate knowledge resources and technical competence to achieve the primary goal and to insure that the development of plutonium-fueled reactors is carried out with adequate consideration of potential environmental consequences.

The planned accomplishments of the proposed program are manifold. The primary accomplishments are the development of adequate criteria for limiting the accumulation of long-lived radionuclides in the biosphere and the development of a radiation standard for reducing the radiation exposure of the population groups adjacent to plutonium-fueled reactors to the lowest practicable level. The secondary accomplishments are:

1. Providing an integrated monitoring system capable of detecting trends in environmental radiation levels early enough so that potential hazards may be controlled before they have a significant impact;

2. Conducting research programs to increase existing knowledge of radiation effects and the environmental movement of long-lived radionuclides;

3. The development of an adequate information resource upon which intelligent decisions can be based;

4. The implementation of a comprehensive systemic strategy for controlling radiation exposure to the population from all sources.

The attainment of the goals may be verified by the degree of incorporation of environmental factors in the development of the LMFBR development program, the lack of a significant buildup of long-lived radionuclides in the environment as determined by radiation monitoring data, and the minimization of radiation exposure to people from the operation of these facilities as shown by surveillance data.

OPERATION - URANIUM

PROGRAM DESCRIPTION

I. Problem Description

A. Problem

A major area of concern about risk to the environment from radiation is that of the generation and utilization of energy through nuclear power. Because the fuel cycle that is necessary for nuclear power has several activities which are distinguished by their functions, geographical locations, and potential impacts, it has been divided into several problem areas--mining and mill tailings, fuel fabrication and associated activities, transportation, fuel reprocessing, and disposal. Fuel cycle steps involving large amounts of polutonium have been separated from those involving principally uranium, and accidents are treated in a problem area separated from routine operations, because their characteristics and potential radiological impacts are distinctly different.

The problem area OPERATION - URANIUM for the reasons stated above is limited to (1) an assessment of the radioactivity added to the environment at the facility site in the course of routine operations, (2) computation of the population dose within 50 miles, with adequate critical exposure pathway transport models, from the subsequent distribution of the added radioactivity in the environment, and (3) validation of all dose predictive models through field studies. A computerized data management and processing system is essential for effective implementation of these activities. Due to frequently changing technology and variations in facility design and operations, an assessment of the environmental impact will be made to determine the effectiveness of the new technology in reducing population dose.

The output from the [illegible] for OPERATION - URANIUM, the impact in terms of radiolog[illegible] to individuals and to the population is: (1) a contribution to knowledge of the total radiological environment, (2) a contribution to the assessment of the validity of the dose models used to determine the impact of nuclear power on the environment, (3) a means of observing trends in the impact so that trends toward excessive impact may be recognized in time to permit efficient counteraction, and (4) an input to the determination of the need for or development of criteria and standards.

B. Background

Among the defined problem areas within ORP, nuclear power production has been the area of much public focus and controversy over the past five years. A major portion of this controversy has been related to the radiation protection standards which have been used in the regulation of the nuclear power industry and in the estimated potential impact of applying these standards to a major portion of the nation's population.

Since its inception, the AEC has, as a matter of policy, depended upon the recommendations of various national and international advisory bodies, such as the FRC and the ICRP, for basic guidance in establishing radiation protection standards. The standards of these groups, of course, are compatible. They have been used by the Commission as the basis for regulations and safety requirements in the AEC's regulatory program.

Recently, the AEC announced the publication for public comment of proposed numerical guides for design objectives and limiting conditions for operation for light-water-cooled nuclear power reactors to keep radioactivity in effluents "as low as practicable". These proposed changes to the reactor licensing regulations were in the form of an additional Appendix I to 10 CFR 50. The term "as low as practicable" as used in the proposed amendments to Part 50 means "as low as is practicably achievable taking into account the state of technology and the economics of improvement in relation to benefits to the public health and safety and in relation to the utilization of atomic energy in the public interest".

In testimony at the AEC hearings on these proposed amendments, the EPA indicated that it would accept the proposed amendments as generally representative of guidance that the EPA would issue if it had set environmental standards for light-water-cooled reactors. In accepting the dose guidance in the proposed changes to 10 CFR 50, the EPA made the following stipulation: "... if actual practice under these guides should result in maximum individual doses over what can be expected under careful operation with the technology implied by the guidelines, EPA will reexamine this decision."

It was further stated that "... we anticipate that timely reports and cooperation will be available from the AEC concerning the performance of its licensees. Individual facilities need not exceed the guides; indeed, in most cases they will probably operate at levels considerably below the guides. EPA will continue to review the environmental impact of individual facilities with these considerations in mind." In making this public declaration, the EPA has committed itself to a minimum of an assessment of the current operations of the industry.

The Office of Radiation Programs and its predecessor organizations have had an active and continuing program related to nuclear power reactors. The two primary endeavors have been assessment of current operations through review of reactor operating and environmental surveillance reports and the assessment of technology through engineering evaluations and special studies.

The assessment of current operations has included the following specific activities:

1. Compilation and publication of analyses relating effluent trends to power production and discharge limits.

2. Assessment of the effectiveness of surveillance programs in providing data necessary for estimation of population doses.

3. Assessment of the adequacy of data in facility operating reports for evaluation of population risk.

4. Preparation of a guide for environmental radioactivity surveillance around light-water-cooled nuclear power facilities.

The assessment of technology has included the following specific activities:

1. A contract to [illegible] cost effectiveness evaluation of waste treatment systems.

2. A contract to perform a literature search on data relative to waste treatment systems.

3. An evaluation of gaseous holdup systems.

4. An evaluation of PWR primary to secondary leakage.

5. A compilation of PWR and BWR operational parameters.

6. Indepth studies at two BWRs and two PWRs (Dresden I, Oyster Creek, Yankee Rowe, and Connecticut Yankee).

7. An evaluation of effluent tritium, iodine-131, and krypton as environmental problems.

Although the area of review of Environmental Impact Statements is to be presented as a separate generic program area it will have an operational relationship with the OPERATION - URANIUM program. This will provide a continuing awareness and analysis of current technology and new issues for assistance to this program and vice versa.

C. Scope

The determination of dose to the population from operating plants is expected to become a routine data processing function after the computer program for calculating environmental pathway doses becomes operational. The development of this program will be the first step in establishing a national dose model which is one of the major overall objectives of ORP.

Initially, field studies to validate the environmental pathway dose models will be necessary. However, once the models have been verified, it is anticipated that further field studies will not be required. This accomplishment is not expected to require more than a few selected field studies over the next few years. Maximum use of the data available from Strategic Studies for new generation plants will be made.

1. Present

In 1972, there are approximately 29 operating light-water-cooled nuclear power plants and one gas-cooled reactor in the United States. The present radioactivity releases from these plants appear to have no significant effects on the environment or the general population based upon assessments of these releases. However, a continuing assessment of critical exposure pathways, specifically for radionuclides that build up or concentrate, is necessary to identify trends which may ultimately lead to significant effects. This continuing assessment will permit remedial actions to be taken early enough to prevent the effects from becoming significant. Concurrently the discharges of radioactive material from nuclear generating stations should continue to be evaluated in terms of population dose.

2. Future

By 1975, the number of operating nuclear power plants in the United States is anticipated to increase to about 80. It may be stated with reasonable certainty that the environmental impact of the operating light-water-cooled reactors has been minimum on an individual basis but may cha[illegible]power levels increase and more reactors become operational at a single site.

Since the environmental impact of a nuclear power plant is related to the reactor site and reactor operating practices, reactor sites must be evaluated on a individual basis. However, as acceptable reactor sites become more scarce, utilities will tend to locate multiple units on already existing sites. Signs of this trend are already apparent. These sites will undoubtedly be in close proximity to one another. We must, therefore, begin to evaluate the accumulative environmental effects of multiple unit reactor sites which have overlapping spheres of influence. This must be done not only on a regional basis but also on a nationwide scale if the true total environmental impact from the production of nuclear power is to be determined.

The same cannot be said with equal certainty for high-temperature-gas-cooled reactors which are just coming on line. The HTGRs, because of their design and method of operation, are anticipated to be less of an environmental problem than light-water-cooled reactors; however, this must be verified by analysis of operational data and through field studies.

New generation reactors with perhaps significantly different environmental considerations (e.g., the floating barge concept) than the current light-water-cooled reactors may pose different and previously uninvestigated environmental problems. These new generation reactors [illegible] to be monitored closely, at least initially, until their environmental impact can be accurately and adequately evaluated.

II. Legislative Status

The statutory authority of EPA to advise the President on radiation matters affecting public health is derived through the transferred authority from the former Federal Radiation Council (FRC) (42 U.S. Code 2021h). Reorganization Plan No. 3 of 1970 gives EPA the responsibilities for setting generally applicable environmental standards, which were formerly held by the Division of Radiation Protection Standards of the Atomic Energy Commission. Authority to protect the public health is derived by EPA from the Public Health Service Act. Possible authority to regulate radioactive materials may be derived through the implementation of the Clean Air Act, the Federal Water Pollution Control Act or the Refuse Act of 1899, although the legislative history of these acts casts some doubt upon their applicability to AEC regulated licensees and radioactive materials. This is because the Atomic Energy Act of 1954 has been interpreted to have preemptive authority in the establishment of radioactivity emission standards.

III. Coordination

A. Interagency Coordination

Coordination is required between the Environmental Protection Agency, the National Bureau of Standards, the states, and the Atomic Energy Commission. The AEC licensees and AEC operating facilities which include operating reactors, are required to report their discharge, operating, and surveillance data to the AEC Division of Compliance or the AEC Division of Operational Safety. The AEC in some instances, interprets and summarizes reports from facilities under its jurisdiction. The EPA/ORP should receive both facility operators reports and the AEC interpretive and summary reports. State radiation control agencies should also receive these reports.

Based on surveillance program needs, EPA/ORP will provide technical assistance and support services (e.g., laboratory and quality assurance) to state agencies for environmental monitoring. Quality assurance will also be provided for federal and commercial contractor monitoring programs. The sources used for quality assurance standards will be traceable to the National Bureau of Standards. Monitoring reports from states are provided to EPA to supplement data provided to EPA from other sources.

The Office of Research and Monitoring will provide laboratory services for quality assurance and research, as required.

IV. Alternative Approaches

Alternative approaches differ principally in the amount of effort required of EPA and in the techniques used to estimate the dose to the population within 50 miles of the operating nuclear power station.

Alternative 1: Dose estimated by others.

The effort of the EPA under this alternative approach is limited to obtaining estimates of dose to the population from the AEC and to evaluating the population dose from each facility in relation to the EPA's environmental standards. The dose estimate for each facility would probably be prepared for the AEC annually by the utility company.

Alternative 2: Dose estimated in-house from data reported by others.

In this alternative approach, the effort consists of preparing estimates of population dose from the routine operation of nuclear power plants based on operating reports such as those prepared in accordance with AEC Safety Guide 21, and on reported data from environmental surveillance reports by the utility company, the AEC, and others. This alternative requires the development or acquisition of critical exposure pathway models for dose computations and methods for making regional and nationwide dose calculations. Data for verification of exposure pathway dose models would be derived from studies performed by others. A data management system would be developed to enable the storage and use of effluent data, transport pathway data, demographic data, and computational models.

Alternative 3 - Proposed Program: Dose estimated in-house from data reported by others; methods validated by field studies.

The Proposed Program consists of estimation of population doses from operating nuclear power plants by the use of validated environmental pathway-dose models. In this program, the radioactivity releases from plants are characterized by acquisition of effluent data from the AEC, from the utility companies, and from state authorities if available. The significant exposure pathways are selected from reported results of the in-depth Strategic Studies of power plants conducted by the Radiochemistry and Nuclear Engineering Research Division of NERC--Cincinnati. A limited number of additional field studies will be conducted at selected, representative facilities to validate pathway-dose models. Once a system for assessing the site-vicinity impact of individual facilities is operational, models will be adopted or developed for calculating the regional impact and the national impact.

Development of a data management system to organize and process the large amounts of data is required. For each facility data are required on effluent radioactivity, on exposure pathways including air, water, and food pathways, on the population distribution and on meteorology. The acquisition of a computer code to calculate exposure by the significant pathways is an important step in the assembly of the data management system. The data management system will have a section for acquisition, preparation, and storage of data, a section for calculating the radioactivity distribution and doses by use of pathway models, and a section for output and storage of results.

The output of this program will contribute to (1) Environmental Impact Statement review, (2) evaluation of the effectiveness of "as low as practicable" technology, (3) evaluation of the adequacy of applicable guidelines and standards, and (4) comparison of actual facility performance with design specifications.

Alternative 4 - Optimum Program: Dose estimated in-house from data reported by others; methods validated by field studies. Unconstrained resources.

The Optimum Program has the same basic structure as the Proposed Program; i.e., estimation of site-vicinity population doses from operating nuclear power plants by validated environmental pathway-dose models using reported data on the sources, site-specific pathway characteristics, population and meteorology, followed by development of regional and nationwide dose estimates, all supported by a computer-centered data management system.

While the Optimum Program has nominally the same scope as the Proposed Program, the Optimum Program could be developed in a time span little more than the minimum, due to the greater application of resources to put a concentration of expertise to work on the program, in particular on the data management. Once the framework of the program is established, attention can be given to improving the depth of technical content. The Optimum Program would thus bring the program to full operation, i.e., impact reporting for all facilities, at an earlier date and permit reevaluation and updating of the program on a shorter time cycle. Minimum time spans for milestone achievement, however, do not permit the Optimum Program to be accomplished much quicker than the Proposed Program. The minimum time spans are determined by the speed of obtaining information, by the speed of communication and response in-house, and by the degree and timeliness of necessary cooperation by other organizations, in particular, the AEC.

Alternative 5: Dose estimated in-house from data reported by others and from data from contracted surveillance of all facilities; methods validated by field studies.

This alternative has the features of the Proposed Program plus continual monitoring under EPA contracts of all nuclear power plants. This alternative is not considered practical due to the amount of time required to bring this program to full operation, the large investment of resources it requires, and the loss of versatility accepted with such an extensive operation. Furthermore, as effluents from individual sources become smaller with improved technology, and sources become closer together increasing the overlap of their influence, the data obtained from external monitoring of individual facilities is likely to become less meaningful.

V. <u>Proposed Program</u>

The program described as alternative 3 in Section IV of this report is recommended as the proposed program because it is cost effective and accomplishes the desired goals.

The solution to the problem of determining the environmental impact of operating nuclear power plants in terms of dose to the population is relatively simple in concept. It involves an assessment of the radioactivity releases from each plant and a determination of the environmental radioactivity levels in the immediate site environs around each plant. The previous information can be translated into resulting population dose by the use of appropriate dose models and computer programs. The computer program approach to the assessment of dose will not only consider individual plants but also the cumulative effects of multiple sources within a given region and on a national basis.

The proposed low-cost program is implemented by the Field Operations Division. FOD will provide program development, technical direction, and will direct and perform the final analysis of data to determine the total impact of nuclear power plants. These assessments will be based upon information received from the regions, the technical service facilities, AEC, states, and licensees. FOD will also provide technical direction for a limited number of field studies directed at validating exposure pathway dose models and effluent data.

The regional offices will continue to be responsible for coordination with the states in obtaining state surveillance data for nuclear power plants.

The technical services facilities (i.e., field laboratories) are responsible for the development of field and analytical data to support the development and verification of exposure pathway dose models and validation of effluent data. Technical direction of the field studies effort will be provided by FOD so that priority program objectives and responsibilities are assigned by a single group.

The basic information derived from this optimum program is assessment of environmental impact of facilities in terms of dose, validation of exposure pathway dose models and reported effluent data, input to the data management systems, input to development of criteria and standards, and input to technology assessment.

A. <u>External Needs</u>

1. Legislative Needs

The present authority vested in the EPA by Reorganization Plan No. 3 appears to provide the necessary flexibility for the EPA to conduct this program.

2. Knowledge

We are fortunate that the voids in our knowledge relative to the component problems and their respective solutions are few in number. A long history of reactor development, the stringent regulatory activities associated with reactor licensing, reactor operating experience and the information assembled during the last 15 years has provided an excellent foundation of knowledge. Information gaps do exist, however, but are not extensive when compared with our general level of knowledge. They are mostly related to refinements in existing areas of knowledge concerning the environmental effects of nuclear power generation. With the development of new waste treatment and reactor technologies, new knowledge gaps will become apparent. These information gaps can be filled through appropriate technology assessment programs.

3. Research and Development

A better understanding of the environmental transport of radionuclides would permit a more accurate prediction of dose to man via the various established food chain pathways. Such doses might also be helpful in defining new or previously unconsidered exposure vectors. These studies would, of course, take into account any reconcentration effects or long-term buildup of activity.

There are inherent errors associated with the current methods used for estimating dose to man from various exposure pathways. These errors are due largely to uncertainties in some of the assumptions that are necessary to estimate doses. An attempt should be made to refine these uncertainties in an effort to improve the accuracy with which dose estimates can be estimated. This is not intended to imply that the errors associated with present dose computation techniques are outside an acceptable range but rather is a suggestion that current techniques can be refined. This is particularly important since the present design basis dose guidance for operating reactors is becoming increasingly smaller.

It is suggested that exposure pathway dose models based on the more refined assumptions be developed into a computer program which will permit translation of environmental radioactivity concentrations into dose to man from any significant exposure pathway.

Developmental efforts to standardize sample collection techniques, analytical techniques, and data reporting formats would assure uniformity in the determination of environmental impact.

Additional developmental work is required to increase the sensitivity of direct radiation measuring devices such as thermoluminescent dosimeters to within the dose range of interest.

4. Interagency Implementation

A close working relationship between AEC and EPA is necessary to avoid duplication of effort where this duplication is undesirable from a cost-effectiveness standpoint.

AEC participation in the program should be limited to (1) a review function for planned and completed activities, (2) an exchange of technical information, and (3) an interface between the EPA and AEC licensees.

B. Internal Requirements

The effective resolution of this problem area is contingent upon the following internal requirements:

1. An inventory of the critical exposure pathways available for each type of reactor and [illegible] reactor sites is the first step in the development of critical exposure pathway dose models. These exposure pathways should include a consideration of any long-term buildup or concentrating mechanisms within the food chain. This information is a generic issue and should be factored into Strategic Studies.

2. Critical exposure pathways must be considered on an individual basis for the development of dose computation models which translate environment radioactivity levels in any exposure pathway into dose to man. This model development should be directed only at those exposure pathways which are anticipated to significantly contribute to man's total dose.

3. Field studies must be developed and implemented that will verify the critical exposure pathway dose models discussed above. These studies should attempt to refine any subjective assumptions inherent in the development of the pathway dose models.

4. Computer applications for the general problem area of OPERATION - URANIUM include both a data management capability for the storage and retrieval of modeling data (demographic data, meteorology, hydrology, source terms, etc.) and the translation of these data, through dose modeling programs, into dose to man.

C. Milestones

The significant milestones for the proposed program are shown in Table 1.

VI. Optimum Program

The problems relat. ' t . ^^^^ATION - URANIUM remain the same regardless of the amount of funds and resources that are available. Therefore, the scope of the Proposed and Optimum Programs is essentially the same. They differ only in the fact that additional funds and resources would permit the Optimum Program to be implemented in greater technical depth and in a quicker time frame relative to milestone accomplishments.

Because of the similarity in the basic problem the component problems of the Proposed Program and this Optimum Program; other considerations, such as, legislation, knowledge, research and development needs as discussed in the Proposed Program above will remain the same. The internal requirements and milestones are also the same.

VII. Impact of Proposed Program Compared to Optimum

Within the above context the variation between the Optimum and Proposed Programs will be related to the technical depth and time frame in which milestones can be completed. The Proposed and Optimum Programs outline an approach for keeping EPA continuously aware on an annual basis, of the performance of each uranium fueled nuclear power plant relative to its potential radiation impact on the environment as well as carry out those activities necessary to evaluate new innovations and problems.

VIII. Expected Accomplishments and Measures of These Goal Attainments

The expected accomplishments and measures of goal attainments in terms of measurable health effects will be indeterminant at the projected dose levels because of the magnitude of the epidemological study required to determine in t[illegible] a causative biological effect relationship. However, it is not altogether unreasonable to expect to find an overall reduction in the health effects (dose to the general population) from nuclear power generation in the future as reactor technology improves. The continued assessment of the population doses from nuclear plants will provide an indication and a measure of this dose reduction factor.

The other major goals are somewhat more tangible and can be considered accomplished when:

1. All critical exposure pathways have been identified for various environmental media, different types of reactors, and reactor sites.

2. Dose computational models considering all of the above have been developed and validated through field measurement programs.

3. A data management system capable of processing the dose computational models derived above.

4. The capability for evaluating the dose from all nuclear power plants is available and used in such a manner that we not only have a cumulative library of doses from a given facility but also have the capability of evaluating any facility at any time. Each of the above represents the attainment of a goal.

The fifth alternative is considered the Optimum Program. It provides monitoring of all facilities by state agencies under contract. Technical support and quality control by EPA assure quality equal to that obtained in the fourth alternative. By involving more local forces in the effort, better insight is obtained into purely local influences on the impact. The costs of administering the large and complex system involved plus the funding of the monitoring contracts limit the cost-effectiveness of this program.

OPTIMUM PROGRAM

The following Optimum Program is premised on the basic assumptions that the necessary resources and technical expertise are available in the regional offices and withing the states involved and that there are no constraints on grants or contracts to states or other contractors. Other commercial contractors would only be considered in those cases where states were either unable or unwilling to participate in the program.

The solution to the problem of determining the environmental impact of operating nuclear power plants in terms of dose to the population is relatively simple in concept. It involves a continuous assessment of the radioactivity releases from each plant and a determination of the environmental radioactivity levels in the immediate site environs around each plant. The previous information can be translated into resulting population dose by the use of appropriate dose models and computer programs. The computer program approach to the assessment of dose should not only consider individual plants but also the cumulative effects of multiple sources within a given region.

Under the generous guidelines for implementation of this problem area, the most worthwhile way to approach the problem on a nationwide basis would be to provide grants or contracts to states for reviewing plant operating data and performing environmental surveillance activities around nuclear power plants. It is not suggested here that these activities be conducted without consideration of what the AEC is presently doing in both of these areas. For, it is the purpose of this program to arrive at a solution to the problem through a combination of independent EPA assessments and field studies in conjunction with information available from other sources such as the AEC. There is no explicit or implied intent to duplicate the work that is presently being performed by the AEC.

The state data will be collated and evaluated by EPA regional offices on a regional basis according to guidelines established by ORP. The final analysis of the impact of each operating nuclear power plant would be made annually by the headquarters staff based on information received from the states through the regions. The Milestone Chart for the Optimum Program is presented in Figure C-25.

Program planning and technical direction would be provided by the FOD. The states and regions would be basically responsible for assessing plant operations in terms of dose and the technical support facilities through field studies would be responsible primarily for validating the dose computational technology used by the states, regions, and headquarters.

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The basic information to be derived from this Optimum Program would be assessment of environmental impact of facilities in terms of dose, validation of exposure pathway dose models, input to the data management systems, input to development of criteria, and standards, and input to technology assessment.

The basic program is directed at obtaining the information necessary to resolve the problem of accurately estimating the doses from nuclear plants. This information is available from a number of sources. To a limited extent the necessary information is available wholly within the EPA. That is, headquarters could direct a program utilizing the technical and analytical resources of the laboratories and other groups within EPA to arrive at an assessment of the environmental impact of nuclear power plants. However, because of the relatively limited resources within EPA, such a program would not be as productive as a program that additionally utilized the resources available with states and/or commercial contractors. Therefore, the Optimum Program takes advantage of all these resources on a grant or contract basis with overall technical direction of the program provided by the Operations Analysis Branch within the Field Operations Division. This, of course, will require a large coordination effort.

Under this program structure the regional offices would, through state or other contractor participation, be assigned the responsibility for the collection, collation, evaluation, and interpretation of data for plants within their region within uniform guides from the Field Operations Division. This information would be forwarded to headquarters for final analysis of the total impact of nuclear power plants and for evaluation of those data which are directed toward validating dose computation models. In the latter regard, field studies (which could also be used in assessing total impact) which use the analytical resources of the field laboratories would be primarily directed at determining critical exposure pathways, validating pathway dose models, and satisfying the requirements for field measurements as specified by the Technology Assessment Division in their continuing effort to keep abreast of changing or advanced reactor technology.

External Needs

Legislative Needs

The present authority vested in the EPA by Reorganization Plan No. 3 appears to provide the necessary flexibility for the EPA to conduct this program. It appears taht what would be more desirable than legislation at this point is a memorandum of understanding between the AEC and the EPA regarding the guidance of activities discussed in this problem area.

Knowledge

We are fortunate that the voids in our knowledge relative to the component problems and their respective solutions are few in number. A long history of reactor development, the stringent regulatory activities associated with reactor licensing, reactor operating experience and the information assembled during the last 15 years has provided an excellent foundation of knowledge. Information gaps do exist, however, but are not extensive when compared with out general level of knowledge. They are mostly related to refinements in existing areas of knowledge concerning the environmental effects of nuclear power generation. With the development of new waste treatment and reactor technologies, new knowledge gaps will become apparent. These information gaps can be filled through appropriate technology assessment programs.

Research and Development

The biological effects of chronic exposure to low-level radiation in the range of doses that one might expect from power reactor operations on an individual and cumulative basis are still uncertain and will probably continue. Therefore, studies directed at determining these effects should continue in an effort to verify with greater certainty that the linear dose effect hypothesis which is presently assumed for low doses is valid.

A better understanding of the environmental transport of radionuclides would be instrumental in permitting a more accurate prediction of dose to man via the various established food chain pathways. Such doses might also be helpful in defining new or previously unconsidered exposure vectors. These studies would, of course, take into account any reconcentration effects which occur in the various media in each food chain pathway.

There are inherent errors associated with the current methods used for estimating dose to man from various exposure pathways. These errors are due largely to uncertainties in some of the assumptions that are necessary to estimate doses. An attempt should be made to refine these uncertainties in an effort to improve the accuracy with which dose estimates can be made. This is not intended to imply that the errors associated with present dose computation techniques are outside an acceptable range but rather is a suggestion that current techniques can be refined. This is particularly important since the present design basis dose guidance for operating reactors is becoming increasingly smaller.

It is suggested that exposure pathway dose models based on the more refined assumptions be developed into a computer program which will permit translation of environmental radioactivity concentrations into dose to man from any significant exposure pathway.

Developmental efforts to standardize the collection of environmental samples, analytical techniques and reporting formats would be very useful in assuring uniformity in the determination of environmental impact.

Additional developmental work is required to increase the sensitivity of direct radiation measuring devices such as thermoluminescent dosimeters to within the dose range of interest.

Interagency Implementation

The largest single obstacle facing the implementation of this optimum program or any other program sponsored by the EPA which attempts to evaluate the environmental effects of AEC lincensed facilities is the interface between the EPA and the AEC. Recently, this interface has been the subject of a great deal of controversy between the EPA and the AEC. The EPA still does not have a satisfactory resolution of the position of the AEC relative to our programs directed at evaluating the environmental impact of operating reactors. Without a memorandum of understanding concerning the AEC's position and a resolution of the AEC policy issues created by EPA's program efforts in this area, it will be difficult, if not impossible, to proceed with this program.

Internal Requirements

The effective resolution of this problem is contingent upon the following internal requirements:

1. An inventory or library of the critical exposure pathways available for each type of reactor and various reactor sites and other considerations is the first step in the development of critical exposure pathway dose models. These exposure pathways should include a consideration of any reconcentrating mechanisms within the food chain. This information is a generic issue and should be factored into the generic issue of monitoring.

2. Critical exposure pathway must be considered on an individual basis for the development of dose computation models which translate environment radioactivity levels in any exposure pathway into ultimate dose to man. This model development should be directed only at those exposure pathways which are anticipated to significantly contribute to man's total dose. Pathways of lesser significance, although of importance from an academic standpoint, are not necessary from the standpoint of determining dose to man.

3. Adequate field studies must be developed and implemented that will validate the critical exposure pathway dose models discussed above. These studies should attempt to refine any subjective assumptions inherent in the development of the pathway dose models.

4. Computer applications for the general problem area of Operations-Uranium include both a data management capability for the storage and retrieval of modeling data (demographic data, meterorology, hydrology source terms, etc.) and the translation of these data into environmental dose modeling programs.

PROPOSED PROGRAM

The third alternative program described in the previous section, is recommended as the Proposed Program, because it is cost effective and accomplishes the desired goals. The Milestone Chart for the Proposed Program is presented in Figure C-26.

The Proposed Program considers the present guidance on staffing and budget. It is identical in scope with the Optimum Program because the problems are the same for each program. It differs from the Optimum Program only in its method of implementation and the rate of accomplishments and attainment of goals. The Proposed Program, because of constraints on resources, would compromise the number and frequency with which the environmental impact of nuclear power plants could be determined. It will not, however, compromise the scope of the functional elements necessary to resolve the problem. It is doubtful that the Proposed Program would permit all operating reactors to be evaluated annually.

The proposed low-cost program is implemented by the Field Operations Division. FOD will provide program development, technical direction, and will perform the final analyses to determine the total impact of

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nuclear power plants based upon information received from the regions, the technical service facilities, AEC, states, and licensees. FOD will also provide technical direction of field studies directed at validating exposure pathway dose models and effluent data. The regional offices will continue to be responsible for coordination with the states in obtaining state surveillance data for nuclear power plants.

The technical services facilities (i.e., field laboratories) will be responsible for the development of field and analytical data to support the development and verification of exposure pathway dose models and validation of effluent data. Technical direction of the field studies effort will be provided by FOD so that priority program objectives and responsibilities will be assigned by a single group.

Because of the similarity in the basic problem the component problems of the optimum program and this proposed program are identical; other considerations, such as, legislation, knowledge, research and development needs, as discussed in the optimum program above, will remain the same. The internal requirements are also the same.

The only difference between the two program with regard to interagency implementation is the elimination of many of the state's responsibilities as previously defined and assumption of those responsibilities by FOD. The states would continue to participate in this program by providing environmental surveillance data around nuclear power plants which is sponsored either by the state, AEC, or the EPA. The states would have no further responsibility in this program.

COMPARISON OF OPTIMUM AND PROPOSED PROGRAMS

The problem area of Operations - Uranium encompasses the ORP activities related to the uranium-fueled reactors which for decades to come will constitute the public's most common interface with the nuclear fuel cycle. Most radiation impact problems from routine operation associated with these facilities are considered soluable of the EIS review, this effort is basically one of maintenance, evaluation of performance, and examination of new innovations. Some notable exceptions to this basic premise will need to be considered such as decommissioning, multiple facility siting, and evaluation of the new generation HTGR.

Within the above context the variance between the Optimum and Proposed Programs will be related to the degree of thoroughness and timeliness of the effort. The Optimum Program outlines an approach for keeping EPA continuously aware on an annual basis, of the performance of each uranium-fueled nuclear power plant relative to its potential radiation impact on the environment as well as carry out those activities necessary to evaluate new innovations and problems. The Proposed Program would not allow the EPA to maintain its cognizance of the industries routine performance on a current basis. Although, as long as the AEC is maintaining its current activities, this in itself would not have a major deleterious effect on the environment and health of the nation, it would have two significant secondary effects. First, this Agency would need to be content with a second place position in the eyes of industry and the public due to its lack of current information. Secondly, other portions of the ORP program, such as EIS review and Strategic Studies would suffer from lack of the insight that current operation analysis should give them.

MEASURES OF GOAL ATTAINMENT

The expected accomplishments and measures of goal attainments in terms of measurable health effects will be indeterminant at the projected dose levels because human biological effects at these low doses are not measurable with existing techniques. However, it is not altogether unreasonable to expect to find an overall reduction in the health effects (dose to the general population) from nuclear power generation in the future as reactor technology improves. The continued assessment of the population doses from nuclear plants will provide an indication and a measure of this dose reduction factor.

The other major goals are somewhat more tangible and can be considered accomplished when:

- All critical exposure pathways have been identified for various environmental media, different types of reactors, and reactor sites.
- Dose computational models considering all of the above have been developed and validated through field measurement programs.
- A data management system capable of processing the dose computational models derived above.
- Data and techniques are available for the immediate evaluation of any nuclear power plant proposal.

FABRICATION-URANIUM

PROBLEM DESCRIPTION

The problem is to determine, assess and mitigate the environmental impact of normal operations of nuclear fuel processing, enriching and fabrication facilities in terms of dose to the population.

Component Problems

The problem consists of three basic components: technology assessment of effluent control practices, assessment of doses due to facility effluents, and dose apportionment for this part of the nuclear fuel cycle. Each component problem has associated sub-elements.

For an adequate technology assessment, current practices must be compared to foreseeable alternatives. Based upon a multidimensional risk/cost/benefit analysis, justifiable ORP recommendations to the AEC can be made, reducing risk where desirable.

In assessing population dose the following sub-elements must be considered:

- characterization of facility effluents by radionuclide,
- definition of all significant exposure pathways,
- development of exposure pathway (radionuclide transport) models,
- development and verification of dose models,
- computation and interpretation of doses and
- development of an automated data management and analysis system to reduce the analysis task to a manageable level.

Dose apportionment to this part of the fuel cycle will be straightforward when these problem sub-elements are all satisfactorily solved.

Uranium

Uranium displays both chemical and radiological toxicity. The maximum permissable concentration (MPC) of transportable natural uranium in the human is limited by the chemical damage to the kidney rather than radiation damage. MPC of non-transportable compounds of natural uranium in the lung or gastrointestinal tract is limited by the doses of radiation they deliver. When natural uranium is enriched twelvefold, control based on radiation dose from uranium-235 becomes necessary.

HTGR

The fuel elements for the HTGR consist of uranium and thorium carbides or oxides in all graphite matrix. While the light water reactor fuels contain U-235 and U-239, the HTGR reactor fuels contain U-233 in addition to the above mentioned isotopes and thorium. It is noteworthy that the ICRP recommends that thorium exposure be kept as low as possible (vs. practical).

Enrichment

Enrichment facilities are all AEC-owned facilities. One expects controls and environmental programs to be considerably more advanced at these facilities.

Background

The Fabrication-Uranium problem area encompasses those steps in the fuel cycle from the mill to the power plant (yellow cake to fuel element). It includes the identical stages of the thorium fuel cycle and is intimately related to the Fabrication-Plutonium problem area.

The radionuclides in this problem area are predominantly of "natural" origin. The problem exists because of their redistribution and concentration. To date the AEC has not imposed upon the facilities the requirement to report effluent data sufficient for a dose assessment. An independent indepth study of typical facilities has not been made. As a result there is inadequate data to support the present estimate that the dose associated with these facilities is low.

The AEC is presently taking steps which will partially rectify the problem. On March 24, 1972, the AEC requested industry comments on a draft effluent reporting license requirement similar to that of AEC Safety Guide 21 for the nuclear power industry. AEC expects to implement their license requirements in early 1973. Effluent data should then be available by early 1974. An AEC environmental data licensing requirement will follow in FY-74. Such data can be manipulated by the EPA regional and national automated data management system providing that the pathway and dose models are developed and verified in a timely fashion. Facility participation in an EPA analytical quality control service (AQCS) program will assure valid data.

Scope

Present

The present status of the number and location of uranium and thorium materials handling facilities in the U.S. is reported in The Nuclear Industry 1971, WASH 1174-71. Table C-15 summarizes the data for uranium and thorium fuels. One or several of the stages of uranium processing leading to fuel fabrication may take place at a given locality.

Table C-15

URANIUM PROCESSING FACILITIES IN THE U.S.

Facility	Number of U.S. Facilities	EPA Regions
Uranium Mills	20	VI, VIII, X
Conversion U_3O_8 to UF_6	2	V, VI
Enrichment	3(AEC Owned)	IV, V
UF_6 to UO_2	7	IV, VI, VII, X
UO_2 Pellets	8	I, III, IV, VI, VII
U Fuel Fabrication (including Special Fuels)	14	I, II, III, IV, VI, IX
Carbide Fuels	8	II, III, IV, VI, VII, IX
Thorium	7	I, IV, VI, VII, IX

GGA ?

The uranium mills listed in Table C-15 represent 16 companies with plants at 20 locations. The other types of uranium or thorium materials handling capability are for 20 companies at 27 different locations. Excluding the two U_3O_8 to UF_6 conversion plants, all other locations include multiple capability for uranium and thorium fuels at a given plant location.

Future

The requirements for processing and fabrication services for uranium and thorium fuels in the future are expected to increase at the rate of increase which commercial nuclear power stations are constructed and placed in operation. The Nuclear Industry 1971 indicates future domestic needs will be met by construction of new facilities at several new locations and expansion of existing fuel fabrication facilities presently operated by the major nuclear steam plant suppliers.

Expansion of uranium conversion facilities is expected to take place at the two existing plants and addition of the process for conversion of slightly enriched U (less than 5%) to UF_6 at fuel reprocessing plants.

Expanded needs for uranium enrichment are expected to be provided by commercial domestic development. One such plant has been proposed by Reynolds Aluminum Corporation. As the LMFBR and light water recycle of plutonium are introduced, enrichment demands by the nuclear industry decrease. AEC projections indicate enrichment demands should peak and decrease by 1990. New enrichment capacity would be required by 1981.

The scope of this program is expected to decrease significantly with time. Some facilities process only solid materials. Many process only uranium. Doses associated with these facilities are expected to be relatively low. Also, the environmental programs and effluent controls of a few facilities are already extensive and their impact is low.

Related Problem Areas

Accidents, waste disposal, fuel reprocessing, fabrication-plutonium, operation-plutonium, operation-uranium, occupational radiation and transportation are related problem areas. For the purpose of problem definition, the accident potential from fire, criticality and chemical releases to the environment have been excluded. Waste disposal of uranium and chemicals has been excluded other than the amounts routinely released during normal operation.

LEGISLATIVE STATUS

Sufficient operational latitude presently exists under the broad authorities transferred to the EPA from the FRC and AEC and from implementation of the Clean Air Act or the Federal Water Pollution Control Act.

COORDINATION

Interagency

- Since all fuel processing and fabrication facilities are either AEC licensed or contractor operated for the AEC, intimate AEC/ORP interactions will be the norm.
- Since fuel processing effluents are chemical and radioactive with respect to toxicity, ORP will interact strongly with state

air and water quality offices as well as state radiation offices.

- The expertise of the Bureau of Mines (Department of Interior) would be utilized.
- Department of Agriculture, ESSA (NOAA), would provide support in the areas of air transport, dispersal mechanisms and meteorological information.
- CEQ may become involved if interagency negotiations reach an impasse over critical issues.

Intra-agency

- Regional offices will play a role in this program.
- OCP support facilities will be involved in an AQCS activity.
- Because of the bulk chemical wastes involved in this problem area, OWP and OAP support will be solicited.
- OTS has expressed confidence in ORP to handle this problem area; however, because of the chemically toxic nature of the wastes, they will be encouraged to participate in at least an advisory capacity.

ALTERNATIVE APPROACHES

Alternative problem solutions were considered within the framework of NEPA, the President's Reorganization Plan No. 3 and the ORP Programming/ Budgetary Proposals for FY 1973 and FY 1974. Solutions such as allowing the states, the AEC or another Federal agency to solve the problem were dismissed as non-responsive to EPA responsibilities. Solutions such as having other EPA offices (such as the Regional Offices, OAP, OWP, or OTS) solve the problem were dismissed as being non-responsive to ORP responsibilities.

The ORP problem solution was developed in recognition of present and future AEC activities, the controllability of the effluents, the predominantly chemical toxicity of the effluents and the assigned weight of this problem.

It was recognized that a small scale program would provide a problem solution within three years, with major tasks completed within two years. Because of physical constraints, a larger program would not effect a solution in proportionately less time. Thus, only one program (the Proposed Program) was developed.

PROPOSED PROGRAM

The Proposed Program requires two separate but allied efforts: a technology assessment in support of EIS reviews required under NEPA and a dose assessment of all facilities in this problem area.

The goal of the technology assessment is to mitigate the environmental impact by requiring the best practicable effluent control technology for each facility. For newer facilities, EIS reviews by ORP would be used as a means to that end. Older facilities would be upgraded by the AEC if their effluents produced doses in excess of their EPA assigned dose apportionment.

As shown in the milestone chart, Figure C-27, the required technology base will be established in three steps: (1) the present state-of-the-art will be appraised, this includes on-site appraisals, (2) forseeable advances in control technology, or alternative processing techniques will be assessed and (3) the relative benefits and costs of (1)

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and (2) can be compared. From this base the risks ascribed by the dose assessment activities can be evaluated against the costs and expected benefits of new technology. Justifiable positions can be attained thereby.

The dose assessment effort begins with a preliminary assessment of dose potential due to the facilities. This will be accomplished by analyses of the gross radioactivity releases presently reported by them. Based upon expertise developed within ORP in the past, radio-nuclide transport (Pathway) and dose models will be developed. Field studies will be inaugurated to provide a firm data base to verify these models. Once verified, the models will be made a part of the automated data management and dose calculational computer code being developed concurrently within a separate ORP generic problem area.

As shown in the milestone chart, AEC imposed license requirements will result in a semi-annual influx of facility generated effluent and environmental data by FY 75. The facility data will have been verified by the EPA AQCS program. Via previous ORP interactions with the AEC, the data will be in a known form and format. The successful and timely completion of the dose assessment tasks will result in an ORP capability to automatically analyze this effluent data. Dose assessments at that time can aid CSD in their dose apportionment activities. Further, by having successfully exercised the ORP computerized system, it will be possible to include it as an operational sub-program in the regional and national automated system in FY 75.

This Proposed Program utilizes maximum leverage to achieve the data necessary to perform a continual dose assessment. All problem elements will be solved by FY 75; major tasks will be accomplished in FY 74. In the sense that it is a timely and cost-effective program, it is an optimum program.

External Needs

Legislative Needs

- Federal - None
- State - State water quality standards for uranium and process chemicals may be needed.

Knowledge and Information

Knowledge and information for initial study fo the problem exists within the open literature, AEC, EPA (OWP), and USGS publications.

R&D Needs

These needs will be met by collection and correlation of existing knowledge and information.

Enforcement and Control Requirements

AEC must impose new license requirements upon facilities, requiring semi-annual reports of effluents by radionuclide.

Interagency Implementation

By commenting upon AEC license amendment drafts, ORP must be assured that the licensee effluent reports will provide data adequate for a dose assessment to be made. The facilities must participate in the EPA AQCS program.

Internal Needs

Legislative

None

Knowledge

Although sufficient background information presently exists in the open literature, such must be accumulated and digested by ORP.

Research and Development Needs

Basic research and development activities will not be required. Assimilation and calibration of state-of-the-art equipment may be necessary for the EPA AQCS program and for the field studies.

Enforcement and Control Requirements

CSD must provide at least a broad population dose guidance and numerical guides if possible. CSD through the AEC must require the facilities to provide site-specific demographic data; a detailed description of the habits of suitable samples of local populations are necessary inputs to models for dose calculations.

OPTIMUM PROGRAM

The Proposed Program is essentially an Optimum Program.

MEASURES OF GOAL ATTAINMENT

The primary goal of these programs is to effect adequate control of all facilities. The control will be effected by the AEC under dose apportionment guides set by the EPA.

Progress toward achieving this goal may be measured by the satisfactory completion of the following activities:

- Implementation by the AEC of facility license amendments to require reporting of radionuclide concentrations in effluents.

- Delineation of all pathways transporting radionuclide effluents through the environment.
- Development and verification of dose models.
- Apportionment by EPA of doses to the nuclear energy field and establishing dose standards for fuel fabrication.
- All facilities participating in an EPA AQCS program.
- Development, verification, implementation of an automated ORP data management system which will translate facility effluent data into dose and dose commitment.
- An upgrading of any facility to effect significantly better effluent control, reducing risk.

TRANSPORTATION

PROBLEM DESCRIPTION

Component Problems

- Nuclear Power Industry
- Industrial Users
- Medical Users
- Other (Plowshare, SNAP, etc.).

Background

The AEC has acheived an impressive safety record in the transportation of nuclear material for their device testing and production programs, as has the Navy for their nuclear ships. Industrial and medical shipments have not presented a major problem since the number of shipments has been relatively small. There have been a few instances of lost sources and of leaking sources. Several of these instances have involved radium which has been in wide use for a much longer time than reactor produced radionuclides.

Responsibility for the safe shipment of radioactive materials has been transferred around the Federal and state governments during the past years. This situation has produced a complex regulatory system. Nuclear Assurance Corporation has prepared probably the most digestible analysis of the situation by breaking the regulators into three categories: Carrier Regulators, Safety Regulators, and Commodity Regulators. In this breakdown, the Interstate Commerce Commission, the Civil Aeronautics Board, and the state Public Service Commissions are the carrier regulators. Various Administrations within DOT, the

CAB, and the state Highway Commissions are the safety regulators. The AEC and various state agencies are the commodity regulators. For radioactive material shipments, and in particular nuclear fuel shipments, the responsibility is shared by several of the regulating authorities. For example, the AEC and DOT have a memorandum of understanding which delineates the responsibilities of their respective agencies in the shipment of nuclear fuel.

Scope

The problem is identified readily by projecting the transportation requirements for the nuclear power industry. By 1990 the AEC projects 350 to 400 operating nuclear power plants in the U.S. Each plant will ship about 100 truckloads of spent fuel (the most hazardous form) per year an average distance of 500 miles. Thus, the total mileage for spent fuel shipments will be about 20 million miles annually. The accident rate for large trucks is about 2 accidents per million miles with about 10% of the accidents classified as serious or causing considerable damage. Thus, 40 accidnets per year involving spent nuclear fuel in shipment from reactors to reprocessing plants can be expected in 1990. About 4 serious accidents per year would also be expected. In addition to potential releases from accidents, the routine exposure to populations along the route must also be considered. This exposure may become significant near reprocessing centers where shipments will be concentrated on a few routes.

A second problem is the shipment of recycled plutonium fresh fuel to LWR's and of U-233:U-235 fresh fuel to HTGR's. Plutonium and U-233 require greater shielding for external exposure than enriched uranium and, of course, present more of a criticality problem under certain conditions.

It appears the largest potential problem is the shipment of spent fuel from LMFBR's to reprocessing plants. The combination of much larger quantities and a shorter cooling time (30 day estimate) indicate that transportation will quite likely be the limiting factor in both site selection and size of LMFBR's. Although much work is required, it is suspected that the economics of transportation may well dictate the necessity of nuclear energy parks in a breeder power program. A summary of the scope of the transportation problem for the nuclear power industry is presented in Table C-16.

Most of this discussion deals with the nuclear power industry because of the growth potential. However, radioactive shipments to medical and industrial users are also expected to increase significantly. In general, the consequences of both routine shipments and accidents are lower than those for nuclear power. This problem should also receive attention to insure protection of health and safety.

COORDINATION

Interagency

Because of the large number of regulators involved in this area the interagency coordination could become a rather extensive effort. However, it can be considerable simplified for purposes of the proposed program.

Table C-16

SUMMARY CHART FOR TRANSPORTATION
REQUIREMENTS OF NUCLEAR POWER INDUSTRY

Media	Mode	Path	Form	Control
Spent Fuel	Truck	Mine to Mill	Solid	AEC
High Level Waste	Rail	Mill to Conversion /Enrichment	Liquid	DOT
Low Level Waste	Air		Gas	States
Pu fuel	Barge	Enrichment to Fabricator		ICC
U Fuel		Fabricator to Reactor		CAB
U-233 Fuel				
Mixed Fuel		Reactor to Waste Site		
U Ore		Reactor to Reprocess		
		Reprocess to Waste Site		
		Reprocess to Fabricator		
		Reprocess to Conversion/ Enrichment		

Headquarters

Cognizance of AEC and DOT efforts in promoting and regulating the transportation of nuclear materials and response to EIS's concerning this topic.

Regional

Coordination with state and local jurisdictions and Federal agencies such as OEP and AEC for the development of emergency response capabilities.

Intragency

It is anticipated that ORP coordination within the agency will fall largely with FOD and the regions in attempting to develop emergency response capabilities. Transportation estimates may be required as input to OSW in their attempts to evaluate the feasibility of Federal hazardous waste repositories.

ALTERNATIVE APPROACHES

Reduced Efforts

EPA participation in the development of emergency response capabilities can be reduced or eliminated. The technical evaluation of trasnportation for the nuclear power industry can also be eliminated and comments on the subject deleted from EIS reviews. However, a contract has been awarded for an analysis of transportation accidents.

Expanded Efforts

EPA could seek the lead role in emergency response through the currently established National Contingency Plan. At present the AEC has the lead role in the radiation area. Participation in the technical development of transportation methodology would require a large effort in terms of man-years and the establishment of working agreements with other agencies.

OPTIMUM PROGRAM

External Needs

Legislative Needs

Legislation is required to enable the EPA to exert control over the shipment of hazardous materials which may lead to contamination of the environment. Such legislation should be closely tied to any proposed system of federal hazardous waste repositories which is currently under study by OSW. Radioactive material shipments under this legislation would require recognition and consideration of existing enabling legislation given to DOT and AEC.

Knowledge

- Nuclear power projections and related transportation requirements
- Potential problems related to the multiple regulatory agencies involved with the inevitable inconsistencies in regulations
- The status of shipping cask development
- Accident statistics for hazardous material shipments
- The status of various modes of shipment (Air transport will be proposed for fresh fuel shipments - Railroads are refusing to ship radioactive material - etc.)

- An analysis of the potential consequences of radioactive material shipment accidents
- An analysis of the potential impact of routine radioactive material shipments
- Costs of shipments especially spent fuel for siting criteria
- Capabilities of state and local jurisdictions for emergency response

Research and Development Needs

- Develop emergency response models and plans
- Develop TLD system for selective monitoring along much travelled routes.

Enforcement and Control Requirements

Routine enforcement should be performed by the regulating agencies, i.e., the states, AEC, and DOT. Overall indirect control may be effectively applied by EPA through siting criteria and guidance or criteria for the energy park concept.

Interagency Implementation

DOT. Liaison with DOT concerning hazardous material shipments relative to federal hazardous waste repositories, and associated legislation. Emergency response requires coordination with DOT.

AEC. Working agreement must be negotiated concerning emergency response lead agency. Exchange of technical information is required. Liaison needed concerning transportation of radioactive material to Federal hazardous waste repository (this is closely related to the issue of whether a system of Federal repositories will be established, who will run them and if radioactive waste will be included). Conduct training courses.

OEP. Liaison concerning emergency response is needed. Definition of lead agency.

States. Development of emergency response models and plans. Cognizance of state regulations concerning radioactive materials shipments.

Internal Needs

- Develop technical staff within ORP
- Develop legal/liaison staff in coordination with OSW
- Generate other information needed for energy park criteria (siting, reprocessing, fabrication, sizing, etc.)
- Develop model plans at regional levels.

PROPOSED PROGRAM

This program is the same as the Optimum Program with the exception of legislative requirements which are deleted here. The Milestone Chart for the Proposed Program is presented in Figure C-28.

COMPARISON OF OPTIMUM AND PROPOSED PROGRAMS

The impact difference between the two programs rests almost entirely on the decision made concerning the system of Federal hazardous waste repositories. If the decision is made to establish such a system and if radioactive material is to be stored in this system, the transportation issue would require definition and delineation.

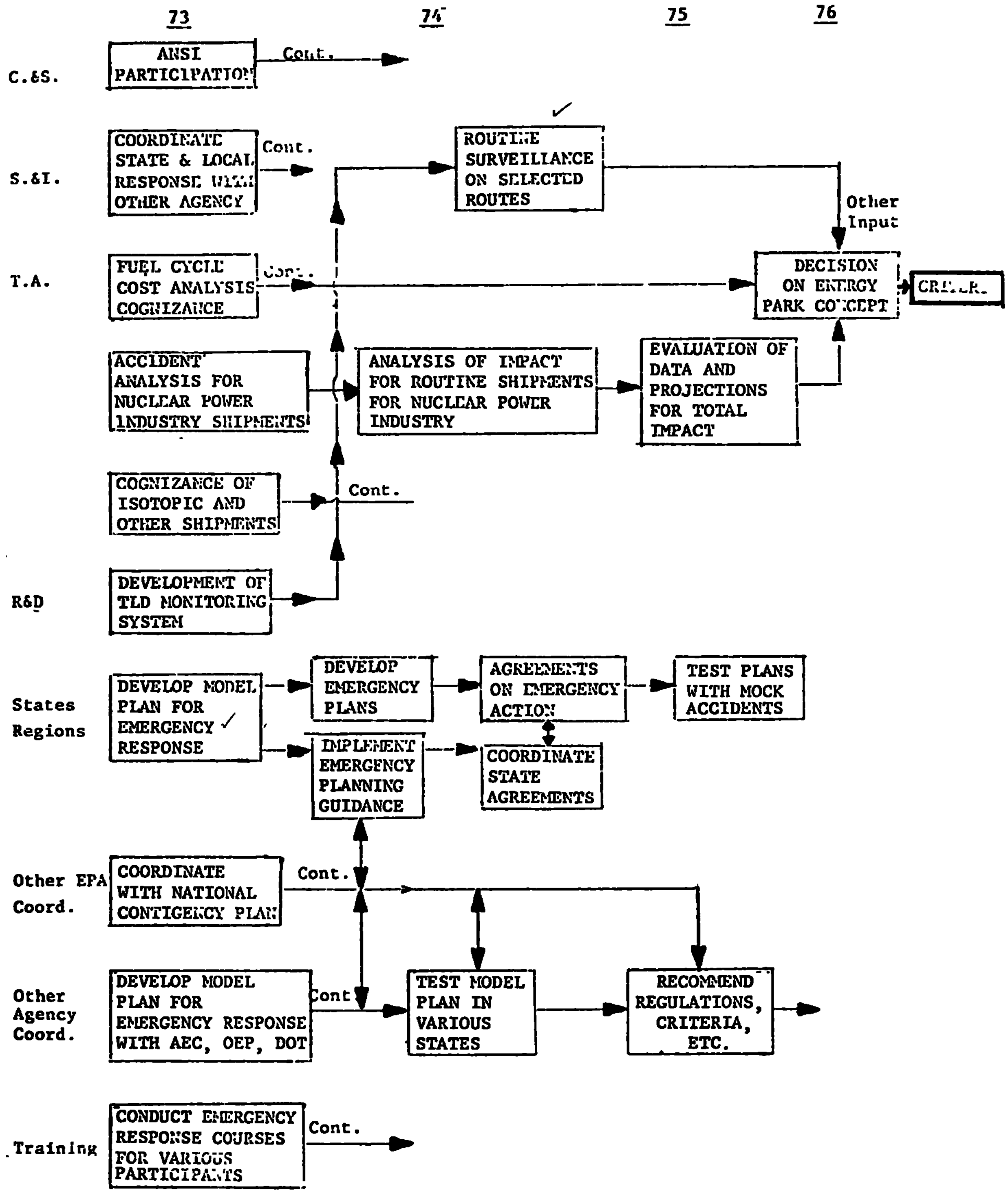

FIGURE C-28

PROPOSED PROGRAM - TRANSPORTATION

MEASURES OF GOAL ATTAINMENT

- Emergency Response Model - complete by FY 1974
- Emergency Response Plan - completed by first half of FY 1975
- Emergency Response Plan Test - completed by second half of FY 1975
- Development of TLD Monitoring System - completed by FY 1974
- Routine Survillance on Shipment Routes - in effect during FY 1974
- Accident Analysis - report completed by FY 1974
- Routine Shipment Analysis - report completed by FY 1975.

CONSTRUCTION MATERIALS

PROBLEM DESCRIPTION

Component Problems

Construction materials account for the largest exposure to the U. S. population resulting from man-caused radiation sources. The problem has not been considered previously by the radiation protection community due to the consideration of the problem as a component of natural radiation, a subject which has been generally neglected. Although construction materials generally attenuate man's exposure to natural terrestrial radiation sources, the reduction is usually offset by the contribution from construction materials themselves, so that there is generally no net change of man's natural radiation exposure due to living in most dwellings. This paper focuses on the potential for exposure through the unknowing and inadvertent use materials bearing elevated levels of natural radioactivity.

There are basically two major component problems of the construction material exposure problem:

1. Whole body exposure to the gamma radiation from K-40 and daughter products of Th-232 and U-238 within the construction material.

2. The inhalation of radon daughters which emanate from the construction materials and result in lung exposures to occupants of dwellings.

The first source of exposure generally accounts for 40-100 mrems/year to the population, or an integral dose equivalent of approximately 8 x 10^6 man-rems. Although there is less quantitative information on man's exposure due to radon daughter exposure, radon daughter products have been measured in various types of dwellings and contribute 1 - 2 rems/year to lung tissues.

A third component problem of the construction material issue does not relate to the construction material exposure per se, but rather to the difficulty in attracting interest to the subject as a serious issue for consideration. Part of this lack of interest may probably be attributed to the fact that natural radiation exposure does not appear to hold the same technical challenges which are associated with exposures to nuclear reactors, fuel reprocessing plants, microwave sources, etc.

Background

Little attention has been given to the incorporation of naturally-occurring radionuclides into our man-made environment, as evidenced recently by the use of uranium mill tailings in construction. Recent studies by EPA of 43,000 structures in 61 communities in western states showed that natural radiation anomalies existed in 6,400 of the surveyed dwellings. The widespread occurence of these anomalies, which were due to high levels of natural radiation in building materials as well as landfill, indicates that the problem is considerably larger in scope than suspected. In addition, certain areas in Florida and Tennessee have been found in which the incorporation of high levels of radioactivity into building materials has increased the exposure of residents.

Even though man's radiation exposure from natural sources varies significantly with geology and elevation, it is properly beyond the scope of government to dictate where people should live relative to their natural radiation exposure. On the other hand, man's propensity for indoor living can influence his exposure because of the variations of naturally occurring radioactivity in building materials; therefore, our concern should be in this area rather than with one's geographical choice of residence. If buildings are made mostly of wood, which has a low natural radioactivity, the overall exposure is reduced because there is some shielding of terrestrial radiation. In contrast to this situation, homes built with masonry, wallboard or stone walls can increase man's exposure to natural sources. The degree to which building trends emphasize use of wood or these other materials will thus influence the changes in the national exposure from this source of radioactivity.

There are limited data available on the precise type of materials used in the construction of dwellings. In view of the amount of new construction which will be built in the United States between now and 1978 (approximately 20 million housing units for 60 million people), it is important to determine the significance of building materials as a potential source of radiation exposure to man. The materials which will be incorporated into these housing units are basically without government control with the exception of concern for structural and fire safety.

The major initial program efforts for materials containing natural radioactivity should be to increase knowledge of the degree of exposure. Current EPA activities are twofold: 1) completion of a general survey of literature pertaining to variations in exposure to natural background in the United States and 2) working with experts in Poland to obtain more extensive field data on the influence of variations in natural background on population dose. These information-gathering programs will be followed by studies of means that could be employed to reduce current exposures and other means for preventing possible future exposures in man-made environments. In order to pursue any major programs to reduce exposure via these routes, it will be necessary to estimate the expected dose savings (in man-rem) that could occur. The difficulties of regulating building material industries and construction practices would be justified only if substantial man-rems could be averted. If estimates indicate a justifiable effort in this area, considerable work will be required to determine the national exposure, to conduct inspections of various high-level sources of basic construction and building materials, and the development of criteria and standards governing their use.

Virtually no attempt has been made to reduce or examine man's exposure to natural radiation sources. The resulting lack of information was particularly evident when EPA was invited to participate in the review of human exposure in several Western states which resulted from the inadvertent use of uranium tailings in various structures. Studies in Grand Junction, Colorado, and other localities have shown that the indoor radon levels resulting from uranium tailings present in building materials and in land fill account for significant exposure to inhabitants in buildings which contain tailings.

Other than operating experience in Grand Junction, which has not been documented in the technical literature, there are few papers on the subject of exposure to building materials. The paucity of information is an interesting contrast to the volumes of materials which occupy the technical literature on radiation exposure due to relatively safe sources such as nuclear reactor waste discharges during normal operation.

Scope

The present scope of the problem is nationwide; the anticipated construction of additional dwellings to relieve a nationwide housing shortage will add to the problem.

An increasing use of man-made materials in dwellings suggests that additional information is required on the nature of these materials before wide-scale use of new materials is justified. Such caution could have prevented the unnecessary exposures which are now occurring to inhabitants in Grand Junction and other localities.

LEGISLATIVE STATUS

At present there is no legislation which controls the levels of radioactivity present in construction materials. Although construction materials must pass the Federal, State, and local standards for fire safety and structural strength, there are no statutes which would allow the removal of construction materials from the market which might be determined to contain elevated levels of radioacitivity. At the Federal level, it appears that EPA, HUD or the FDA could undertake the responsibility for implementing enforcement of safe levels of exposure due to construction materials. However, under the authority transferred to the EPA by Reorganization Plan No. 3, it is the responsibility of EPA, under the Federal Radiation Council's guidance authority, to establish guidelines for use by Federal agencies for exposure to natural radiation sources.

COORDINATION

Interagency Coordination would be required with those agencies having an input into the selection and quality of construction materials used in the United States. Therefore, interagency cooperation may be necessary between HUD, the various branches of the government which control financing of construction, and various state and local agencies which establish building codes. As previously noted, EPA's FRC guidance function places primary responsibility upon EPA for taking the lead in providing safe exposure criteria to other Federal agencies.

Intra-Agency Coordination would be required with the Office of Legislation to determine the best possible approach for legislating man's allowable exposure to natural sources in construction materials. In addition, the Office of Research and Monitoring would be requested to assist in the nationwide determination of the present level of radioactivity present in various construction materials.

ALTERNATIVE APPROACHES

First Alternative

HUD implements standards which would be binding upon lending agencies and which would require certain levels of radioactivity in construction materials. These standards would be established as a result of EPA guidance to all federal agencies. The ORP would act as technical consultant in determining the extent of the problem and recommending a level for construction materials, but HUD would carry out the actual exposure reduction on a nationwide basis.

Second Alternative

EPA would request the Food and Drug Administration (or new Consumer Protection Agency) to use their consumer protection authority to remove potentially unsafe materials from the market. EPA would provide FRC guidance for acceptable exposure levels.

Third Alternative

A third alternative approach would be for EPA to seek legislative authority to recuce man's exposure to construction materials. This would enable EPA to establish national standards as well as guidance to other Federal agencies.

Fourth Alternative

Do nothing. This approach would not involve any damage to EPA since there has little public interest in the problem in the past, and it is not likely that interest will develop in the future if no government activity is initiated.

OPTIMUM PROGRAM

At present there is no legislation concerning the use of building materials insofar as natural radiation is concerned. It should be noted that legislation is required immediately to initiate EPA's effort under an optimum program. The legislation is required in order to respond effectively to HUD, which seeks to establish a limit on exposures resulting from building material radioactivity. During FY 1976, it is likely that legislation would be necessary to permit an enforcement role for EPA to license building material suppliers. In addition, it would be useful to request posting of exposure levels in high dosage areas where building materials using high levels of natural radioactivity were once used. This procedure could be useful in the case of resale of a residence in the Grand Junction area, for example.

Virtually no information exists at present on the natural radiation content of building materials. In order to fill this knowledge gap, two approaches are required in order to gain information.

One is research and development, which would concentrate upon the correlation of external gamma levels with indoor radon levels and the effect of inhaled particles on lung tissue. In addition, it is necessary to study the possible substitution of material bearing low levels of radioactive material for materials bearing higher levels of natural radiation, such as certain masonry materials. At the same time that research and development in these areas is going on, additional work is required to develop instrumentation and procedures at technical support facilities for scanning relatively large areas quickly. These techniques may include mobile laboratories and aerial surveys.

It is likely that enforcement and control requirements will be necessary within the next year. As previously mentioned, these measures will focus upon the EPA's ability to control the use of various materials, perhaps through a license program. Interagency implementation of these requirements may be effected through HUD or perhaps through the proposed Consumer Protection Agency.

As noted on the attached Milestone Chart, the primary internal needs for the Optimum program are directed towards monitoring and field operations in order to establish current state of knowledge on the subject. In addition, considerable importance is attached to training since radiation protection specialists have received virtually no training in natural radiation and are unfamiliar with the radionuclides present in the natural environment and the mechanism of buildup of radon in enclosed structures.

PROPOSED PROGRAM

The Milestone Chart for the Proposed Program is presented in Figure C-29. There are two positions and $175,000 (overage program) planned for the construction material program for the next year, and therefore, it is likely that efforts in this field will be accomplished through contracts, literature surveys of existing information, and the use of results from PL 480 research. Much of the preliminary information has already been assembled in an EPA report which will be published in FY 1973, and therefore, future work in this area should consist of performing sufficient background work via contracts so that HUD may be persuaded to consider the control of natural radiation in its material selection programs.

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Another possible procedure in the future for accomplishing results with minimum EPA expenditures would be to request the proposed Consumer Protection Agency to undertake this form of protection of the public.

COMPARISON OF OPTIMUM AND PROPOSED PROGRAMS

The Optimum and Proposed Programs differ in two significant aspects. Although the scientific accomplishments of both programs are identical, the Proposed Program results will be accomplished on a time scale of approximately 1.5 times the Optimum Program. The second major difference is that the Proposed Program will not include EPA legislation or envorcement, unlike the Optimum Program. The results of the scientific accomplishments will be given to other agencies along with EPA recommendations for implementing a population exposure control program.

MEASURES OF GOAL ATTAINMENT

The goal attainment is simply a measure of reduction of man-rems from what would be projected if present materials were used in the future. Since accurate estimates of the present levels of exposure due to natural radiation and building materials do not exist, an estimate of the goal attainment is not possible at this time.

URANIUM MINING AND MILL TAILINGS

PROBLEM DESCRIPTION

Component Problems

Uranium Mining

The problem is to insure that exposure standard of 4 working level months (WLM) per year previously published as Agency guidance is being implemented and enforced by the U.S. Bureau of Mines (USBM) of the Department of Interior (DOI).

Uranium Mill Tailings

Agency action is required to (1) prohibit the use of mill tailings in construction and (2) monitor and review the policies practiced by the Atomic Energy Commission (AEC), or, alternatively, by Agreement States, in the regulation of radioactive discharge from uranium mills, including a review of the operational policies regarding the stabilization and long-term control of uranium mill tailings. Such an exercise could culminate in the development of an EPA land use policy. The use of uranium tailings in Grand Junction, Colorado, for construction purposes has resulted in a radon problem for approximately 2,000 homes. Legislation has been passed to authorize funds for a remedial action program in Grand Junction by the Atomic Energy Commission and the State of Colorado. The role of EPA in the remedial action program is that of a consultant and advisor, and to remain cognizant of the program.

It is still necessary to develop a passive dosimeter for monitoring indoor radon daughter levels more effectively than presently in use in

Grand Junction, Colorado. Investigation of the possible use of uranium tailings for construction purposes in nine other western states indicates that follow up corrective action may also be required in a limited number of locations.

Background

Uranium Mining

In 1967, the Federal Radiation Council (FRC) at the request of the Department of Labor, recommended to the President an exposure standard for underground uranium miners of 12 working level months per year. This standard was to be enforced by the USBM. Later, the FRC revised its recommendation downward to 4 WLM, to become effective January 1, 1971. This effective date was later changed to July 1, 1971. The recommendation was published as EPA guidance (the EPA having assumed the responsibilities of the FRC by Reorganization Plan No. 3 of 1970), with enforcement responsibility resting with USBM. Since that time, USBM has published procedures for variance applications against the 4 WLM standard (Federal Register, June 27, 1972). These regulations would allow variances for concentrations of radioactivity in the mines for periods of no longer than 18 months, but would not allow an individual miner to exceed the 4 WLM per year exposure standard.

Uranium Mill Tailings

Uranium mill tailings are sand-like radioactive waste products resulting from the milling of uranium ore. The quantity of tailings generated is about equal to the quantity of ore processed. In the past tailings have been used as fill under and around homes and other buildings, resulting in increased radiation exposure to occupants of the buildings, both from gamma radiation and from radioactive radium progeny. This problem exists primarily in the Grand Junction, Colorado area, although other milling communities in Colorado and nine other western states potentially have a similar problem of lesser magnitude. EPA has completed a preliminary assessment of other communities in Colorado and the nine other western states affected. Assessment of the problem in Grand Junction is almost completed, and plans are underway for a remedial action program, which is the responsibility of the Atomic Energy Commission and the States.

An associated facet of this problem concerns the environmental impact of active and inactive uranium mills. Specifically, this relates to the discharge of radioactive effluents to the air and water and the long-term stabilization and control of uranium mill tailings. The AEC or an Agreement State regulates the discharges to the air or water; however, the measures for control of tailings at inactive sites and the adequacy of the monitoring of radioactive effluents by the AEC or Agreement States need further study. Some states exercise adequate control, while others are highly deficient. The responsibilities and authorities of the AEC with regard to controlling tailings are somewhat nebulous at the present time. An additional dimension of the problem concerns land use policy and whether "disposal" of tailings, by setting aside land areas as a permanent tailings site requiring perpetual control, is the best land use or the best method of managing this radioactive solid waste product. The resolution of this facet appears to be within the purview of the Bureau of Land Reclamation, which should establish a policy in the face of USBM recommendations for backfilling open-pit uranium mines.

Scope

Uranium Mining

Uranium mining activity is regional in nature, being confined to ten western states. In the last decade, economic demand for the ore has decreased, the 1971 estimate for ore production being 13,200 tons U_3O_8, compared to a peak of 17,600 tons in 1961.* A concurrent decrease in the number of mines and miners was also experienced. The number of underground mines dropped from the peak of 850 in 1958 to only 193 in 1971; miners totalled 4,908 in 1960, compared to 1,567 in 1971.* The scope of the problem revolves around the primary cause of mine closures and the impact of enforcing the 4 WLM per year standard on the closures.

Uranium Mill Tailings

Since virtually all the uranium ore processed ends up as tailings, the 13,200 tons of U_3O_8 produced in 1971 represent only a small fraction of the quantity of raw ore processed. The volume of these radioactive solid wastes has created problems with regard to land use. With uranium mining on an economic decline, however, the volume of tailings generated will necessarily decrease.

Surveys have been made to determine the gamma levels and radon concentrations in homes in Grand Junction, Colorado. Both mobile and house-to-house surveys have identified structures with excessive backgrounds, presumably due to tailings, in other states. Remedial action programs are being implemented in Grand Junction and will have to be developed in the

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*Division of Raw Materials, U.S. Atomic Energy Commission.

other affected States.

LEGISLATIVE STATUS

The EPA has functioned in an advisory capacity only in addressing uranium mining and in both advisory and technical assistance capacities in milling problems. Standards for underground uranium miners were developed by the Federal Radiation Council at the request of the Department of Labor; cooperative programs have been developed with the States under the FRC mandate transferred to EPA by Reorganization Plan No. 3 of 1970; advice and technical assistance has been rendered under the transferred authority for EPA to respond to situations potentially affecting the public health; and model legislation for the control of uranium mill tailings has been supplied the States.

Congress has authorized five-million dollars for corrective actions in Grand Junction, Colorado. The Atomic Energy Commission is the lead Federal agency in this program, although EPA will be involved on a consultant basis to the State in determining the extent of the problem.

COORDINATION

Interagency

The Department of Interior has the responsibility for enforcement of the radiation standard for miners recommended by EPA. With regard to mill tailings, involvement has been in the form of technical assistance and extensive resources to the States by the EPA and AEC, although the States bear the primary responsibility for resolving the problem. The EPA has developed a draft of model legislation for mill tailings control for States to assist them in this matter. The EPA has served on the State of Colorado Interagency Indoor Radon Steering Committee. This committee was dissolved in September 1972. A new policy level advisory committee is to be formed by the AEC and the State to advise them regarding the corrective action phase of the Grand Junction project. The EPA is expected to participate on this advisory committee.

Intragency

After the determination of the extent of the mill tailings problem, there should be more intra-EPA involvement: the Office of Water Programs and the Office of Air Programs should review and determine the implementation of standards promulgated by Agreement States or by the AEC to regulate effluents into water and air, respectively; and the Solid Waste Office should become involved in solving the disposal problems created by mill operation. With regard to non-radioactive hazards, the Office of Toxic Substances should have a role in reviewing the standards pertaining to the release of toxic substances such as sulfates or acids into the water.

ALTERNATIVE APPROACHES

Uranium Mining

First Alternative

Continue to apply Agency leverage to insure the implementation of the 4 WLM per year exposure standard for underground uranium miners.

Second Alternative

Develop new standards for gamma exposure in mines, if necessary.

Third Alternative

Conduct study of control measures in mines to reduce exposures of mine workers.

Uranium Mill Tailings

First Alternative

Providing the States with model EPA regulations, such as those recently presented at the Colorado River Basin Conference, to encourage States to adopt legislation to control the use and disposal of tailings. (Subsequent Agency leverage by way of Environmental Impact Statement review will be required to assure resolution of the problem.)

Second Alternative

Studies by EPA to determine the best land use policy with regard to the disposal of mill tailings.

OPTIMUM PROGRAM

External Needs

Legislative Needs

- Uranium Mining: Publication by Department of Interior of regulations already published as EPA guidance on exposure limits.
- Uranium Mill Tailings: Appropriate enabling legislation for the States to control the tailings problem.

Knowledge and Research Development

- Uranium Mining: Technical assessment of the accuracy and reliability of personnel monitors and air samplers used in uranium mines.
- Uranium Mill Tailings: Consultant efforts toward the determination

of biological effects resulting from radiation exposure due to proximity of mill tailings; continue development of methods of stabilizing tailings piles to minimize or eliminate the radiation exposure associated with them; and development of the optimum "disposal" methods.

Enforcement and Control

- Uranium Mining: Enforcement by DOI of either EPA guidance or of their own regulations.
- Uranium Mill Tailings: Enforcement of effluent limits on radioactivity release by the AEC or by Agreement States; prohibition by the States of the use of mill tailings in construction; and control of abandoned piles of mill tailings.

Interagency Implementation

- Uranium Mining: Cooperative efforts between EPA and DOI to insure the radiation safety required for uranium miners.
- Uranium Mill Tailings: Cooperation between the States, EPA, and AEC to provide for the control of mill tailings use.

Internal Needs

Uranium Mining

Periodic checking by Headquarters and Regional personnel to determine how effectively the exposure standard is being enforced by USBM (DOI). Obtain from USBM an annual report on the exposure of uranium miners.

Uranium Mill Tailings

Periodic checking by NERC-LV and Regional personnel to determine the adequacy of control of mill effluents and operations, along with the adequacy of control over mill tailings, including a determination of who is actually responsible for exercising such control. The program for FY 73 is as follows:

- Negotiate new contract with Colorado for position to assist in Track Etch Study.
- Continue the readout and supply of air sampling equipment until completion of Track-Etch field trial. This includes the make-up, readout, and data reporting of the TLD detectors at NERC-LV. Parts for the air sampling equipment will still be supplied by EPA.
- Provide computer services including programming data storage, and various data printouts for the Uranium Mill Tailings Gamma Survey Data Base and Indoor Radon Study.
- Completion of the Track-Etch evaluation study by October 1973.
- Continue work on determining applicable methods for tailings pile stabilization and conduct surveys of existing piles upon request.
- Provide the States with model EPA regulations to encourage States to adopt legislation to control the use and disposal of tailings.

<u>Estimated Effort</u>

One-half to one man-year at Headquarters, FY 73; one man-year from Regional personnel, FY 73; both resource requirements expected to double in FY 73. The budget for this project at NERC-LV is shown in Table C-17. Approximately 6 man-years of effort are being planned.

<u>Milestone Chart</u>

The milestone chart for the Optimum Program is shown in Figure C-33.

TABLE C-17
REVISED ORP PROJECT BUDGET

TITLE:	Uranium Mill Tailings Project	Project Element/ Project No: 2F2191
PROJECT MANAGER:	David L. Duncan	FY 72 $000: 266.6 FY 72 Positions: 15
LOCATION:	NERC-LV	Original
OUTPUT:	Data Collection, Monitoring Systems development, reports and recommendations	FY 73 $000: 262.0 FY 73 Position: 17 Revised FY 73 $000: 192.7
COMPLETION:	Continuing	FY 73 Positions: 5

Item	Man Years	Estimated Expenditures through October	Projected Expenditures FY 1973
Colorado			
(1) Instruments	(2 da/mon)	$450	$450 (Discontinue)
(2) TLD Heads	0.6	$3,800	$11,650
(3) Sampler parts	0*	$2,800	$8,400
(4) Ambient Ra Study	0.3**	$400	$7,920
(5) Colorado Contract		0	Renegotiate for (7)
(6) Computer Services	0.2	$1,200	$3,600
(7) Consultation & Advice	0.1	$600	$600
Track Etch	1	0	$20,450***
Other			
Project Officer	1	$6,400	$32,500
Asst. Project Officer	1	$5,000	$19,000
Staff Officer	1	$4,000	$20,000
Laboratory Technician	1	$3,000	$15,000
Secretary	1	$3,350	$10,000
Mobile Scanner	1	$21,000****	$21,000
Vitro	0.05	0	$1,000
Riverton	0.05	0	$1,000
Mexican Hat	0.1	$1,000	$1,000
Other	0.1	0	$3,000
Temporary Employees			
Through July (2)	0.3	$4,900	$4,900
Through Sept (2)	0.3	$6,600	$6,600
Through Oct (1)	0.3	$4,600	$4,600
	9.4	$69,100	$192,670

* Cost of labor provided by AEC
** 0.3 man years contributed by State of Colorado
*** Includes $10,000 for readout of 1000 badges and $10,200 for Colorado Contract
**** Terminated as of the end of Sept [illegible] 1972

PROPOSED PROGRAM

Uranium Mining

The proposed program consists of EPA encouragement for the publication by DOI of exposure standards for underground uranium miners; or, alternatively, assurance of the implementation by USBM (DOI) of EPA guidance in this area.

Uranium Mill Tailings

The EPA should provide model regulations to the States to encourage their legislating against the uncontrolled use of uranium mill tailings in construction. A study should be initiated to determine the adequacy of control of mill effluents and tailings by the AEC or by Agreement States. Research projects to determine the biological consequences of exposure to the radiation associated with mill tailings, as well as attempts to develop methods of treating tailings to minimize such exposure, including the determination of the optimum "disposal" method, should be conducted.

The recommended proposed program is essentially identical with the optimum program. Due to the relatively low priority assigned this problem area, however, the time frame under which the activity is conducted may vary from optimum conditions, primarily due to minimal involvement of EPA resources compared to other problem areas. These resource requirements will be fully developed at a later date.

Milestone Chart

The milestone chart for the Proposed Program is shown in Figure C-30.

PAGE NOT

AVAILABLE

DIGITALLY

Figure C-30

COMPARISON OF OPTIMUM AND PROPOSED PROGRAMS

There should be negligible difference in impact of the proposed program compared to the optimum, with the possible exception of the time frame involved.

MEASURES OF GOAL ATTAINMENT

Uranium Mining

- Determination of whether or not miner exposure is kept below the four WLM per year standard, by assessing the personnel monitoring equipment and monitoring programs for adequacy.
- Determination of the philosophy involved in the enforcement of the four WLM per year standard by USBM (DOI).
- Categorization of the actual causes for mine closures in the western states involved, with particular attention to mines allegedly closed solely due to the implementation of the exposure standard.

Uranium Mill Tailings

- Determination of whether or not Agreement States or the AEC have adequate regulations to control uranium mill effluent concentrations of radioactivity and to control the use of mill tailings; determination of whether or not these regulations are being enforced.
- Determination of a method to determine the radon concentration in a short period of time for homes where uranium tailings have been used for construction purposes.

- Development of a method or methods to stabilize tailings piles to minimize or eliminate the potential hazard from the associated radon daughter emanations.
- Study will be made of the existing legislation to determine if there are gaps in the laws for control of uranium mill tailings. From this study a determination will be made if new State or Federal legislation is necessary.

RADIOFREQUENCY AND MICROWAVE

PROBLEM DESCRIPTION

Introduction

The pollution of the environment by nonionizing electromagnetic radiation is rapidly increasing. There is concern about two types of exposure, the exposure of the entire population to low levels which result from the superposition of the fields from multiple sources such as broadcast and communications systems and the exposure of smaller groups to potentially higher levels from sources such as radar, microwave ovens, medical diathermy devices, and industrail heating equipment. The concern arises because the existence and importance of nonthermal effects at low levels are uncertain and the criteria for setting an acceptable level of exposure, either for thermal insult or interference effects, have not been defined for the population at large. Ambient levels already exist which are in the range of uncertainty for the onset of nonthermal effects (10 microwatts/cm^2) and which do interfere with health related devices such as cardian pacemakers and essential communications systems. The highest population exposure is thought to occur in urban areas and in the vicinity of airports, military installations, and satellite tracking centers. A careful determination of current environmental levels, their rate of growth, and a knowledgeable evaluation of low level effects are needed to assess the present and future impact of electromagnetic radiation on health and the environment.

Component Problems

Since radiation effects depend upon the wavelength, or equivalently the frequency of the radiation, it is convenient to consider the health and environmental problems associated with nonionizing electromagnetic radiation as three component problem areas which are defined by wavelength or frequency, namely, microwave, radiofrequency, and extremely low frequency radiation. In addition, consideration must be given to the low-level, so called nonthermal effects, which may occur at all frequencies.

Microwave

Microwaves are very high frequency radiation with wavelengths between 10 meters and 1 millimeter (30 MHz - 300 GHz). The principal applications are in the area of communications, including FM broadcast, television, microwave point-to-point, and satellite communication; radar systems; and heat treatment processes including medical diathermy, industrial drying, and home and commercial food preparation. Most of the concern over direct health effects, especially thermal effects, is focused on the microwave frequency range. Current occupational exposure standards apply to the 10 MHz to 100 GHz frequency range. Other effects include indirect effects on health through interference with health related devices such as cardiac pacemakers, hearing aids, and monitoring equipment in hospitals. Consideration must also be given to the inadvertent detonation of ordinance and ignition of aircraft fuels as well as interference with communications and TV and FM reception.

Radiofrequency

Radiofrequency radiation covers the wavelength region from 10,000 meters to 10 meters (30 KHz - 30 MHz). The principal application is for communications including AM standard broadcast and amateur radio. Other applications include radionavigation, radiotelephone and some medical diathermy. Apart from nonthermal effects, the principal problem in this frequency range is interference with health related devices and communications. There are no standards or guidelines in the U.S. for permissible exposure of the general public or occupationally exposed groups for frequencies below 10 MHz.

Extremely Low Frequency

Wavelengths from direct current up to 10,000 meters (0 - 30 KHz) are termed extremely low frequency (ELF). The principal application is for power transmission at 60 Hz. Some military communications operate in this frequency range. Of particular note is the ELF communications system termed Sanguine, because of its high power and requirement for burying an extensive antenna array (100 miles) in a location accessible to the public. The principal problem in this frequency range is the induction of voltages in long conductors such as telephone lines, fences, and pipelines, and the corresponding problems of electrical shock and interference.

Thermal Versus Nonthermal Riological Effects

Two types of biological effects are distinguished, that due to tissue heating which is called thermal and that due to some other mechanism which is called nonthermal. Exposure intensities high enough and of duration long enough to generate heat can cause adverse health effects. In addition to physiologic heat stress, cataract induction, and impaired testicular function are thought to be important effects. Permissible levels of exposure for occupational activities in the U.S., both civilian and military, are set solely on the basis of heat generation. Studies of effects conducted in the USSR and some Eastern European countries have been oriented toward effects on, or mediated by the central nervous system, and the overall conclusion arrived at through such studies is that biological systems are more sensitive to central nervous system effects than to direct thermal effects. Many other nonthermal effects have been reported. There is considerable controversy concerning these low-level nonthermal effects and whether they can be considered hazardous. However, in the USSR these effects are given serious weight and the guidelines for permissible occupational exposure are 100 to 1000 times less than those used in the U.S. depending on the exposure conditions.

In the U.S., guidelines for permissible exposure of the general public in nonoccupational situations have not been developed. Some argue that the current occupational standard could be used. However, exposure to electromagnetic radiation is but one of several sources of heat input into the body. Body temperature depends in part on sources of heat input such as electromagnetic radiation, physical labor, and high ambient temperature and on heat dissipation capability as affected by clothing, humidity, state of health, etc. In occupational situations it is presumed that the ambient environment can be controlled or the exposure level reduced to compensate for additional sources of heat. This is not the case for nonoccupational situations, and if a guideline for the public at large is set on the basis of thermal insult, careful consideration must be given to determining the characteristics of the population that are most sensitive to heat stress.

Serious questions can be raised concerning the philosophy of using a thermal basis for setting population exposure standards for nonionizing electromagnetic radiation. First, there is the possibility that low-level nonthermal effects have a real impact on health. Second, interference with electronic devices which are important to health or the quality of the environment occurs at levels below those required to heat tissue. The compatibility of the electromagnetic environment with other sources and useful devices must be considered in arriving at acceptable levels.

Background

The biological effects of nonionizing electromagentic radiation have been studied since their discovery by Hertz in 1888. During the period 1930-1940, attention was focused on molecular and chemical effects and effects on elemental biological systems. After World War II, the emphasis in the U.S. was placed on studying whole body irradiation effects in mammals and man because of exposure of military personnel to levels intense enough to cause detectable heating of the skin.

With the proliferation of applications of modern technology to radar, television, and communications systems, the entire population of the U.S. is exposed to radiation from these sources at power densities well below thermal levels. Because of the lack of definitive scientific data on the genetic, clinical, physiological, and behavioral effects at low levels of exposure, a coordinated governmental program for control of electromagnetic pollution of the environment recommended by the Electromagnetic Radiation Management Advisory Committee, ERMAC, has been accepted by the Director of Telecommunications Policy and endorsed by the various governmental agencies concerned. The recommended program is estimated to cost $63 million for FY 1974-78. Spending for current Federal government programs in this area approximates $4 million/year, most of which is by DOD, EPA, and DHEW. In addition to research on biological effects, the ERMAC program notes the necessity for surveys of power density levels in urban areas, airports, and military installations to obtain an estimate of the population at risk.

Scope

Present

The increase in the number of radiofrequency and microwave sources since 1940, has been phenomenal and it is generally accepted that environmental levels are rapidly increasing. Only limited information is available on actual environmental levels where sources and population are concentrated. Exclusive of Federal Government systems, there are over six million transmitting devices authorized by the Federal Communications Commission, including in 1971, 892 TV stations and 6,976 broadcast stations. There are over 71,000 microwave relay towers and 2,800 fixed radar sources in the U.S. As an example of congestion in urban areas, there are 276 unclassified sources within a 50-mile radius of Washington, D.C. having a transmitter power equal to or greater than one kilowatt.

Future

The number of radiofrequency and microwave sources is estimated to increase 15% each year. This rate of growth may increase with new applications and advances in technology. Cheaper microwave sources are becoming available which will increase the use of frequencies above 10 GHz for communications. High power microwave systems have been proposed for use in agriculture as a substitute for herbicides and for pesticides. By 1975, it is predicted that the annual sales of microwave ovens for the home will reach 200,000. Industrial and medical applications of heat treatment processes will also increase. Radars are being installed on some small boats used for recreation and the number will increase as prices are reduced. Microwave power transmission of converted solar energy from satellites to large antennas on the Earth's surface has been proposed as a significant electrical energy source for the year 2000.

LEGISLATIVE STATUS

At the present time, there is no legislative authority for the specific control of nonionizing electromagnetic radiation pollution of the environment. However, as a pollutant, nonionizing radiation comes under the broad authority of EPA to protect the environment. In Reorganization Plan NO. 3 of 1970, EPA is directed to "...by itself and together with other agencies, monitor the condition of the environment-biological as well as physical" and "... in concert with the States - to set and enforce standards for air and water quality and for individual pollutants." Leverage to control environmental levels can be exerted through the National Environmental Policy Act and the required Environmental Impact Statements. Guidance to other Federal agencies can be provided through the authority transferred from the Federal Radiation Council to EPA, providing EPA can argue convincingly that all radiation, not just ionizing radiation, is within the FRC authority.

Civilian broadcast sources are controlled by the FCC but the health effects of high powered sources are not directly considered in frequency allocation or in the siting of transmitters. Frequency assignments for government sources are made by the Office of Telecommunications Policy based on recommendations of the Interdepartment Radio Advisory Committee (IRAC). The health and environmental effects of government sources are given indirect consideration through the Side Effects Working Group of IRAC. This working group is also serving as the interagency coordinating point for the program recommended by the Electromagnetic Radiation Management Advisory Council to OTP.

The Food and Drug Adminsitration has authority to set performance standards for consumer products and has done so for microwave ovens. Occupational exposures are controlled by the Department of Labor using a national consensus standard based on the recommendations of the American National Standards Institute. The military services use similar guidelines to control occupational exposure.

COORDINATION

Interagency

The Electromagnetic Radiation Management Advisory Council (ERMAC) has the responsibility to adivse and recommend to the Executive Office of the President through the Director of Telecommunications Policy (DTP) on measures to investigate side effects of radiation which arise from telecommunications activities to include protection of the general health. The ERMAC first met on March 27, 1969, and recognized the problems of possible health and ecological hazards of microwave and radiofrequency radiation exposure. The Council has recommended a five-year, 63 million ✓

dollar program to assist DTP in coordinating the research programs of the participating federal agencies to accomplish program objectives and avoid unwarranted duplication. EPA has two observers on ERMAC and two representatives on the Side Effects Working Group of the Inter-department Radio Advisory Committee, the group selected by the Office of Telecommunications Policy (OTP) to coordinate the ERMAC program.

Department of Health, Education, and Welfare (DHEW) is charged by Public Law 90-602, Radiation Control for Health and Safety Act of 1968, with the protection of public health and safety from the dangers of electronic product radiation. The control is accomplished through the issuance of product performance standards by the Bureau of Radiological Health. The National Institutes of Occupational Safety and Health evaluates occupational exposure situations and the National Institutes of Environmental Health Sciences and the Bureau of Radiological Health support biological effects studies. Direct liaison has been established between the Office of Radiation Programs, EPA, and the Bureau of Radiological Health, FDA, in the area of lasers and other electromagnetic radiation.

Department of Defense (DOD) activities of the several military departments with regard to research on health and environmental aspects of electromagnetic radiation are coordinated by the Director of Research and Engineering (DDR&E). Each of the component departments, Army, Navy, and Air Force, conducts research on frequencies and devices of particular interest to that service and conducts epidemiological surveys and hazard assessments for its own personnel and its own environmental situations.

In addition to OTP coordination, EPA is represented on the Navy's Biological and Ecological Subcommittee for Project Sanguine and has an interagency agreement with the Electromagnetic Compatibility Analysis Center for data and analysis on environmental levels.

The Department of Commerce offers the services of the National Bureau of Standards (NBS) and the Institute of Telecommunications Sciences (ITS) at Washington, D.C. and Boulder, Colorado for guidance in instrumentation, dosimetric methodologies and primary standardization of measurement devices. Coordination with EPA programs is through OTP and informal staff contacts.

National Science Foundation (NSF) will make available to the general reserrch community and particularly to the academic community funds to elucidate basic mechanisms involved in the interaction of electromagnetic radiation with biological systems. Long-range fundamental studies will be particularly encouraged. Coordination with EPA programs is through OTP. In addition, EPA staff serve as reviewers for research proposals to NSF on nonionizing electromagnetic effects.

Federal Communications Commission (FCC) has close contact with and detailed knowledge of non-government radiation sources which they license. Their survey and monitoring activities of existing and proposed non-government communications devices and systems will provide valuable data on radiation levels. Principal coordination with EPA is through OTP. EPA staff also serve on the Radio Technical Commission for Marine Services Special Committee on Ships Radar which is supported by the FCC.

Federal Aviation Administration (FAA) has primary responsibility for flight crew health and performance. Data from the exposure of airport personnel and flight crews to airport electromagnetic radiation environments should be applicable to a program for the protection of airline and airport personnel as well as to airline passengers and the general public. Principal coordination with EPA programs is through OTP.

United States Information Agency (USIA) measures and monitors radiation intensities for USIA domestic and overseas transmission. Principal coordination with EPA programs is through OTP.

The Department of Agriculture (USDA) is concerned with investigating the effects of electromagnetic radiation on crop growth and development and related ecological aspects. Principal coordination with EPA programs is through OTP.

National Aeronautics and Space Administration (NASA) is responsible for surveying the electromagnetic environment of launch areas, spacecraft, and tracking radar under their control. Principal coordination with EPA programs is through OTP.

Central Intelligence Agency (CIA) surveys and monitors programs of foreign countries dealing with health and environmental aspects of electromagnetic radiation. Principal coordination with EPA programs is through OTP.

Department of Labor (DOL) has responsibility for administration and enforcement of the Williams-Steiger Occupational Safety and Health Act of 1970 (PL 91-596) through the Secretary of Labor and the Occupational Safety and Health Review Board, a quasijudicial board appointed by the President. Research and related functions are vested in the Secretary of DHEW. Principal coordination with EPA programs is through OTP.

States

EPA is directed in Reorganization Plan No. 3 to "be able -- in concert with the States -- to set and enforce standards for air and water quality and for individual pollutants."

ALTERNATIVE APPROACHES

The nonionizing electromagnetic radiation program goals will be accomplished by implementing four main program elements within ORP:

- Determination of the status of the environment through measurement of environmental levels and recognition of potentially adverse situations and sources of radiation.
- Evaluation of effects due to nonionizing electromagnetic radiation.
- Development of guidelines for acceptable environmental levels of nonionizing radiation.
- Development of a program for control of environmental pollution due to electromagnetic radiation.

Consideration of alternative approaches to the program is based on possible alternatives to the program components associated with the four main program elements.

Determination of the Status of the Environment

Recommended Approach

Continue to develop the capabilities, resources, and facilities to measure environmental electromagnetic radiation (including data reduction and analytical techniques).

First Alternative Approach

Do not implement a measurement program, but attempt to predict, by mathematical modeling, environmental EM fields using knowledge of known sources and their characteristics.

Impact. Though fields from a single well characterized source may be predicted mathematically, the general EM radiation environment cannot be described in this manner. All significantly contributing sources and their spatial distributions are not catalogued. The required characteristics of catalogued sources are not completely specified. The physical geometry at the specified location cannot easily be described mathematically, if known.

There will be no emergency response capability and the evaluation of potentially adverse situations will be impeded. There will be a limited capability to provide technical assistance to local and state agencies. Requests for assistance will be directed to Federal agencies with measurement capability. Evaluation of EIS's, with respect to effects on the existing EM environmental levels, will be inaccurate if not impossible.

Second Alternative Approach

Implement an environmental EM measurement program by contracting with private organizations and/or other Federal agencies, with RF and microwave capabilities and facilities, to perform measurements.

Impact. The contractor will still need to develop techniques and instrumentation systems applicable to environmental radiation measurements. Organizations now possessing RF and microwave capabilities have developed these capabilities with emphasis on communication and radar applications, where directionality, high antenna gains, and narrow frequency band characteristics are important. Environmental measurements require capabilities involving broad frequency response and omnidirectional antenna characteristics, and will also include instrumentation systems having good frequency and time resoltuion properties. Development and specification of field measurement procedures for environmental measurements will need to be defined by ORP to ensure uniformity in procedure and the quality of measurements and this is best accomplished through direct experience. Dependence on other organizations or agencies will result in reduced ORP competence and could affect program implementation, ability to evaluate instrumentation development, application, and quality of data. Costs will be high because of private industry overhead. Emergency response capacility will be limited with respect to immediate response capability and proper measurement procedures. Development of capabilities in other Federal agencies will essentially transfer ORP responsibility to that agency.

Evaluation of Electromagnetic Radiation Effects

Recommended Approach

Development of an information inventory and synthesis of knowledge.

Alternative Approach

There is no alternative to the development of an information inventory. This program element must be implemented to provide a basis for the interpretation of the environmental impact of existing and projected levels of radiation, evaluation of the impact of existing and new technology, and identification of gaps in knowledge to specify the research required to develop guidelines and standards required for the protection of health and the environment.

Development of Guidelines

Recommended Approach

Guidelines for permissible or acceptable environmental levels must be established to provide a basis for evalutating the total problem of nonionizing radiation in the environment. This requires a knowledge of current levels, the rate of growth of environmental levels and an evaluation of the research, current and future, on biological, environmental and interference effects. The status of knowledge in this radiation effects area is preliminary and effects are not yet well defined. Development of guidelines will proceed in steps over an undefined period of time as the pertinent information is generated.

First Alternative Approach

No development of guidelines and standards.

Impact. There will be no control over electromagnetic radiation in the environment, the radiation sources, and the impact of this radiation on the health and quality of life of the general public and the responsibility to succeeding generations.

Second Alternative Approach

Accept the USSR standards which exist now and are conservative as guidelines for acceptable exposure.

Impact. The full impact of such a restrictive guideline cannot be determined at the present time. However, environmental levels certainly exceed the USSR standards in some areas and the useful applications of nonionizing radiation could be severely curtailed with a yet as undetermined benefit.

Development of Control Program for EM Radiation Pollution

Recommended Approach

Development of a program to control and reduce (where necessary) environmental EM radiation pollution to include siting and operation requirements for existing and proposed sources. This will require a determination of the best method of control. Possible methods include (1) using influence through the National Environmental Policy Act, Federal Radiation Council responsibilities, and guidance to states to maintain levels below those guideline levels recommended by EPA and (2) establishing radiation pollution.

Alternative Approach

To fulfill responsibilities under the National Environmental Policy Act, there is no alternative to developing a control at least as it applies to evaluating Environmental Impact Statements. The alternatives for direct control need to be determined after a basis for acceptable levels is established and compared to existing levels and rates of growth.

OPTIMUM PROGRAM

Introduction

The primary objectives of the nonionizing electromagnetic radiation program are: 1) to identify the effects of electromagnetic radiation and their impact on the health of the general population and the environment, and 2) to develop and implement controls to ensure that the state of the electromagnetic radiation environment is not detrimental to health.

These goals will be accomplished by implementing four program elements, i.e.,

- determination of the status of the environment, monitoring and problem source identification
- determination and evaluation of effects due to electromagnetic radiation
- development of guidelines for acceptable environmental levels of nonionizing electromagnetic radiation
- development of a program for control of pollution due to electromagnetic radiation.

The program also includes other elements which require considerable effort, but are associated with the more immediate aspects of the problem and implementation of the program. These additional program elements consist of:

- development of an emergency response capability
- responses to requests for technical assistance,
- review of Environmental Impact Statements

- identification of needed research programs in concert with the Office of Research and Monitoring, EPA
- development of a field support capability
- preparation and publication of the required technical reports.

In addition, certain auxiliary activities are essential to provide the support necessary to the development and success of the proposed program. These include the development of an information inventory, evaluation of the past and current state of research pertinent to the problems involved, development of the required analytical procedures, a liaison activity which ensures that ORP has developed the necessary working relationships with other organizations, both within and outside of the Federal government, and continuing program development which will anticipate program needs on a long- and short-term basis to ensure that the efforts and resources required are not lacking.

The program elements and auxiliary activities are generally described in the text of this paper prior to specification of program needs. Figure C-32, Elements of ORP FY 1973 and FY 1974 Radiofrequency and Microwave Program, illustrates the relationships between the major program elements.

It is considered imperative that ORP have the capabilities required to plan and implement all aspects of the program proposed. Fulfillment of the responsibilities and goals of the program is dependent upon the capabilities which exist within ORP. Dependence upon external sources for basic technical knowledge and assistance could result in a program lacking the capability for long-range planning, improper definition

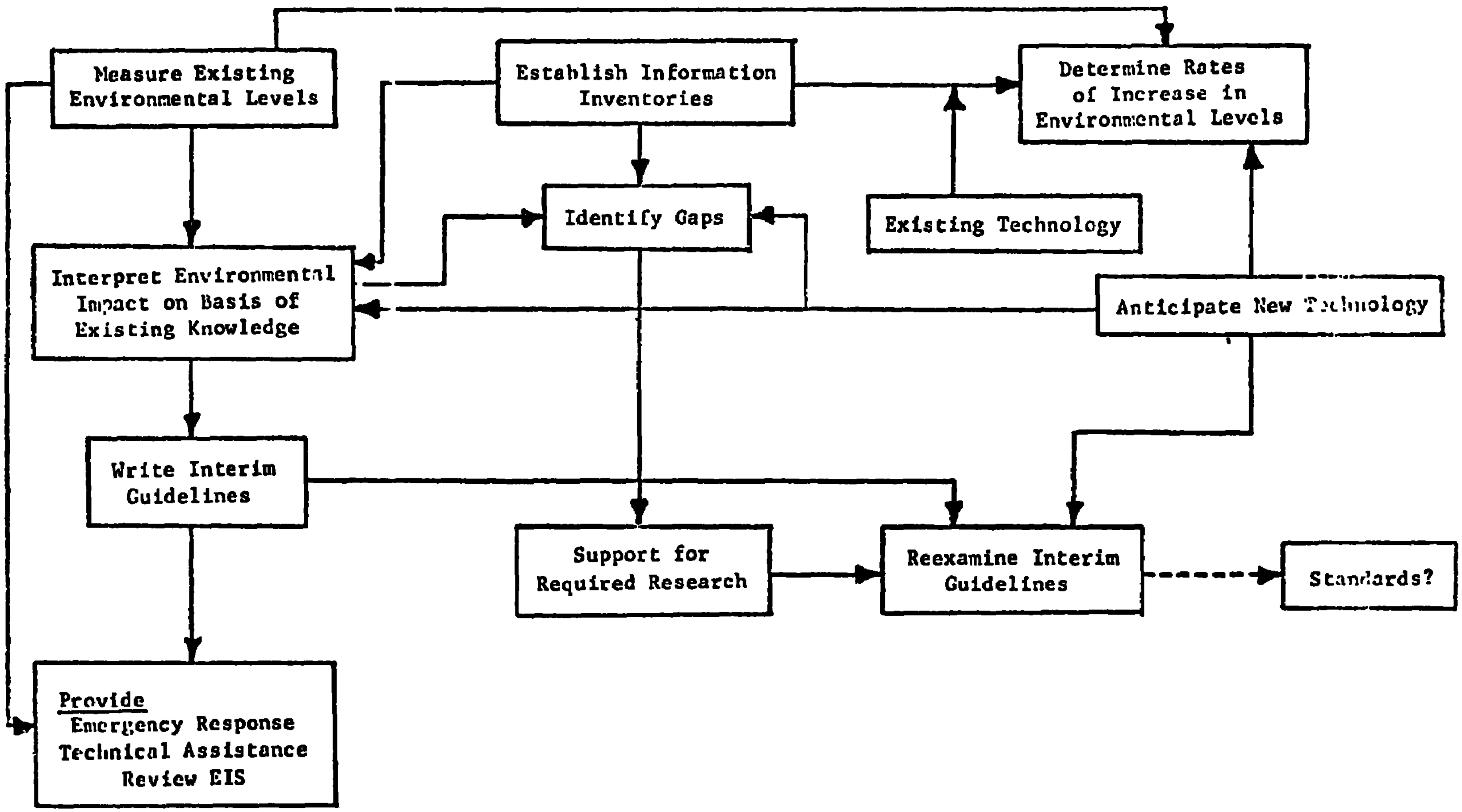

FIGURE C-32

ELEMENTS OF ORP FY 1973 & FY 1974 RADIOFREQUENCY AND MICROWAVE PROGRAM and management of technical programs and program elements, inefficient discharge of technical and program responsibilities, and intolerable time delays in responding to future demands and situations requiring immediate attention.

Significant consideration and effort has been given to the problems associated with electromagnetic radiation as an environmental pollutant and the approaches to solution of these problems. The program can be immediately initiated as is indicated by the time schedule contained within the milestone charts of the Optimum Program, Figure C-33.

The environmental nonionizing electromagnetic radiation program efforts will develop basic techniques and information specifically required before it is possible to recognize, control, and correct undesirable environmental EM radiation pollution problems. Much of the basic information and measurement techniques required for an environmental nonionizing radiation program have not yet been developed and applied, as opposed to the case of environmental nuclear radiation sources for which standard measurement techniques exist, effects of given intensities and energies of specific types of radiation are relatively well established, and standards have been written and enacted into law. Therefore, this program, at least in its initial development phase, can be considered to be one of technical development, dependent upon research which is both basic and applied in nature. This technical program has been developed with the definition of program elements such that its goals will be achieved in what appears to be the most direct manner. In addition, program direction and development

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appear to be achieved most efficiently through the definition of program elements in this manner.

Determination of the Status of the Environment

The determination of the status of the environment requires the quantitative measurement of those characteristics of the electromagnetic radiation present in the environment which are significant in affecting human health and the environment in which we live. The evaluation of the information obtained will be used to characterize the environment by allowing potentially adverse situations to be identified and permitting an analysis which recognizes environmental changes and trends which can be used to predict the future environment. Evaluation of the environmental impact of existing ambient radiation is essential, and is required in the development and implementation of guidelines and standards.

The means to acquiring the necessary environmental information involves the adaptation of existing technology to our specific purpose. The Office of Radiation Programs will in concert with the Office of Research and Monitoring design, develop, and apply the instrumentation and data acquisition systems, and the field measurement and analytical procedures required to quantitatively determine the pertinent environmental EM field characteristics and evaluate the environmental impact. The development and acquisition of measurement and data handling capabilities and determination of systems application procedures requires that a support facility be establsihed. Sampling of the EM environment will provide realistic conditions for development of the required systems. In addition, simulation of realistic signals for preliminary evaluation of system operation will also be an essential feature of system development.

Measurements will be made so as to determine EM radiation characteristics over extended areas where the existing fields may be due to the cumulative effect of several individual sources of EM radiation. In addition, fields due to specific single sources will be investigated, possibly requiring a field study of the facility or source involved in order to develop and validate models so that fields can be estimated.

The first year of program implementation will allow for a limited number of field studies due to validate models. However, as the program develops further, the selection of sites and sources for measurement will be carefully made to ensure that the greatest benefit be gained in defining and evaluating the environment. The information now available in existing data banks will be extremely valuable in the selection process.

Further program development will determine the need for facilities in existing EPA field laboratories.

The implementation of this program element may require establishment of authority to perform environmental measurements, however, the establishment of relationships with existing Federal, State, and local agencies should be a valuable asset to the measurement program.

<u>Determination and Evaluation of Effects</u>

The determination of the impact on health and the environment of existing ambient electromagnetic radiation and the anticipated application of developing technology depends upon a synthesis of current knowledge and the continued generation of information from current and future research activity. The relationships between exposure to EM radiation and effects is determined through a continual evalaution of available information in which a correlation is made relating specific effects to field intensity and/or power density, frequency, and modulation characteristics. Effects, classified as biological, interference, and environmental in nature, must be identified because of the potential impact on the present and future quality of life of individuals and society as a whole. Immediate and near future impact may be most obvious, but the identification of less intense, long-term effects which could influence the lives of future generations are no less important. Awareness of developing technology and anticipation of future applications is essential in preparing an effective program which attempts to determine environmental impact and provides for long-range planning which is essential in maintaining and developing the capabilities and resources needed. The Office of Radiation Programs in concert with the Office of Research adn Monitoring (ORM) will identify the research required to identify hazardous effects. Intramural and extramural support for the necessary biological effects research will be implemented through ORM.

Development of Guidelines

Guidelines for acceptable or permissible environmental levels are essential for control of EM environmental pollution and for correction of potentially adverse and hazardous situations. The determination of guidelines is based on cause and effect relationships, particularly in the areas of biological effects, and interference with the operation of devices and systems in fulfilling the purposes for which they are intended. The necessity for standards and the decision concerning when they must be established depends upon existing and anticipated environmental EM radiation levels and the degree of the impact on health and the environment. Continuing development of information through the information inventory and research is expected to provide the basis to determine the need for standards.

Emergency Response Capability

The capability to respond quickly and competently to emergency "short notice" situations will be developed. This necessitates rapid development of portable and mobile instrumentation systems, establishing the authority and means to test human subjects, authority to perform measurements wherever and whenever required in emergency situations, and close liaison with other agencies, particularly State health departments, DOD, and Regional Offices to establish emergency procedures and facilitate acquisition of additional equipment if required. Determination of impact and decisions with regard to required corrective action requires establishment of guidelines and authority to impose whatever corrective measures are required.

Response to Requests for Technical Assistance

The program includes provision for assistance in the form of information, technical guidance and direction, equipment loans, training, and action to States and Regional Offices upon request.

Review of Environmental Impact Statements

The review of EIS's where effects of EM radiation is concerned will be a continuing effort. The demands cannot yet be anticipated, but will depend on the number of EIS's and the specific characteristic of the sources of facilities involved. The basis for evaluation exists in the other primary program elements, i.e., determination of environmental status, evaluation of effects, and guidelines and standards. Criteria for evaluation of EIS's will be developed in a format which will permit efficient evaluation. Recommendations and conclusions will be provided. Extensive use will be made of the information inventory, and existing data banks in the Department of Defense and Office of Telecommunications.

Research

Research activities in the U.S. will be evaluated with respect to their potential for providing cause-effect information where gaps in information exist. Recommendations for research needed by the program will be developed for implementation by the Office of Research and Monitoring and coordinated with other interested government agencies through OTP.

Field Support Facility Development

Once the basic development in techniques, systems, and procedures has been completed and a full scale program of determination of the status of the environment is outlined, the need for mission support facilities in existing EPA laboratories will be determined.

This determination will include the requirements for technical capabilities, specification of systems and measurement procedures, and maintenance and calibration of instrumentation and equipment.

Technical Publications

Publication of technical reports and scientific articles is one means of providing technical support and allows the best use to be made of the acquired data, information, and analysis. Further, the goal of publishing articles in well recognized scientific journals will assist the Office of Radiation Programs to develop its capabilities, to develop and enhance its technical reputation by generating respect in the scientific community, and to facilitate the process of attaining its program objectives.

Program for Control of Environmental Electromagnetic Radiation Pollution

A program will be developed to control and reduce (where necessary) environmental EM radiation pollution. The program should ensure that proposed sources meet EPA requirements prior to siting or operation, and be able to bring operating sources into compliance with guidelines for acceptable or permissible exposure. To be effective it may be necessary for EPA to establish and enforce standards for environmental levels of nonionizing radiation.

Information Inventory Development

An information inventory is being developed which is directed toward providing the necessary information inputs to all of the EM radiation program elements. It would supplement, certainly not duplicate, certain information and data which is obtainable from sources such as the Electromagnetic Compatibility Analysis Center and the Office of Telecommunications. The information (including classified information) contained in this inventory cannot be all inclusive, but must be selectively chosen.

The kinds of information to be included consist of: nonionizing radiation sources and categories of sources, location, source power, frequency, pulse characteristics, antenna characteristics, facility

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operational characteristics, terrain description; environmental EM radiation field characteristics; correlations of environmental EM radiation with population distributions; field measurement data generated; analytical results; and technical literature and reference material concerning measurement techniques, EM instrumentation and systems, data handling systems, biological effects, interference effects, existing and developing technology, and biological, ecological, and related EM radiation research.

Liaison Activity

External Needs

Legislative Needs. Implementation of the ORP programs may require establishment of EPA authority in order to fulfill certain program responsibilities. Possibilities for required legislation, in view of the still undefined status of existing legislation, include establishing authority to: perform measurements and source inspections wherever designated and, in the event of emergency situations, whenever necessary; test humans if necessary due to emergency and unusual situations; permit access to classified information regarding military EM sources and facilities, enact into law EPA electromagnetic radiation standards; and enforce standards and bring sources into compliance.

Knowledge. The Electromagnetic Radiation Analysis Branch nonionizing radition program requires extensive use of existing knowledge in developing the means and program to determine the status of the environment, in the evaluation of effects, and development of guidelines and standards. All program elements are dependent upon obtaining and synthesizing the information required. The development of the information inventory is an essential supporting program activity.

Research and Development Needs. The generation of new information relating to environmental effects, measurement techniques, and development of guidelines and standards is dependent upon current and future research. Effects of RF and microwave radiations on biological systems are not well defined and understood. The USSR and some other Eastern European countries have reported nonthermal effects which have to some extent been qualitatively supportec by the limited research done in the U.S. On the basis of these effects, standards have been adopted in the USSR which include $\mu W/cm^2$ thresholds.

Additional knowledge is required to clearly define and understand the relationships between electromagnetic radiation and the associated nonthermal effects. The research required to provide a basis for acceptable environmental levels will be identified. The required research can then be implemented through the Office of Research and Monitoring and in coordination with other agencies through the Office of Telecommunications ERMAC program.

Enforcement and Control Requirements

A program will be developed to enforce standards, once they are enacted into law, to control and reduce (where necessary) environmental EM radiation pollution. The program will ensure that proposed sources meet EPA requirements prior to siting or operation, and will bring operating sources into compliance with standards, implementing ERAB recommendations if necessary.

Interagency Implementation. Coordination of the nonionizing radiation activities is through the Electromagnetic Radiation Management Advisory Council. The ERMAC was formed in 1968 to advise the Director, Office of Telecommunications Policy, and to make recommendations on potential side effects on the environment, biological and physical, and the adequacy of control of electromagnetic radiation. EPA has two observers on the ERMAC.

An interagency working group on biological effects of nonionizing electromagnetic radiation was recently formed to serve as an intragovernment coordination mechanism for the ERMAC program. It has been made a part of the Side Effects Working Group of the recently reconstituted Technical Subcommittee of the Interdepartment Radio Advisory Committee. This body is comprised of representatives designated by the heads of agencies with a role in the ERMAC program. The agencies are:

Agriculture
Atomic Energy Commission
Central Intelligence Agency
Commerce
Defense (Director of the Division of Research and Evaluation, U.S. Army, U.S. Navy, U.S. Air Force)
Transportation (Federal Aviation Administration)
EPA
Federal Communications Commission
Health, Education and Welfare
Interior
Labor
NASA
National Science Foundation
Office of Telecommunications Policy
U.S. Information Agency
Veterans Administration

Coordination will be continued through direct participation with the interagency working group on biological effects of nonionizing radiation.

Internal Needs

The primary objective of the program is to develop the means (staff, instrumentation, and procedure) to determine the status of the environment by performing measurements of ambient levels of EM radiation in selected extended areas in the environment and to conduct field studies of specific sources of nonionizing electromagnetic radaation; to make determinations and evalautions of effects; to develop guidelines and standards; and to control environmental pollution due to electromagnetic radiation by enactment and implementation of standards. Manpower and cost requirements for the Optimum Program are shown in Table C-17.

The measurement process consists of the quantitative determination of environmental electromagnetic radiation field characteristics such as: field intensity and/or power density, pulsed characteristics, and variation with time over a given frequency range (DC to 18 GHz). These determinations will be made within defined limits regarding magnitude, polarization, resolution (with regard to frequency, intensity, time), and near and far field characteristics. The information acquired must be evaluated and pertinent conclusions reached where possible.

This first year of program implementation will allow for only a limited number of field studies due to the need for development and acquisition of capabilities and determination of system application procedures. However, the selection of sites and sources will be carefully made to ensure that the greatest advantage be gained in this development phase.

TABLE C-17

REQUIREMENTS - OPTIMUM PROGRAM

PERSONNEL REQUIREMENTS

The requirements for personnel are based upon a two-year estimate of needs and costs. The program provides for inclusion of personnel at the supporting environmental research laboratories.

(1)	Biophysicist or Physicist:	Program direction, evaluation	(24 mos) GS-14
(1)	Physicist:	System design & development, effects evaluation, analysis, measurement protocol	(24 mos) GS-12, 13
(1)	Engineering Physicist:	Instrumentation support facility, system design and development, analysis	(24 mos) GS-12, 13
(1)	Biophysicist:	Effects evaluation, information inventory, Environmental Impact Statements, guidelines and standards	(22 mos) GS-12, 13
(1)	Secretary:		(24 mos) GS-6, 7
(1)	Engineering Physicist	Data analysis and data acquisition systems	(12 mos) GS-12
(2)	Physicist or Electrical Engineer:	Systems development, development of field laboratory capability for EERL, WERL	(12 mos) GS-12
(2)	Electrical Engineer:	Field studies and data anslysis	(10 mos) GS-12
(2)	Physicists or Biophysicists:	Analysis and Environmental Impact Statements	(12 mos) GS-12
(3)	Electronic and Instrumentation Technicians:	Instrumentation support facility, field studies	(12 mos) GS-9
(1)	Computer Systems Specialist:	Computer systems and software	(12 mos) GS-12, 13

TABLE C-17 (Cont'd)

(1)	Secretary:		(12 mos) GS-6
(2)	Electrical Engineers:	Field studies conducted from EERL and WERL	(12 mos) GS-11, 12
(2)	Technicians:	EERL and WERL	(12 mos) GS-9

Salary Costs: $382,800

INSTRUMENTATION SYSTEMS AND SUPPORT FACILITY REQUIREMENTS

Gross survey instrumentation	$12,000
Field intensity measurement systems	95,000
Spectrum analysis instrumentation (manual and computer controlled)	230,000
Support instrumentation and equipment	150,000
Antenna systems: Acquisition, development calibration	50,000
Data acquisition systems	100,000
Mobile units	80,000
Maintenance and calibration	60,000
Total Costs:	$777,000

The total systems costs include requirements for the Electromagnetic Radiation Analysis Branch and the field studies support facilities at EERL and WERL.

INTERAGENCY AGREEMENTS AND SERVICE CONTRACTS

Interagency agreements and service contracts will provide support for the information inventory and the analytical program requirements.

Computer use and software	$100,000
Electromagnetic Compatibility Analysis Center Data Bank	80,000
Office of Telecommunications Data Bank	60,000
Walter Reed Data Bank	15,000
Total Cost:	$255,000

PROGRAM SUPPORT

Additional support includes purchases of reference literature and support for the information inventory, publication, travel and transportation, and supplies.

TABLE C-17 (Cont'd)

Information inventory needs (books, journals, literature surveys)	$ 5,000
Publication	9,000
Travel	20,000
Transportation	45,000
Supplies	30,000
Total Cost:	$109,000

TOTAL PROGRAM COST: FY 1973 and FY 1974

The total program cost for the optimum program is summarized for FY 1973 and FY 1974.

Personnel	$382,800
Instrumentation systems and support facility requirements	777,000
Interagency agreements and service contracts	255,000
Program support	109,000
Total Optimum Program Cost:	$1,523,800

Additional goals include: development of the capability required to respond to emergency (short notice) situations; development of requirements for existing laboratories such as the Eastern Environmental Research Laboratory; preparation to respond with technical assistance to requests made by other EPA offices, Federal, State, and local agencies; review of Environmental Impact Statements; and publication of field study results and technical accomplishments through reports and articles.

All of these goals will be accomplished through establishment within the Office of Radiation Programs of the following capabilities:

- program direction and development;
- design, development, acquisition, and application of instrumentation and data handling systems;
- information inventory;
- analytical procedures and computer application capability; and
- liaison with external organizations.

The needs can be generally described as being included in the following categories:

- personnel;
- instrumentation systems and support facilities;
- interagency agreements and service contracts for development of analytical support and the information inventory;
- program support for publication, travel, transportation, and general supplies.

PROPOSED PROGRAM

External Needs

The proposed nonionizing electromagnetic radiation program differs from the optimum program only in the time schedule required to accomplish the program elements. The same program objectives are intended for accomplishment, but over a longer period of time. The Proposed Program is shown in the Milestone Chart, Figure C-34. All external needs are the same as that for the Optimum Program.

Internal Needs

The program is now in its initial stages of development. The internal needs of the program are determined through modification of Optimum Program internal needs, on the basis of an extended time schedule. Reductions in personnel requirements are made possible by programming a less intensive effort in the field study program and in the associated analytical studies required for determination of the status of the environment. In addition, development of the measurement capability in the field support laboratories will be delayed; the training effort for personnel will be reduced; the instrumentation supplied to support groups for FY 1974 will consist only of gross electromagnetic radiation survey meters with the additional field intensity measurement and spectrum analysis capability delayed until FY 1975. Manpower and cost requirements for the Proposed Program are shown in Table C-18.

COMPARISON OF OPTIMUM AND PROPOSED PROGRAMS

Proposed and optimum programs developed by the Electromagnetic Radiation Analysis Branch for purposes of solution of the radio-

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TABLE C-18

REQUIREMENTS - PROPOSED PROGRAM

FY 1973 REQUIREMENTS

PERSONNEL REQUIREMENTS

(1)	Biophysicist or Physicist:	Program direction, evaluation	(12 mos) GS-14
(1)	Physicist:	System design and development, effects evaluation, analysis, measurement protocol	(12 mos) GS-12, 13
(1)	Engineering Physicist:	Instrumentation support facility, system design and development, analysis	(12 mos) GS-12, 13
(1)	Biophysicist	Effects evaluation, information inventory, Environmental Impact Statements, Guidelines and Standards	(8 mos) GS-12, 13
(1)	Secretary:		(12 mos) GS-6, 7

Total Salary Cost: $89,000

INSTRUMENTATION SYSTEMS AND SUPPORT FACILITY REQUIREMENTS

Gross survey instrumentation	$ 2,000
Spectrum analysis instrumentation (additions to existing systems)	7,000
Support instrumentation and equipment	22,000
Antenna systems	10,000
Data Acquisition systems	30,000
Mobile unit	15,000
Maintenance and calibration	6,000
Total Cost	$92,000

INTERAGENCY AGREEMENTS AND SERVICE CONTRACTS

Computer use and software	$ 8,000
Electromagnetic Compatibility Analysis Center	20,000
Total Cost	$28,000

TABLE C-18 (Cont'd)

PROGRAM SUPPORT

Information inventory needs	$ 2,000
Publication	2,000
Travel	4,000
Transportation	8,000
Supplies	5,000
Total Cost	$21,000

TOTAL PROPOSED PROGRAM COSTS: FY 1973

Personnel	$89,000
Instrumentation Systems and Support Facility	92,000
Interagency Agreements and Service Contracts	28,000
Program Support	21,000
Total Cost	$230,000

TABLE C-18 (Cont'd)

FY 1974 REQUIREMENTS

PERSONNEL REQUIREMENTS

(1)	Biophysicist or Physicist:	Program direction, evaluation	(12 mos) GS-14
(1)	Physicist:	System design and development, effects evaluation, analysis, measurement protocol	(12 mos) GS-12, 13
(1)	Engineering Physicist:	Instrumentation support facility, system design and development, analysis	(12 mos) GS-12, 13
(1)	Biophysicist:	Effects evaluation, information inventory, Environmental Impact Statements, guidelines and standards	(12 mos) GS-12, 13
(1)	Secretary:		(12 mos) GS-6, 7
(1)	Physicist or Electrical Engineer:	Systems development, data analysis, development of field laboratory capability for EERL and WERL	(12 mos) GS-12
(1)	Electrical Engineer:	Field studies and data analysis	(10 mos) GS-12
(2)	Physicist or Biophysicist:	Effects analysis and Environmental Impact Statements	(12 mos) GS-12
(1)	Computer System Specialist:	Computer systems and software	(8 mos) GS-12, 13
(2)	Electronic and Instrumentation Technicians:	Instrumentation support and field studies	(10 mos) GS-9
(1)	Secretary:		(12 mos) GS-6
(2)	Electrical Engineers:	From EERL and WERL	(4 mos) GS-12
(2)	Technicians:	From EERL and WERL	(4 mos) GS-9

Total Salary Cost: $226,000

TABLE C-18 (Cont'd)

INSTRUMENTATION SYSTEMS AND SUPPORT FACILITY REQUIREMENTS

Gross survey instrumentation	$ 12,000
Field intensity measurement instrumentation	12,000
Spectrum analysis instrumentation computer controlled system	135,000
Support instrumentation and equipment	55,000
Antenna systems	25,000
Data acquisition systems	20,000
Mobile unit	25,000
Maintenance and calibration	29,000
Total cost	$313,000

INTERAGENCY AGREEMENTS AND SERVICE CONTRACTS

Computer use and software	$ 40,000
Electromagnetic Compatibility Analysis Center	40,000
Office of Telecommunications	40,000
Walter Reed data base	10,000
Total Cost	$130,000

PROGRAM SUPPORT

Information inventory needs	$ 3,000
Publication	5,000
Travel	12,000
Transportation	27,000
Supplies	15,000
Total Cost	$ 62,000

TOTAL PROPOSED PROGRAM COSTS: FY 1974

Personnel	$226,000
Instrumentation Systems and Support Facility	313,000
Interagency Agreements and Service Contracts	130,000
Program Support	62,000
Total Cost	$731,000

frequency - microwave problem area are presented in Table C-19. All major program elements are specifically designated.

MEASURES OF GOAL ATTAINMENT

Because of the various effects of nonionizing electromagnetic radiation are not well defined at this time, the use of any specific or gross health effect as an indicator of program effectiveness is not possible, at least initially. Consequently, the radiofrequency-microwave program must be evaluated differently as time goes on and as more biological-effects information is obtained. Initially, an evaluation of the various program element achievements is reasonable with, possible, later evaluation being done on the basis of actual health effects.

One possible method of measuring the program's effectiveness, on other than a health effects basis, would involve the determination of the general population exposure to RF and microwave energy. This could be accomplished by measuring environmental levels and applying this information to population distribution data. If, as a function of time, over the first several years, no detectable increase in average population exposure occurred, the program could be judged as, at least, having held the status quo.

A listing of the expected accomplishments and measures of these goal attainments in terms of specific program elements follows.

Authorization to Monitor

Immediate authorization to conduct general environmental monitoring and perform specific source measurements must be obtained. This

TABLE C-19

COMPARISON OF OPTIMUM AND PROPOSED PROGRAMS

	Optimum Program	Proposed Program	Impact
Enforcement			
Develop program for enforcement of guidelines and/or standards to control EM pollution in environment	Program to be in effect by 1/76, to: (1) ensure proposed sources meet requirements prior to operation, (2) bring operating sources into compliance with standards	Program to be in effect by 1/77 to ensure proposed sources meet requirements prior to operations	Operating sources will have increased in number and power enhancing adverse environmental effects. Pertains to introduction of OTH Radar, automotive control systems, super power UHF-TV, etc.
Legislative Requirements			
Authority to conduct measurements wherever ERAB designates and whenever necessary for emergency situations	Immediate Requirement	Immediate Requirement	None
Authority to test humans	Immediate Requirement	No later than 1/73	Delay in responding to currently existing requests for assistance and potential emergency situation
Establish clear authorization for access to classified information regarding EM sources	Immediate Requirement	Immediate Requirement	None
EPA authority to enforce standards and bring sources into compliance	Necessary for effective and immediate implementation of standards by 6/75	Necessary for effective implementation of standards by 6/76	Number of sources that could have been controlled prior to operation will have increased
Enactment of Standards into law	Required by 12/75 to implement standards and allow	Required by 12/76 to implement standards	Number of sources that could have been controlled prior to operation will have increased

TABLE C-19 (CONT'D)

	Optimum Program	Proposed Program	Impact
Research & Development			
Generation of essential information through implementation of specified research needs	EM radiation biological effects information needs and recommended research activities will be specified by ERAB for action by OR&M. Starting 9/72	Same	None
Monitoring Information			
Instrumentation systems, measurement techniques	Emphasis on gross indicators of long-term exposure at selected sites. Starting 7/73	Same	None
Field Support Program	Monitoring performed by selected field facilities under direction of ERAB. Data returned to ERAB headquarters for analysis and evaluation. Should be started by 7/74	Reducted in effort by 50%.	Environmental status data is less comprehensive
Analytical Procedures	Electromagnetic radiation analysis including monitoring data, ECAC, OT, FCC data, etc. Includes preparation of essential software. Starting 7/72	Same	None
Environmental Assessment	Permits trend analysis required for long range planning. Assists in identifying potentially adverse situations. Starting 9/74	Same	None

TABLE C-19 (CONT'D)

	Optimum Program	Proposed Program	Impact
Criteria and Standards			
Evaluation of effects and environmental impact	Synthesize current knowledge of effects (e.g., cataract formation and sterility and non-thermal hazards), dosimetry, and RFI effects on various equipments. Fund research where appropriate. Starting 7/72	Same	None
Interim Guidelines	EPA, EM radiation guidelines necessary to ensure maximum effectiveness in EM pollution program by 6/73	Delay guidelines to 9/73	Diminished program effectiveness and delayed response to public health EM radiation needs
Guidelines & Standards	Determine implications of setting standards (e.g., health, economics, spectrum utilization). Starting 9/72	Delay one (1) year	Will not significantly affect development of standards
Decision on Proposed Standards	Necessity for standards determined by 1/74	Delay decision to 1/75	Standards delayed one (1) year
Proposed Environmental Standard	Proposed environmental standards for EM radiation exposure available by 6/74	Delay proposed standards to 6/75	Number of sources that could have been controlled prior to operation increased
Technology Assessment	Technology Assessment will be a continuing program which naturally evolves from the efforts being conducted under information inventory development, research effects analysis, development of guidelines and standards. Environmental impact statement reviews constitute a part of this program.	Limitation in scope	Review of the impact of classes of developing technology and potential applications will be reduced

TABLE C-19 (CONT'D)

	Optimum Program	Proposed Program	Impact
Surveillance & Inspection			
EM parameters and measurement techniques	Specify meaningful EM parameters and measurement techniques to characterize status of environmental EM pollution	Same	None
Instrumentation and data acquisition systems	Necessary instrumentation and data acquisition systems that will be developed and acquired are included in the following categories:		
	gross measurement instrumentation. Necessary 7/72	Same	None
	improve current state-of-the-art for hazard instrumentation. Starting 7/72	Reduced effort	No dramatic effect initially, but hazard measurements instrumentation development is slowed
	manually operated spectrum . analysis and precision . field intensity equipment . necessary 9/72	Same	None
	automated spectrum analysis . and precision field . intensity equipment . necessary 10/72	Delayed until 10/73	Rate of collection of environmental data is reduced resulting in less accuracy in describing the environmental status and related impact. Delayed field support facility involvement restricts geographic deployment
	associated data acquisition and processing systems. Necessary 9/72	Same	None

TABLE C-19 (CONT'd)

	Optimum Program	Proposed Program	Impact
Data reduction and analysis techniques	Develop the required analytical techniques and software capabilities Start 7/72	Same	None
Field measurement protocol	Specification of procedures required for efficient performance of field measurements. Start 1/73	Same	None
Implementation of field measurement capability	Adaptation of systems for mobility and field applications. Start 2/73	Same	None
Site selection	Initial emphasis will be placed on describing urban EM environments and special population groups. Start 8/72	Same	None
Field measurement program	Ensure efficient and meaningful data acquisition and optimum use of equipment. Field support facilities will be phased into program. Start 7/73	Same	None
Environmental assessment	Evaluation of environmental quality and identification of potentially adverse situations in terms of health effects, interference effects, and general quality of life. Start 7/73	Same	None

TABLE C-19 (CONT'D)

	Optimum Program	Proposed Program	Impact
Training			
Field Facility Personnel	Technical information and instruction required for implementation of ERAB field facility program. Starting 10/73	Same	None
State & Federal Agencies and Regional Offices	Provide technical guidance and instruction. Starting 3/73	Same	None
Technical Support			
Instrumentation Support Facility	Required for maintenance, calibrations, and general support of monitoring and surveillance aspects of program located at ERAB headquarters. Must be available by 9/72	Same	None
Technical Publications	Essential output for demonstration of program productivity and dispersal of information developed. Should begin 7/72	Same	None
Review of Environmental Impact Statements	Assistance to Technical Assessment Division until adequate internal capability is developed. Starting 7/72	Same	None
Data Base Requirements	Use of ECAC, OT data bank. Needed 7/72	Same	None

TABLE C-19 (CONT'D)

	Optimum Program	Proposed Program	Impact
States			
Assistance in solution of nonionizing radiation problems	Assists states where expertise is lacking and speeds solution to EM problems in environment. Provides technical guidance. Includes instrument loans, measurement and analysis capabilities. Phased into program but various aspects beginning 7/73	Same	None
Regions			
Liaison activities	Coordination of activities involving monitoring, surveillance and inspection and emergency response facilitates the implementation of these program aspects. Provides for regional awareness of headquarter activity to ensure rapid response to environmental issues. Begins 8/72	Same	None
Other EPA Coordination			
OR&M Liaison	Develop need statements for OR&M from gaps identified in knowledge. Maintain liaison with respect to equipment and technical capabilities in event of possible reciprocal assistance requirements. Starts 7/72	Same	None

TABLE C-19 (CONT'D)

	Optimum Program	Proposed Program	Impact
Other Agency Coordination			
FCC, FAA, OT, OTP, DOD Liaison	Required for efficient program implementation. Possible fall-back measurement capability in case of emergency or equipment failure. Starts 7/72	Same	None

authority is mandatory to develop initial information for purposes of evaluating current environmental levels of electromagnetic radiation. Certain aspects of this goal may be attained by working through and utilizing the established authority of the present Interagency Radiological Assistance Plan (IRAP) program within SID. Such a working relationship will be established by appropriate memoranda between the programs involved. Authorization for those aspects not covered within the context of the IRAP program will be sought through coordination with other agencies such as the FCC, DOD, and OT.

Access to ECAC and OT Source Data Bank

Immediate access to the extensive EM source data banks maintained by ECAC and OT must be obtained. This information is mandatory in order to apply appropriate analytical procedures for EM analysis, both for general environmental population exposure estimates as well as specific source level calculations. The attainment of this information access will be indicated by the signing of necessary interagency agreements, as soon after the start of FY 1973 as possible.

Emergency Response Capability

The immediate development of an emergency response capability in terms of making high level EM measurements is needed. This capability is required to make RF exposure assessments about suspected offensive sources in light of currently used voluntary guidelines. A primary indicator of this goal attainment will be the acquisition of broad-band, handheld survey type meters.

Synthesis of Current Effects Knowledge

A synthesis of the current knowledge regarding both biological and interference effects if required before interim guidelines are developed. Attainment of this goal will be indicated by the publication of an ORP technical report in 8/73.

Development of Instrumentation for EM Measurements

Development of instrumentation systems is required for meaningful determination of ambient EM radiation levels. Though this development work may be of a continuing nature, well defined systems will be operational by 6/73 and 6/74, respectively. These systems will consitute (1) a manually controlled spectrum analyzer interfaced with a data acquisition system and a tuneable precision field intensity meter, and (2) a completely automated spectrum analysis system utilizing computer control and data processing and storage.

Characterization of Urban EM Spectra

The first major field effort is a careful spectral characterization of various urban EM environments during the summer of 1973. Indications of this accomplishment will include adaptation of the required measurement systems for mobility, field deployment of the mobile surveillance facility, and a final report giving results, conclusions, and recommendations for similar future work by 11/73.

Headquarters Instrumentation Support Facility

In order to develop, calibrate, and properly maintain the required instrumentation systems and develop appropriate measurement methodology and techniques for environmental EM measurements, a headquarters based instrumentation support facility is mandatory. Initial development of the facility will be initiated as soon as possible and the successful attainment of this goal will be indicated by the acquisition and installation of the required maintenance and calibration equipment and fixed monitoring antennas at the facility. This facility will be operational initially by 9/72 and completely outfitted by 6/73.

EM Ambient Level Determination

Emphasis on meaningfully specifying, from field measurements, the ambient environmental levels of EM radiation will be stressed during FY 1974. Initial indications of this accomplishment will be in the form of technical reports issued during the Fall of 1974.

Specific Source Monitoring Data

A detailed measurement procedure must be developed and applied to a variety of common EM emitters found in the environment. This constitutes both short- and long-term measurement projects for the purpose of defining actual-radiation characteristics of these emitters for ultimate use in assessing the current status of population exposure to RF. A measure of this goal attainment will be the issuance of various technical reports.

Analytical Procedures for EM Radiation Analysis and Software Requirements

The development and application of analytical procedures for modeling and calculation of EM source levels for various geographic configurations is required. Also, the development of special software for data acquisition systems used in the collection of field data is necessary. These goals will be attained with the simultaneous issuance of documentary memoranda indicating the status of particular mathematical methods and/or computer programs.

Rate of Growth Determination

To facilitate long-range planning, program effectiveness, and possible standards development, the rate of growth of nonionizing EM sources and the associated total ambient EM levels must be assessed. This goal will be accomplished by both theoretical and field monitoring methods. As a minimum, a preliminary report detailing current indications and yielding projections for the future will be issued by 11/74.

Interim Guidelines

Effective implementation of the ERAB program to identify and solve nonionizing electromagnetic radiation problems requires the development of operating, interim guidelines for RF exposure. These interim guidelines will be published in a technical publication, among other places, by 9/73. These interim guidelines will be reviewed on a continuing basis and serve as the primary input for a decision on the necessity of developing proposed EM standards for the environment.

Decision on Proposed Standards

It is anticipated that the necessary input data will be available for making a decision as to the necessity of proposing environmental EM standards by 1/75. The outcome of the decision process will represent a preliminary determination of ORP's responsibility.

Write and Enact Standards

Dependent upon the outcome of the aforementioned decision process, standards may, or may not, be written for the purposes of protecting the public health and preservation or improvement of the environment with respect to EM nonionizing radiation. This process, should it be determined necessary, will take place approximately 6/75 for writing of the proposed standards and approximately 12/76 for enactment of the proposed standards into law, allowing 18 months for the necessary legislative aspects.

Annual Report

As a continuing aid to evaluation of program effectiveness and productivity, a comprehensive report describing accomplishments will be produced annually. This report will provide an overview of the RF-microwave problem area and its solution.

LASER RADIATION

PROBLEM DESCRIPTION

The potential for irradiation of the general population by the light emitted by laser systems is small. Lasers are not generally used in applications which affect the environment, but are usually confined in use to areas restricted in accessibility. A few exceptions do exist however, where lasers are used in the environment and could conceivably create hazards to individuals through thoughtless or careless application and control of the laser system and area in which it is used.

The use of lasers in scientific, industrial, and military applications is growing. The potential for application to the communications industry is great. However, in these applications unintentional irradiation of individuals is easily avoided with proper precautions being taken, i.e., by restricting the accessibility to areas in which these systems are used. Persons working with laser systems are trained to avoid direct irradiation, and protective measures must be taken to avoid hazards due to reflections from surfaces.

Potential hazards exist primarily because of ignorance or carelessness with the most significant possibilities for hazardous exposure to the general public existing in educational institutions, medical, and dental facilities, and in the environment due to surveying and ranging applications.

Background

The laser can be generally characterized as a source of high intensity, coherent, monochromatic light with a very small angle of beam divergence ($\approx 10^{-4}$ radian). Depending upon the laser material and purpose, systems may be operated either in a continuous or pulsed mode. Laser systems (not a single individual system) can produce light with wavelengths ranging from the vacuum ultraviolet to the infrared, and have produced peak powers above 1×10^9 watts.

Biological damage consists primarily of thermal effects on the eye and skin; the eye being the most sensitive organ due mostly to efficient transmission of light in the visible and infrared wavelengths (up to $\approx$1200 nm), high retinal absorption over these wavelengths, and the focusing characteristics of the lens. The latter characteristic is responsible for the extremely low level of incident laser light used as a threshold to avoid retinal damage. While a number of exposure guidelines exist, the cornea exposure levels are typically 1×10^{-6} watt/cm^2 for CW laser systems and 10^{-7} joule/cm^2 for pulsed systems. The proposed American National Standards Institute (ANSI) standard recommends a maximum permissible exposure level of 1×10^{-3} watt/cm^2 to the cornea. This level, while three orders of magnitude higher than the previously mentioned level, is under attack by representatives of private industry because the vast majority of some 90,000 low power CW lasers now in use in this country transmit power to the cornea at 2.6 to 13 mw/cm^2.

LEGISLATIVE STATUS AND COORDINATION

The U.S. Department of Health, Education, and Welfare (DHEW), the U.S. Department of Labor; and the ANSI all have or might have a role in regulating the manufacture and use of lasers.

DHEW is obligated by PL 90-602 - known as the "Radiation Control for Health and Safety Act of 1968" - to develop and promulgate a standard (now being developed) that will apply to lasers, laser systems, and laser-containing products intended to produce laser light. The purpose of the standard is to ensure that laser products will be manufactured to meet the appropriate performance requirements which minimize the possibility of radiation injury.

The Department of Labor, through PL 91-596 - the "Occupational Health and Safety Act of 1968" - may adopt any national consensus standard, such as a standard adopted and promulgated by ANSI. Any standard adopted by the Department of Labor for PL 91-596 would apply, to all lasers used by workers in industry. At this time, the greatest prospect of a national consensus standard appears to be the standard currently being reviewed within ANSI.

ANSI has established committee Z-136 to develop a laser standard. The committee's membership is comprised of representatives from approximately 50 organizations (technical, professional and industry organizations, universities, government agencies, etc.), and several individual experts.

Proposed Program

It is recommended that the ORP program for minimization of environmental and biological effects due to use of laser systems be one of maintaining cognizance in this area because of the minimal risk for exposure of the general population. Cognizance will be maintained through the implementation of the Information Inventory Development program element of the Radiofrequency and Microwave Radiation Program within ORP. Up-to-date awareness of the extent of general population exposure to applications of laser systems will permit modifications in the ORP program to be made if required, and in addition, permit evaluation of Environmental Impact Statements.

Maintenance of liaison and coordination with other Federal agencies is made possible by membership in ERMAC as is the case for RF and microwave radiation. ERMAC intends to include radiation from lasers as an area for its consideration.

MEDICAL ISOTOPES

PROBLEM DESCRIPTION

Component Problems

When radionuclides are used in medicine, five distinct groups of people experience radiation exposure:

- production, shipment and burial personnel,
- patients,
- occupational personnel (physicians, technicians, nurses, aids, other patients, housekeeping staff, and administrative personnel),
- visitors, and
- the general population outside the hospital but in the vicinity of the nuclear medical center.

The five groups of people represent five different problems. This proposal, however, will not be concerned with the occupational exposure of personnel involved with production, shipment and official burial of radionuclides used in nuclear medicine since the AEC, OSHA and another team within ORP, EPA has this responsibility; nor will it be concerned with the environmental radiation exposure, contamination and body burdens of the medical community (internal environmental radiation exposure) and of the general population outside the hospital (external environmental radiation exposure). To date, the general population in the vicinity of the nuclear medical facility is exposed to an undefined quantity of radiation.

A special problem in itself, within the internal environment is the official record of man-made radionuclides used in medicine. To date, some hospitals produce some of their own radionuclides which are thus not controlled by the AEC.

Background

According to a document entitled "Survey of the Use of Radionuclides in Medicine" prepared by the Stanford Research Institute for the Bureau of Radiological Health, the use of radiopharmaceuticals has markedly increased from 400,000 administrations in 1959 to 1,575,000 administrations in 1966. Only three years later, Glenn T. Seaborg, AEC, reported that 3,000,000 radiopharmaceutical administrations were made annually. According to Dr. Abraham Goldin of Harvard, patient administrations will increase 20 percent annually, yielding 20 million administrations by the year 1980. Within the last decade the percentage of short-term general hospitals, equipped with radionuclide facilities increased from 22 percent to 35 percent, therefore, involving more than 2,000 such hospitals by 1970. To date, the relative importance of the total radiation dose received by patients and other members of the medical community from radionuclides as compared to X-ray exposures is small (10-15 percent). However, only eight years ago, radioisotopes contributed only five percent. In other words, the problem of environmental medical isotope exposure is increasing faster than the X-ray exposure problem as indicated in a Houston hospital where the average gonadal radiation dose per patient increased from 0.06 rads in 1964 to 0.14 rads in 1968. The radiation dose, on the other hand, from X-ray examinations, remained the same for 1964 and 1968 (1.2 rads).

The external environmental radiation contamination, which occurs by way of radionuclide release to the air via incineration and to the water via sewer systems, remains essentially uncontrolled. Although the AEC allows only one Curie per year per institution to be released to the sewer system, this restraint does not include the radioactive contamination in excreta from individuals undergoing medical diagnosis or therapy with man-made radioactive material.

Scope

In a recent study of five hospitals in the Boston area, Drs. B. Shleien and E. LeCroy, Jr. reported that the average I-125 thyroid burden in the medical community working with the nuclide was 5 nCi per individual, the maximum thyroid burden being 20 nCi. In other words, the average and maximum thyroid radiation dose from I-125 was 105 and 420 mrad per year per person. Other radionuclides accumulate in various critical organs as well and the whole body does from other man-made medical isotopes would, of course, be added to these simple figures.

Ironic, however, is the fact that the radiation dose from I-125 alone for the medical community at risk was 10,000 times greater than that expected for the population at risk in the vicinity of a nuclear power plant where the man-rem risk from all radionuclides is only 0.0091 mrem/person at risk. If priority is placed in relation to the man-rem at risk concept, the environmental medical isotope problem should be placed higher than nuclear power plant radioactive pollution.

Argument for nuclear power studies could be made on the basis of the rapid growth of such plants, however, the debating point is reduced when an individual considers also a 20 percent annual increase in medical isotope administrations. Argument for nuclear power plant studies could also be made on the basis of real power needs of our population. However, most sick people feel the diagnostic need for radiopharmaceuticals is equally as important, or even a bit more.

LEGISLATIVE STATUS

To date, five government bodies have rules and regulations covering part, but in no case all, of the radiation problems associated with medical isotopes in the medical community including the patient and the external environment surrounding the hospital. These groups by name include:

- Atomic Energy Commission (AEC),
- Bureau of Radiological Health (BRH),
- National Institute of Occupational Safety and Health (NIOSH),
- Occupational Safety and Health Administration (OSHA),
- Criteria and Standards Division, Office of Radiation Programs, Environmental Protection Agency (CSD, ORP, EPA).

The original legislative status of the external environmental radiation exposure via the sewer system is not adequate even though the AEC has partial restriction in this area under their rules and regulations, Title 10, Part 20, Section 303. The total radioactivity released to the sewer systems presently is not limited by law. The

Environmental Protection Agency should establish the maximum permissible radiation dose from radioactive contaminants released by a nuclear medical facility to the external environment in order to fill the present loophole. However, the new standard can only be established and enforced after the proper assessment of the existing and projected problem is completed scientifically via monitoring and evaluated on a health risk and dose allowance basis. (In other words, no additional legislation is required since EPA needs only to set the limitation of radiation dose which must be followed by the correct limitation of radioactive release set by the AEC.)

COORDINATION

Interagency

Five different governmental bodies need to coordinate their efforts towards reducing unnecessary radiation contamination and exposure:

AEC

Presently, AEC is only involved in the partial restriction of radionuclides used in medicine since radiopharmaceuticals produced within hospitals are not restricted by the commission. As a result, the AEC should evaluate and consider the entire radionuclide usage of each prospective licensee before awarding the permit and should set maximum limitations of all radionuclides on hand, regardless of the method of production.

BRH

BRH should continue their radiation epidemiological work in regards to patient exposure, continue the educational efforts of training and upgrading techniques of the medical community, and continue their standards concerned with quality radiation equipment and sources.

NIOSH

NIOSH of DHEW should establish their concern with toxicological research.

OSHA

OSHA of the Department of Labor should continue to strengthen their concern for occupational radiation exposure.

ORP

ORP of EPA should assess especially the external environmental radiation exposure problem from hospitals, monitor and review the internal environmental radiation exposure as well, establish a new standard(s), if necessary, and encourage enforcement thereafter.

ALTERNATIVE APPROACHES

The ORP, EPA could request that the other four governmental bodies, especially the AEC, assess the external environmental radiation exposure and other related problems. A weaker alternative would be to request directly that state agencies, for example the Environmental Improvement Agency in New Mexico, provide ORP with data so that CSD could assess the problem area.

OPTIMUM PROGRAM

External Needs

Legislative Needs

By the end of 1975 ORP, EPA should have had qualitative and quantitative analyses of the internal and external environmental radiation exposure and contimination completed. Furthermore, CSD, ORP, EPA should have completed the health risk evaluation associated with present and projected levels of internal and external environmental radiation exposures before 1977. As a result, during 1977, CSD, ORP, EPA should establish a standard, setting the maximum permissible limits for nuclear medicine release per year, month and week to the external environment (vicinity of hospital releasing radiopharmaceuticals). No legislation, then, is needed.

Knowledge

The radiation exposure and body burdens of the medical community in the internal environment need to be substantiated by additional data. More importantly, however, is the unknown amount of radioactive contamination in the environment resulting from releases from hospitals. The external environmental radioactive contamination needs to be monitored and evaluated.

Research and Development Needs

Through the use of lithium fluoride thermoluminescent dosimeters, comparative environmental dose measurements should be made (1) within the sewer system in the effluent discharge line leading from the nuclear medicine section, patients section alone, research section, and the entire hospital where no additional dilution occurs between the hospital and the city sewer system; and (2) within the stack of the incinerator. These dose estimates should be related to the total quantity of discharge released per time radiation dose is measured, discharge depth, and concentration of radionuclides in the actual effluent discharge material.

Through the use of film badges, comparative dose measurements should also be made for each type of individual exposed: physicians, technicians, nurses, aids, janitors, visitors, etc.

The Optimum Program requires five different investigations of the internal environmental radiation exposure and ten different investigations of the air and water routes of contamination (external environmental radiation exposure). In the Optimum Program, two grants would be awarded for internal environmental radiation exposure analyses and seven grants would be awarded for external environmental radiation contamination.

Enforcement and Control Requirements

At the present time, AEC, BRH, NIOSH, OSHA, and ORP should essentially mark time until the assessment by CSD, ORP, EPA is made and a need for additional limitations has been shown to be scientifically sound. Then, the AEC and associated State agencies must enforce those limitations or standards established by CSD, ORP, EPA.

Interagency Implementation

Within EPA, three laboratories will be requested to monitor both the internal and external environmental radiation exposure. In the latter analysis, both air and water radiocontamination must be determined.

The three laboratories for this program are:

Radiological Engineering Laboratory
National Environmental Research Center
5555 Ridge Avenue
Cincinnati, Ohio 45213

Eastern Environmental Radiation Laboratory
P.O. Box 61
Montgomery, Alabama 36101

Western Environmental Research Laboratory
P.O. Box 15027
Las Vegas, Nevada 89114

Once a new standard is established, however, regional radiation representatives of EPA will need to provide guidance to medical communities and State agencies.

Internal Needs

Monitoring data in the requested form will be sent to CSD, ORP, EPA for evaluation. Health risk analyses will be made and a standard will be developed if the Director of CSD so seems necessary. If a new standard is desired at that time, legal advice and preparation will be required internally. ORP manpower will consist of one person in CSD for FY 73, 74, 77, and 78 and three people in CSD during FY 75 and 76.

PROPOSED PROGRAM

Exactly the same as the "Optimum Program" with two exceptions:

(1) Three groups will be analyzing the internal environmental radiation exposure problem instead of five groups. No grants will be awarded since all monitoring will be conducted with ORM.

(2) Five groups will be analyzing the external environmental radiation contamination instead of ten groups. Only two grants will be awarded since three external environmental radiation contamination analyses will be made by ORM.

COMPARISON OF THE OPTIMUM AND PROPOSED PROGRAMS

Only the degree of significance associated with the assessment of radiation dose and contamination will be affected.

MEASURES OF GOAL ATTAINMENT

ORP, EPA will have recognized, assessed and evaluated the problem concerned with radiation exposure to the medical community. If the problem warrants the setting of a standard, the establishment of such a limitation will be the second measure of accomplishment. If such restraints are established and the enforcement and control measures are implemented so that the radiation exposure and contamination to both the internal and external environs are reduced or stabilized as measured by State agencies, the third goal will have been reached.

OCCUPATIONAL EXPOSURE

PROBLEM DESCRIPTION

The problem is that personnel are being occupationally exposed to radiation in an industry that is rapidly expanding and little or no effort is being expended to prevent exposures from increasing. The contribution of occupational exposure to the population dose from radiation is poorly documented in the scientific literature. Despite the lack of published information, a vast quantity of data has been accumulated in various personnel dosimetry programs throughout the United States.

In general, the data collected by the various reporting agencies have been primarily for verification of the adequacy of radiation protection practice and to preclude, where possible, over-exposure of the worker. The retention of the data by the employer is in most instances, for medical-legal purposes.

Component Problems

Problem 1

Occupational exposure regulations are established for the purpose of controlling individual exposures. Under present regulations each individual is limited to an average annual dose of five rem. However, there is no limit as to the number of persons that may receive this dose for a particular activity. Thus the potential man-rem exposure is almost unlimited and presents an unacceptable situation on a national basis. Under present regulations any person who is 18 years of age or more and is not pregnant, can be exposed to an average of five rem per/year by designating that that person is occupationally exposed. Further, there are no nuclear facility design requirements limiting man-rem dose from occupational exposure.

Problem 2

There are limited requirements for uniformity in collecting and reporting of all occupational exposure to radiation and there are no required standards for accuracy in personnel exposure measurements.

Problem 3

In small nuclear installations, the adequacy of definition of occupational exposure is questionable and the controls for and measurement of occupational exposure are generally inadequate.

Background

The statutory authority of EPA to advise the President on radiation matters affecting public health is derived through the transfer of authority from the former Federal Radiation Council (FRC) (42 U.S. Code 2021 M). Although EPA has no specific authority to set occupational exposure limits, participation in standards setting for exposure of uranium miners at the request of the Department of Interior is an example of the general EPA policy of advising other Federal agencies with regard to radiation safety.

Regulations controlling the occupational exposure are provided by the AEC and by state health departments for by-products material and by state health departments for electronic devices which emit radiation. These regulations define radiation areas in terms of radiation exposure rate and identify the controls required for personnel entering or working in these areas. General observation indicates that the controls established in accordance with these regulations for nuclear facilities of sufficient magnitude to have full-time personnel devoted to radiation safety are generally adequate for control of individual exposure to levels prescribed by the regulations. However, controls in smaller facilities are estimated to be generally less adequate with the definition as to which areas and which personnel are to be controlled being rather vague. These situations generally are limited to small medical facilities, research facilities, and educational institutions.

Experience with nuclear maintenance operations at major nuclear facilities indicates a lack of design considerations for maintaining occupational exposure to a minimum. A general solution by the facility operator is to accept the facility design and to attempt to work out procedures and equipment for performing maintenance in such a fashion as to keep individual exposures within the required limits. In cases where procedures and equipment are inadequate to maintain low exposure, additional personnel (generally from the local area due to union requirements) are brought on the job to spread the exposure, thus reducing individual exposure but increasing the total man-rem dose.

No current program exists to correct the above problems and continued expansion of the nuclear industry could result in unacceptable population dose due to occupational exposure. This situation may already exist in localized areas wherein the genetic exposure could become important due to continued exposure of the same population over generations.

Scope

Present

The present scope of the problem is partially defined in Table C-18. Additional information relative to the causes of occupational exposure is needed. This information can only be developed by those present and involved during maintenance operations to nuclear facilities, or by observation of practices at nuclear medical, research and educational facilities.

The data in Table C-20 generally represent information collected in 1969 and 1970. There is considerable uncertainty as to how much the data varies from one year to the next. This is particularly true for occupational exposure from nuclear power facility operations and maintenance. For example, Table C-20 shows the total annual occupational exposure from all such facilities to be only 497 man-rem. These data are from 1969 records. However, a report from Consolidated Edison shows the occupational exposure at the Indian Point-1 facility to be approximately 770 man-rem to approximately 900 persons in a six-month period in 1970 during which the plant was shut down for refueling and maintenance. Extrapolating the Indian Point-1 exposure situation to the current situation where up to four nuclear facilities with a total electrical capacity of about 15 time the capacity of Indian Point-1 are constructed on one site, the potential exists for occupational exposure to increase to a significant level.

Based on the following assumptions, the somatic risk from occupational exposure associated with nuclear power facility operations in the

Table C-20

Estimated U. S. Occupational Dose

Activity	Approximate No. employees included in study	Annual mean exposure (mrem)	Man-rem per year
Air Force	35,000	88	1,555
Army	7,400	95	708
Navy	55,000	200	10,900
AEC	103,000	197	20,361
AEC Licensees			
Medical	20,228	260	5,260
Major Processor	1,789	276	495
Waste Disposal	21	457	96
Radiography	1,894	397	752
Industrial	13,331	160	2,139
Academic	7,738	116	903
Reactors	2,302	216	497
Fuel Processing	6,637	328	2,177
Packing & Transport	335	65	22
Total AEC Licensees . . .	62,090	215	13,365
Agreement State Licensees	24,500	273	6,700
Non-federal Medical x-ray	194,600	320	62,000
Non-federal Dental x-ray	171,200	125	21,400
Medical Radium	37,900	540	20,500

year 2000 can be calculated.

- The exposure rate at a plant the size of Indian Point-1 is 1/4 the average rate for a facility that size or approximately 385 man-rem/year (arbitrary assumption).
- Occupational exposure rate will be directly proportional to facility size.
- Nuclear power production will grow at the rate indicated in Figure C-35.
- Risk values in ICRP 8 of 20 leukemia cases, 20 other fatal neoplasms and 10-20 thyroid carcinomas per 10^6 man radiation exposures, are realistic estimates.

The above assumptions result in the following calculations:

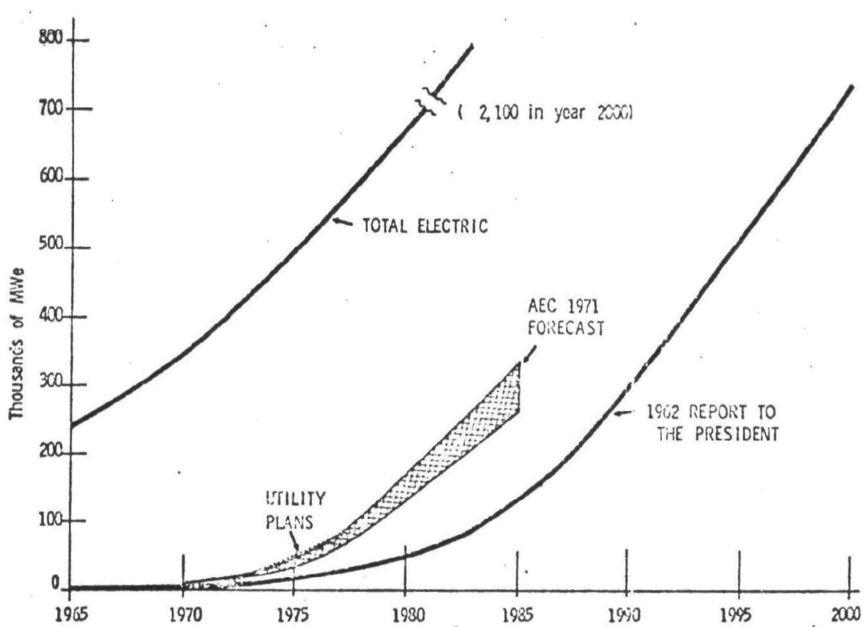
$$\frac{2.1 \times 10^6 \text{ megawatts in year 2000}}{2.65 \times 10^2 \text{ megawatts at Indian Point-1}} = \text{8000 times as much nuclear power in year 2000 as presently at Indian Point-1.}$$

8000 X 190 man rem/year = 1.5×10^6 man rem/year in year 2000. This represents a risk of 1.5 times the values for risk discussed in ICRP possibly involving a total population of 7.2×10^6 persons.

With continued effort to reduce population exposure from emissions from nuclear facilities causing more in-plant exposures, and considering increased size and number of plants, and increased age of operating facilities, occupational exposure from nuclear power facilities may become one of the major sources of man-made population dose. Figure C-35 shows the anticipated growth rate of the use of nuclear energy for nuclear power with a factor of six increase in capacity by the year 2000.

Figure C-35

ESTIMATED NUCLEAR GENERATING CAPACITY IN THE U.S.
THROUGH THE YEAR 2000



Without additional controls, occupational exposure from these facilities will increase at a rate at least equal to the nuclear power growth rate.

The scope of the problem relative to occupational exposure at medical, research, and educational facilities in terms of the number of personnel exposed and the estimated extent of their exposure is defined in Table C-20. The first step in solution of the problem is to determine the causes of exposure, the areas where improvement can be made and the actions required to effect those improvements.

LEGISLATIVE STATUS

The basic legislative authority for controlling occupational exposure to radiation from by-product materials is contained in the Atomic Energy Act of 1954. The Department of Labor has the authority to regulate worker exposure through the Occupational Safety and Health Act of 1970 with DHEW providing research input.

Based on the Atomic Energy Act of 1954, Title 10, Code of Federal Regulations, contains several parts dealing with the licensing of by-product and special nuclear material. Part 20 of these Regulations, limits the occupational exposure of individuals to specified concentrations of these products in air and water, as well as to specified exposure rates from external radiation. These limits exceed the limits for exposure of population groups by a factor of 30, and exceed the design guide limits for population exposure of individuals from operation of nuclear power facilities by a factor of 500 to 1,000. No regulations exist which limit the total man-rem of occupational exposure related to a specific activity. Regulations pertaining to nuclear power facilities provide design guidance limiting discharges to levels as low as practicable. "Low as practicable" is defined in terms of population exposure. No similar regulations exist for occupational exposure.

Figure C-36 is a diagram of the process by which occupational exposure to radiation is controlled.

INTERAGENCY COORDINATION

Agencies involved for controlling occupational exposure are the Atomic Energy Commission, the Department of Defense, States, the Department of Health, Education, and Welfare, FDA/BRH, Department of Labor, Department of Interior, and the Environmental Protection Agency Office of Radiation Programs.

Figure C-37 is a diagram of interagency relationships relative to the control of occupational exposure. It is apparent from this chart there is no formal arrangement for feedback of exposure data to EPA, the agency responsible for providing guidance and standards.

ALTERNATIVE APPROACHES

Description of Alternatives

First Alternative

Take no action and depend on present programs to control occupational exposure.

Second Alternative

Point out potential problem to AEC and suggest corrective action.

Third Alternative

Perform limited study to investigate the extent of the problem and

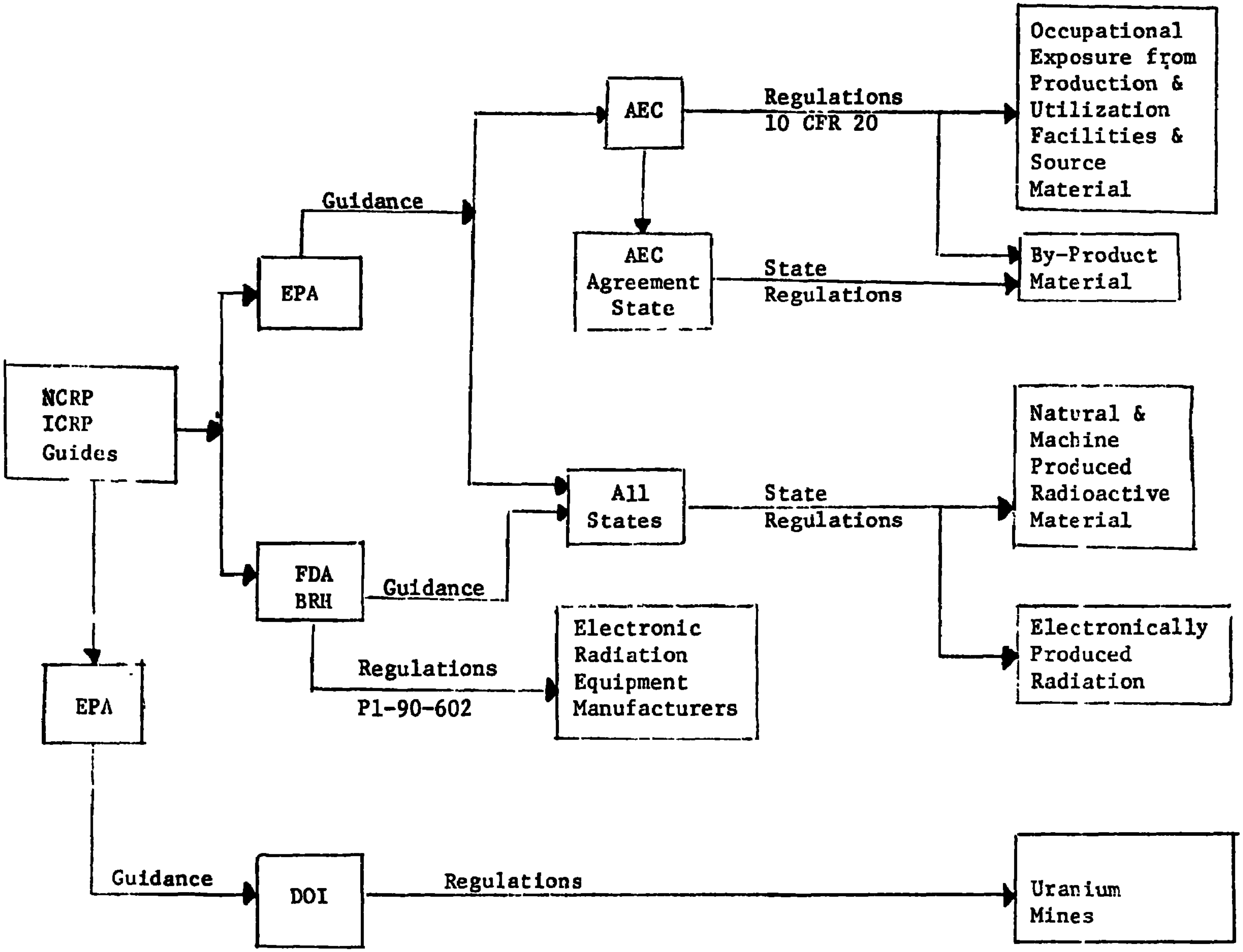


FIGURE C-36

LEGISLATIVE STATUS FOR OCCUPATIONAL RADIATION EXPOSURE

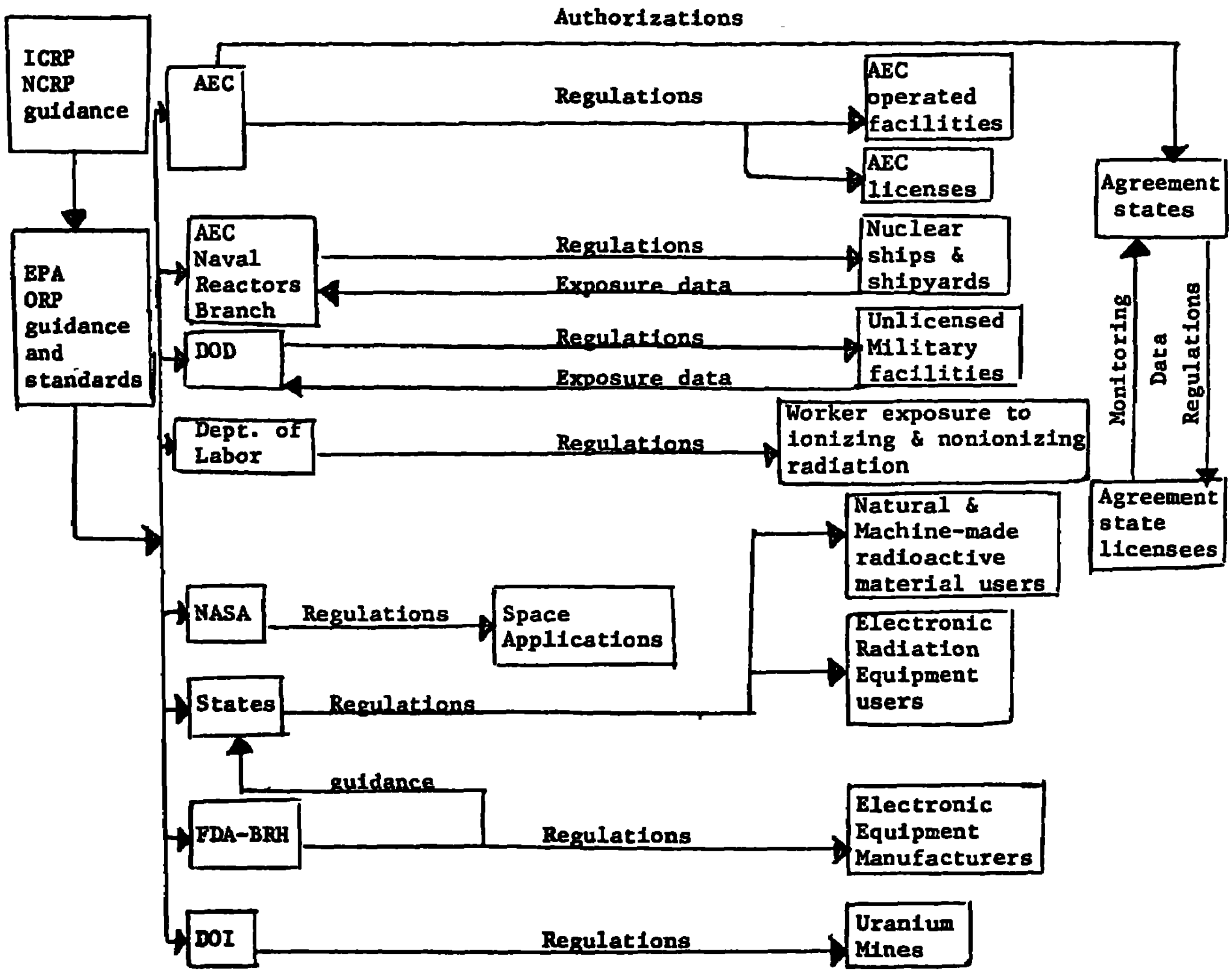


Figure C-37

INTERAGENCY COORDINATION

OCCUPATIONAL EXPOSURE (Current Program)

develop a report with suggested actions by government agencies and industry.

Fourth Alternative

Establish a program to:

- Perform special studies to investigate the extent of the problem as indicated in the third alternative
- Perform special studies to determine actions needed to reduce exposure potential based on findings of special studies
- Advise Federal, and state agencies concerning regulations or other actions needed to reduce occupational exposure
- Monitor corrective action and determining the effectiveness of the revised programs.

Fifth Alternative

Perform the first three items above, and also establish an occupational exposure registry. This registry would be computerized and all occupational exposure would be compiled into the registry for analysis and for prediction of situations requiring corrective action.

Comparison of Alternatives

The fourth alternative is chosen as the Optimum Program. The first and second alternatives would provide little or no information not already available, and would provide no solution to the problem. The third alternative could be performed with minimal funding, but provides no assurance of corrective action. The fifth alternative which includes a registry of occupational exposure would probably meet with objection from industry due to the increased effort required to provide data for the registry. Further, there is no assurance that such a registry and data analysis program would be required to solve the problem. If computerized data management is required, details of such a program can better be defined after initial studies are complete.

OPTIMUM PROGRAM

The Optimum Program would include the steps defined under the fourth alternative, above. The extent of the program will be dependent on the findings in the initial studies. Initially arrangements must be made for AEC, DOD, DOL, and States to provide ORP with information on occupational exposures that have occurred and studies that have been made relative to the causes of these exposures. Agreements must also be negotiated with the AEC and AEC agreement states for special studies of exposures resulting from licensee operations. The Milestone Chart for the Optimum Program is presented in Figure C-38.

External Needs

Legislation Needs

Legislation already exists for controlling occupational exposure.

Knowledge Needs

Information on occupational exposure will be needed as a function of type of facility, trade, and type of job in order to determine the extent of the problem, the potential for continued increases in exposure rates and the corrective actions necessary. Acquisition of this information is the first step in the proposed program.

Research and Development Needs

Additional information is needed to determine the dose risk relationship.

PAGE NOT

AVAILABLE

DIGITALLY

Enforcement and Control Requirements

It is anticipated that EPA will not be directly involved in the enforcement of occupational exposure regulations. The enforcement should be exercised by the AEC or other agencies having regulatory authority over sources of radiation. EPA should be involved in the establishment of standards and control requirements. EPA should also have some type of program to assure through data review that the standards are being enforced by the agencies involved and possibly some degree of independent validation of results.

Interagency Implementation

Operation of this program by EPA will require the cooperation of the AEC, DOD, FDA-BRH, and the States. These are the agencies currently in control of occupational exposure.

Internal Needs

Internal needs outside the Office of Radiation Programs will be limited and will be defined after the initial studies. It is anticipated that regional offices will provide coordination with States in the acquisition of information for the initial and followup studies.

Two personnel should be assigned in ORP during the initial year of the program, to determine the extent of the problem and to establish detailed plans for solutions to the problem. At least one of these should be experienced in occupational exposure control and in methods used for exposure prevention. This person will need assistance in data compilation and analyses and secretarial assistance. Further personnel assignment needs will be determined as part of the initial studies.

MEASURES OF GOAL ATTAINMENT

Under the current program in a particular industry, occupational exposure is expected to grow at a rate at least equal to the rate of growth of that industry. An effective control program should be capable of reducing the rate of increase from the major contributors by at least 25 percent. Monitoring of these programs should be established such that occupational exposure for a particular industry can be related to the operating level of that industry.

The degree of goal attainment should be determined by comparing the rate of growth of an industry to the rate of growth of occupational radiation exposure resulting from that industry.

MEDICAL X-RAY

PROBLEM DESCRIPTION

Medical diagnostic X-ray exposure is now recognized as the major source of man-caused radiation dose to the U.S. population. The purpose of this paper is to outline the Office of Radiation Programs' (ORP) plan of involvement with this problem.

Component problems

Since this problem is only in the cognizance and recognition stage, as far as ORP is concerned, the first task is to assess the parameters of the problem to determine its magnitude and scope. This involves risk/benefit methodology and dose and technology assessments.

Secondly, dose reduction goals need to be set and decisions made on how these goals are to be achieved. This involves determining ORP's authority to act in this area and how best to interact with other agencies in meeting the goals. After this second step, further problems will arise. They cannot be defined at this time.

Throughout the whole program a component problem is to work out sufficient coordination and cooperation with other Federal and State agencies in the various programs, i.e., in acquiring new legislation or carrying out a training program.

Background

Although the medical use of radiation has long been recognized as a major source of human exposure, past radiation exposure guidance has excluded this source from being covered under the recommended limits. The difficulty of controlling this source as well as the undesirability of restricting the physician's ability to treat his patients have led to this exclusion.

However, it is now recognized that some medical radiation exposure may be unnecessary and that research and development activities could produce better equipment and techniques to reduce radiation exposure. Therefore, some control may be indicated. Also, much money is being spent to reduce small exposures from other sources, i.e., reactor effluents, whereas, a smaller amount of money may reduce medical X-ray exposure by a greater amount.

Scope

Medical radiation use constitutes the largest source of man-made radiation exposure of the population of the United States. The Special Studies Group report indicates that in 1970 medical diagnostic X-ray radiation contributed about 90% of all man-made radiation exposure. This percentage will decrease in the future as radiopharmaceuticals increase in use, but the magnitude of the exposure from medical X-ray sources is expected to remain about the same.

The characterization of medical X-radiation exposure is difficult since it depends on the age of individuals exposed, the area of the body exposed, the type of procedure involved, exposed people vs. unexposed people, and high dose rates for short periods of time.

The use of medical diagnostic X-radiation involves the exposure of three groups of people: patients, workers involved in making the X-ray exposure, and people working or located near the exposure area.

The latter two groups are covered by the occupational radiation problem paper. Thus, this problem paper is limited to only considering patient exposure (including dental exposure).

LEGISLATIVE STATUS

EPA

The functions of the Federal Radiation Council were transferred to EPA by Reorganization Plan No. 3 of 1970. These functions include advising "the President with respect to radiation matters, directly or indirectly affecting health, including guidance for all Federal agencies in the formulation of radiation standards and in the establishment and execution of programs of cooperation with States."

Department of Health, Education, and Welfare (DHEW)

The Public Health Service Act as amended by the Radiation Control for Health and Safety Act of 1968 (PL 90-602) provides for the establishment "of an electronic product radiation control program which shall include the development and administration of performance standards to control the emission of electronic product radiation from electronic products." This is administered by the Bureau of Radiological Health (BRH) of the Food and Drug Administration of DHEW. Under this authority BRH will soon publish, in the Federal Register, performance standards for diagnostic X-ray systems and their major components. These go into effect one year after publication.

States

Some States have developed their own regulations for the use of radiation. The Council of State Governments in cooperation with BRH and AEC has developed model legislation for use by the States and a model for State regulations is being revised with assistance from the Conference of Radiation Control Program Directors. Performance aspects of State regulations must be identical to the same performance aspects of Federal regulations in the areas where Federal regulations have been established. In other areas the States are free to establish their own regulations. There is no requirement for States to develop regulations for the use of radiation and about 20 of them have not done so.

Voluntary Standards

Several groups develop voluntary standards for users of medical X-radiation. These groups include the International Commission on Radiological Protection, the International Commission on Radiation Units and Measurements, the National Council on Radiation Protection and Measurements, Committee N-44 of the American National Standards Institute, the American College of Radiology, and the American College of Chest Physicians. Compliance with standards issued by these groups is not mandatory unless they are incorporated by rule-making bodies.

COORDINATION

Interagency

Since this problem is limited to patient exposure from medical X-radiation and since BRH has authority in this area, the major interagency coordination would be with BRH. This coordination should occur at every point in the program since BRH will actually be doing much of the work in program implementation. Some of the sections of BRH that should be included in the coordination are:

- Program Office (XES and other special projects)
- Office of Criteria and Standards
- N.E. Radiological Health Lab (Division of Medical Radiation Surveillance)
- Division of Training and Medical Activities
- Division of Bio-Effects
- X-ray Exposure Control Lab (Division of Electronic Products)

This coordination can probably best be implemented through one contact point with BRH. A few sections of other Federal agencies may be involved in the implementation of a program to lower medical X-ray exposure, e.g., the Medicare program and the Veteran's Administration.

Coordination with the states in regulations and monitoring will be required. The Criteria and Standards Division (CSD) or ORP is administering a contract recently negotiated with the State of Illinois. The contract is for Phases I and II of a three-phase study. The first two phases are to develop models for the inventory and categorization of all radiation sources and for dose assessment and to test these models over an 18 county area in Illinois. These phases are expected to last for 12 months at a cost of $88,260. Phase III would extend the survey to the entire state at a cost of about $170,000 over 2 years.

Coordination would also be required with groups and individuals both inside and outside the government concerning risk-benefit determinations.

Intragency

The Regional program will be involved with working with the states in setting up State-run dose assessment programs (such as the Illinois program) and in assisting them in developing or revising State regulations to reflect EPA guidance.

Some parts of a proposed program can be carried out in cooperation with other programs within ORP, e.g., contracts with States to carry out dose assessment programs.

ALTERNATIVE APPROACHES

Since this problem is only in Stage 1, all approaches to a solution will involve three basic components: (1) assessment of the problem, (2) setting goals and deciding how to achieve these goals, and (3) implementing a program to achieve the goals and to measure goal achievement.

A guiding priciple for the entire program will be to attempt to reduce exposure to a minimum by regulating devices and techniques used in making medical X-ray examinations and by searching for less harmful diagnostic techniques, while not reducing diagnostic capability and not restricting practitioners in the number of examinations indicated. Two alternates are suggested and briefly discussed.

First Alternative

Do nothing - let BRH and the States handle the problem. This essentially involves having no goals and thus no program is needed. BRH and the States can probably handle the problem, but FRC-type guidance would be useful for them. EPA should assess the problem further to see if guidance is needed. This approach is not recommended.

Second Alternative

All other approaches involve an assessment program and the making of a decision. The assessment program involves dose, risk-benefit methodology, and technology assessment. This program can be: (a) minimal, (b) partial, or (c) in great detail, and it could be done solely by ORP or by direct involvement with BRH and possibly some other Federal agencies. The decision could be:

- issue findings of the assessment program and let public pressure, the medical profession, and other governmental agencies determine future courses of action,
- issue FRC-type guidance on dose; let BRH implement,
- issue FRC-type guidance in more detail (including techniques and equipment); let BRH implement, or
- seek further legislation to allow EPA to implement and enforce decision.

OPTIMUM PROGRAM

The optimum program is to set up a joint program with BRH to carry out a partial assessment program and to issue a series of

FRC-type detailed guidance with BRH implementation with EPA assistance.

A joint program with BRH is recommended for several reasons. The guidance to be issued is of the FRC-type which has been formulated in the past by joint efforts of the agencies concerned with the guidance. Much of the information to be used in formulating the guidance will come from BRH, and BRH will be concerned with implementing much of the guidance. Also, it is desired that there be no duplication of effort by ORP and BRH.

Partial assessment (maximum use of current data plus a detailed monitroing contract with one State in each region) is recommended. Minimum assessment (maximum use of current data plus one or two contracts with States) would most likely not be enough to reflect the national situation and wourl not provide enough bases for issuing detailed guidance. Maximum assessment (monitoring contracts with all States) would be unnecessarily time consuming and wourl be unnecessary to describe problem areas.

FRC-type guidance with BRH implementation is more desirable than for EPA to seek legislation to allow implementation and enforcement. BRH has sufficient legislation to act in this area, although it would be desirable to have legislation requiring States to develop radiation protection standards. This problem would also be considered by most people to be outside the environmental sphere. Thus, EPA should not be the lead agency in this area.

Issuing a series of detailed guidance rather than a one-time guidance of minimum scope would allow certain problem areas to be addressed first in one manner and then other problem areas could be addressed in a different manner if necessary. It will probably be necessary to speak specifically in the medical area rather than issue a broad guidance on dose as has been done in other areas in the past.

External Needs

Legislative Needs

Work with BRH and the Conference of Radiation Control Program Directors to obtain legislation requiring States to develop radiation standards.

Knowledge

Use currently available knowledge on dose, risk-benefit methodology, and technology - obtainable mainly from BRH and the States (the 1964 and 1970 USPHS X-ray Exposure Studies will provide much data). Supplement this by having regions contract with one State in each region to carry out a statewide monitoring program for dose, methodlogy and technology. This could be followed up by gradually adding more States to the program. An alternative to the contract State monitoring program would be to work through a program soon to be implemented by BRH in cooperation with the States. The Nationwide Evaluation of X-ray Trends (NEXT) program is scheduled to start in October utilizing data furnished by State inspection programs to monitor trends. It is uncertain if the program will be useful for standard setting purposes, but the required information could be requested to be obtained through this program.

Risk/benefit information could be obtained by talks with and papers from outside interested groups.

Research and Development Needs

Research and development is needed for good monitoring methods of medical exposure and for new methodology and technology to reduce exposure. This can probably be carried out by BRH.

Enforcement and Control Requirements

BRH will carry out enforcement and control within the limits of its legislation. A few other Federal agencies may be affected to a small degree. The type of guidance issued will suggest the need for enforcement and control.

Interagency Implementation

BRH and the States through BRH will implement the program required through the FRC-type guides issued by EPA. Regions will make contract arrangements with the States.

Internal Needs

Legislative Needs

None.

Knowledge

ORP will need to evaluate the information received for all sources in terms of the usefulness and harmfulness of medical X-ray exposure.

Research and Development Needs

Some dose, risk/benefit methodology, and technology evaluation techniques may need to be developed.

Enforcement and Control Requirements

ORP will have some control over the States monitoring program through the contract arrangements. The future legislation may give ORP more direct control over State regulations.

Interagency Implementation

ORP should provide coordination and assistance to BRH and the States, expecially in research and development, in monitoring for goal attainment and in providing any required training.

Implementation

To implement the assessment program it is recommended that several top-level people from both ORP and BRH have a 2-3 day brainstorming type conference to discuss the issues and decide on the approach that will be made to the problem. From this conference a team of one or two people from ORP and BRH should be established to see that the assessment program is carried out. This would not necessarily be a working group but would be mainly a coordination group. They would provide close coordination between ORP and BRH, good exchange of information, and coordination of efforts within their own agencies. They would obtain guidance and assistance from the two agencies in carrying out the assessment program. This would not be a full-time assignment unless they were to function as a working group.

Milestone Chart

The milestone chart for the Optimum Program is shown in Figure C-39. This shows the approximate time scale suggested for the various

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phases of the optimum program. Figure C-39 shows many parts of the program that would have to be performed outside ORP.

PROPOSED PROGRAM

The Proposed Program is to carry out the Optimum Program but with a longer time scale and with fewer states in the monitoring program. This lowers the man-power and dollar requirements of the Optimum Program.

External Needs

The external needs are the same as for the Optimum Program except that only 2-3 States will be contracted with to set up monitoring programs. This will mean that less information will be available on which to base decisions. Therefore, the FRC-type guidance will be slower in coming and will be less detailed than in the Optimum Program.

The NEXT program could be expanded to provide the desired information or more States could be added to the monitoring program in the future.

Internal Needs

The internal needs are the same as for the optimum program except that personnel and budget restrictions will slow the process.

Milestone Chart

The milestone chart for the proposed program showing ORP's functions is given in Figure C-40.

Comparison of Optimum and Proposed Programs

The major impact of the proposed program compared to the optimum program will be that the doses in 1980 will probably not be as low as

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they would be if the optimum program was instituted. This results because the FRC-type guidance will not be as detailed as in the optimum program. It will not be as detailed because less State data will allow less assessment of improvement areas. Less detail will lead to fewer changes in State regulations and fewer items for BRH to implement and enforce.

It is possible that the States' standards in themselves will be sufficient control, and, that along with training, the proposed program will lower the doses as much as the optimum program would. This would be a plus, but the chances of this happening are not as great with the proposed program.

MEASURES OF GOAL ATTAINMENT

Goals

- To develop a continuing medical X-ray dose and use assessment program.
- To eliminate unnecessary radiation exposure due to medical X-ray use.

Measures of Goal Attainments

- The number of States participating in the monitoring program.
- The trend of the data resulting from these monitoring programs.
- The numbers of people being trained in the better uses of medical X-rays.
- The doses measured in about 1980 in State or national studies compared to the doses measured in the 1964 and 1970 PHS studies.

NUCLEAR DEVICE TESTING

PROBLEM DESCRIPTION

There exists a potential risk to the health of the general population from exposure to radiation that may result from the testing of nuclear devices. The magnitude of this risk is determined by measuring any increase in levels of environmental radioactivity and assessing the exposure to the general population.

Component Problems

Sources

An unusual component of this general problem is the variability and uncontrollability of the sources of testing, the sites at which tests are conducted, and the types of tests. Since the first tests by the United States in 1945, there have been tests conducted by the U.S.S.R., Great Britain, and France. They have ranged from safety tests of the equivalent of several pounds of high explosive to tests of the equivalent of fifty or more megatons. They have been sited from the Arctic to the equator and far into the southern hemisphere. They have been detonated underground, underwater, on the surface, in the atmosphere, and beyond the atmosphere.

Background Levels

As a result of the atmospheric tests prior to the nuclear test ban treaty, the natural background radioactivity of the whole planet has been changed. During the height of the U.S. testing program during the 1950's, extensive fallout measurement programs were conducted across this country and selected overseas locations. These studies make possible the estimation of the present levels from past testing activities throughout this country, and the prediction of how these levels will decrease with time, in the absence of any appreciable new testing.

Source Related Levels

Another component to this general problem area, is the measurement or prediction of environmental radioactivity levels, arising from specific tests. There is a response time limitation required to establish field surveillance/monitoring programs, the time frame in which analysis must be completed, and the temporal limitations under which protective actions must be initiated.

Of great importance to this component problem is the degree of credibility which attaches itself to the end product of these surveillance/monitoring efforts. The timeliness of the data gathering and analysis and the credibility of the finished product, however, only serves as stepping stones which lead; in cases of difficulty, to the implementation of corrective actions. The critical question regarding corrective actions is of course, the governmental siting of the legal authority to initiate such actions, the speed with which they can be instituted, and their public acceptance.

Finally, with regard to this problem, a major difficulty is the necessity of maintaining the necessary manpower, equipment, and facilities in a standby status. The difficulty is compounded during times, such as the present, when the testing program is reduced far below the years of peak activity and the continuation of the entire testing program is a matter of public and international discussion.

Synergistic Aspects

It must be continually stressed that the environmental radiation contribution from weapon testing activities must not be viewed alone. It must be assessed as a part of the total with which the population is faced. Another part which is very closely related is that arising from the nuclear detonations-~~which~~ are conducted, in the Plowshare Program. The distinction between nuclear devices used for weapon development reasons and those used for peaceful reasons pales into insignificance when the resulting effects are looked at from an environmental protection viewpoint.

Background

The majority of the U.S. nuclear device tests were carried out either at the Eniwetok Proving Grounds (EPG) in the South Pacific, or at the Nevada Test Site (NTS) near Las Vegas, Nevada. The NTS has been used primarily for atmospheric, surface, and underground tests with yields below one megaton. As a result of the nuclear test ban treaty, all nuclear devices tests at NTS are conducted underground. A summary of the U.S. nuclear detonations as of July 1, 1972, is presented in Table C-21.

In 1954, the U.S. Public Health Service (USPHS) of the Department of Health, Education, and Welfare, signed a memorandum of understanding with the Atomic Energy Commission (AEC) to provide a comprehensive offsite radiological surveillance and safety program in areas adjacent to the NTS and other testing locations as requested. This program was conducted by the USPHS until December of 1970 when the responsibility for

TABLE C-21

U.S. NUCLEAR DETONATION SUMMARY

	Number of Tests
CY-1945	
Trinity, Alamogordo, New Mexico	1
Combat detonations, Japan	2
CY-1946	
Crossroads Series, Bikini	2
CY-1948	
Sandstone Series, Eniwetok	3
CY-1951	
Ranger Series, Nevada Test Site	5
Greenhouse Series, Eniwetok	4
Buster-Jangle Series, Nevada Test Site	7
CY-1952	
Tumbler-Snapper Series, Nevada Test Site	8
Ivy Series, Eniwetok	2
CY-1953	
Upshot-Knothole Series, Nevada Test Site	11
CY-1954	
Castle Series, Eniwetok and Bikini	6
CY-1955	
Teapot Series, Nevada Test Site	14
Wigwam, Pacific Ocean	1
CY-1956	
Redwing Series, Eniwetok	13
CY-1957	
Plumbbob Series, Nevada Test Site	24
CY-1958	
Hardtack I Series, Eniwetok and Bikini	31
Hardtack II Series, Nevada Test Site	18
Argus Series, South Atlantic	3

Testing was suspended on October 30, 1958 under a voluntary moratorium which lasted until September 1, 1961 when the Soviets resumed atmospheric testing. The United States resumed testing on September 15, 1961 with an underground test at the Nevada Test Site. Since that time statistics have been recorded on a Fiscal Year Basis.

	Number of Tests
FY-1962	
Nougat Series, Nevada Test Site	41
Project Gnome, Carlsbad, New Mexico (12/10/61)	1
United Kingdom Test, Nevada Test Site	1
Dominic Series, Christmas Island and Eastern Pacific	24
FY-1963	
Storax Series, Nevada Test Site	30 (d)
United Kingdom Test, Nevada Test Site	1
Dominic Series, Johnston Island area and Christmas Island area	12

TABLE C-21 (CONT'D)

	Number of Tests
FY-1962/1963 (additional)	
The limited test ban treaty restricting tests to underfround emplacements was signed in Moscow on August 5, 1963. On August 20, 1963, President Kennedy told reporters there had been 97 tests at NTS between September 15, 1961 and the treaty signing. This included 23 tests not previously announced. These tests have not been identified as to date of name.	23
FY-1964	
Niblick Series, Nevada Test Site	26 (e)
Project Shoal, Fallon, Nevada (10/26/63)	1
FY-1965	
Whetstone Series, Nevada Test Site	31 (e)
United Kingdom Test, Nevada Test Site	1
Project Salmon, Hattiesburg, Mississippi (10/22/64)	1
FY-1966	
Flintlock Series, Nevada Test Site	38 (c)
United Kingdom Test, Nevada Test Site	1
Project Long Shot, Amchitka, Alaska (10/29/65)	1
FY-1967	
Latchkey Series, Nevada Test Site	26 (d)
Project Sterling, Hattiesburg, Mississippi (12/3/66)	1
FY-1968	
Crosstie Series, Nevada Test Site	28 (a)(d)
Project Gasbuggy, Farmington, New Mexico (12/10/67)	1
Faultless, Central Nevada (1/19/68)	1
FY-1969	
Bowline Series, Nevada Test Site	26 (c)
FY-1970	
Mandrel Series, Nevada Test Site	39 (a)(b)
Project Rulison, Grand Valley, Colorado (9/10/69)	1
Project Milrow, Amchitka, Alaska (10/2/69)	1
FY-1971	
Emery Series, Nevada Test Site	9
FY-1972	
Grommet Series, Nevada Test Site	10 (a)(b)
Project Cannikin, Amchitka, Alaska (11/6/71)	1
TOTAL ANNOUNCED U.S. NUCLEAR DETONATIONS	532

(a) Includes 1 Vela Uniform event.
(b) Includes 1 Plowshare event.
(c) Includes 2 Plowshare events.
(d) Includes 3 Plowshare events.
(e) Includes 4 Plowshare events.

environmental studies of radioactivity was transferred to the Environmental Protection Agency (EPA) under the President's Reorganization Plan #3.

The purpose of the EPA program is to document and evaluate the radiological situation through comprehensive environmental sampling and radiation monitoring. A public contact and information program is conducted to advise the public regarding safeguards employed to protect public health and property from radiation hazards. The EPA performs necessary investigations of incidents which might be attributed to radioactivity and which could result in claims against the Government or create unwarranted public opinion. Special field investigations are also performed to determine biological effects or to gather other information of interest.

Scope

Present

The EPA program in this area is conducted by the National Environmental Research Center, Las Vegas, (NERC-LV), on a reimbursable basis with the USAEC. In addition to the weapon testing program, NERC-LV also provides support for the Nuclear Rocket Development Station (NRDS) program, the Plowshare program, and work for other EPA programs.

In FY 72, the operating expenses supported by the AEC were $2,364,000 with 138 man-years of effort. The weapons testing program utilized $2,254,800 and 133.5 man-years. Tables C-22 and C-23 provide a detailed analysis of the expenditures and manpower for the weapons testing program. The computer expenses are not included in this analysis. The off-continent

TABLE C-22

ANALYSIS OF OPERATING EXPENSES BY PROGRAM
(In Thousands)

ENVIRONMENTAL PROTECTION AGENCY

PROGRAM DESCRIPTION	FY 1972	FY 1973	FY 1974
Device Program:			
Rad-Safety Off-Site NTS	$1,552.8	$1,983.2[1]	$2,048.0[1]
Bio-Environmental	380.0	430.6	410.0
Bio-Environmental-Animal Investigation Program	65.0	75.0	80.0
Rad-Safety Off-Continent	30.0	0.0	0.0
Supplemental Test Site	227.0	0.0	0.0
Total Device Program	2,254.8	2,488.8	2,538.0
NRDS Support	35.0	30.0	30.0
Plowshare Program	16.3	30.0	0.0
Reimbursable Work	10.5	20.0	20.0
Capital Equipment - Weapons	48.0	75.0	97.3
Capital Equipment - Plowshare	0.0	0.0	0.0
Total Equipment	48.0	75.0	97.3
TOTAL PROGRAM COSTS[2]	$2,364.6	$2,643.8	$2,685.3

[1]Includes $156,000 for buildings lease.

[2]Excludes computer facilities costs.

TABLE C-23

ANALYSIS OF YEAR-END EMPLOYMENT BY PROGRAM
(Man-Years)

ENVIRONMENTAL PROTECTION AGENCY

	FY 1972			FY 1973			FY 1974		
	Direct	Indirect	Total	Direct	Indirect	Total	Direct	Indirect	Total
Device Program:									
Rad-Safety Off-Site NTS	63.0	32.5	95.5	69.5	36.5	106.0	71.0	37.0	108.0
Bio-Environmental	17.0	6.0	23.0	17.0	6.0	23.0	17.0	6.0	23.0
Bio-Environmental AIP	4.0	0.0	4.0	4.0	0.0	4.0	4.0	0.0	4.0
Rad-Safety Off-Continent	1.5	0.5	2.0	--	--	--	--	--	--
Supplemental Test Site	6.5	2.5	9.0	--	--	--	--	--	--
NRDS Support	1.5	1.0	2.5	1.5	1.0	2.5	1.5	1.0	2.5
Plowshare Program	1.0	0.5	1.5	1.5	0.5	2.0	--	--	--
Reimbursable Work	0.5	0.0	0.5	0.5	0.0	0.5	0.5	0.0	0.5
TOTAL	97.0	41.0	138.0	96.0	42.0	138.0	96.0	42.0	138.0

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and supplemental test site program will not be funded after FY 72.

The bio-environmental aspect of this program is more directly related to the programs of the Office of Research and Monitoring (ORM) while the remaining program relates directly to programs in the Office of Radiation Programs (ORP). A tenant agreement has been established for an Office of Radiation Programs technical support facility at the National Environmental ~~Research~~ Center, Las Vegas. Certain organizational changes and functional relationships have been agreed upon. The Director, NERC, Las Vegas, will report to the Assistant Administrator, ORM. An Assistant Director for Radiation Operations will be appointed by ORP and concurred in by ORM and will be responsible for the tenant program of special studies and AEC offsite monitoring.

The offsite radiological monitoring function and responsibilities are as follows:

Function	Responsible Office
1. Program definition, objective, priorities, and allocation of resources	Office of Categorical Programs (OCP) Headquarters
2. Policy guidelines for executing program	OCP Headquarters
3. Evaluation of results	OCP Headquarters
4. Execution of defined programs	Director, NERC-LV

In support of the offsite program for weapons testing and Plowshare activities, NERC-LV maintains continual radiological surveillance to detect and document radioactivity, regardless of its origin, particularly in the areas around NTS. This surveillance includes personnel and field dosimetry monitoring with radiation measuring instruments and sampling of air, water, milk, soil, vegetation and animal tissue. An immediate action readiness posture is maintained to assist in protecting the population from exposure to environmental radiation. Prior to and during each event conducted at the NTS or the Plowshare sites, aerial tracking and surveillance is initiated to determine cloud trajectory and gather data to estimate the general magnitude of the release and the resulting environmental contamination.

The monitoring and surveillance services are oriented toward a two-part program. The first phase is directed specifically toward the individual by employing a dosimetry system to measure individual or area exposures, and mobile monitors equipped with suitable instruments to measure exposure rates. This phase also incorporates a capability for rapid response to an emergency radiation situation.

The second phase is to ascertain the exposure of a large segment of the population by obtaining estimates of the dose equivalent from radiation levels attributable to nuclear detonations, whether underground tests, excavation projects or nuclear rocket engine tests. Routine sampling of the environment is conducted at fixed locations with established sampling networks.

An Office of Dose Assessment and Systems Analysis at NERC-LV evaluates the impact on the environment of nuclear testing and other radiological activities, particularly in terms of the health and safety of the general public. Calculations are performed to document exposures to members of the population based on environmental sampling and monitoring. A whole-body counting and scanning facility is used to locate, identify, and measure gamma-emitting radioactive materials deposited within the body as a result of inhalation and/or ingestion.

The NERC-LV conducts extensive field and laboratory experimental studies into the ecology of specific pollutants and the methods and effectiveness of the transport to man through the various media. Research efforts are principally applied to investigations into the causes, characteristics, and effects of man-made and natural radiation.

The AEC sponsors an organization known as the Medical Liaison Officer Network (MLON) which provides physicians in locations other than Nevada to investigate radiation injuries which are reportedly due to nuclear testing activities. The coordinator is an EPA medical officer who also is responsible for investigating the medical aspects of alleged offsite radiation exposure around the NTS in Nevada. Representing every State, the District of Columbia, and Puerto Rico, MLON membership is composed of physicians knowledgeable in the field of radiation bio-effects and radiation injury.

A veterinary or animal investigation program is conducted to provide background information to answer inquiries and resolve complaints or claims by livestock raisers, wildlife management personnel, and other groups concerned with the welfare of animals. Wildlife and a domestic herd are studied on and adjacent to the NTS, in cooperation with other agencies, to assess the radionuclide constant of edible species.

Future

The scope of the EPA program in this problem area will be basically the same and will be conducted by NERC-LV under a memorandum of agreement with the AEC.

LEGISLATIVE STATUS

The primary responsibility for conducting the national weapons testing program is mandated to the AEC. The principle legislation relating to the AEC is the Atomic Energy Act of 1954.

COORDINATION

Interagency

The primary agency with which EPA coordinates its activities in this problem area is the AEC. The AEC operates NTS and conducts, primarily through its Los Alamos and Livermore Laboratories, the nuclear weapon development test programs. In addition, some coordination is necessary with the Department of Defense (DOD), particularly the Defense Nuclear Agency. The DOD is primarily involved with weapon effects testing programs. Joint concern for the health and safety of the population also necessitates some coordination efforts with HEW and State and local health agencies. There is a need for coordination with the State Department or other executive branch organizations for testing involving international areas or the territory of other nations whenever venting occurs following a planned test.

Coöperation is maintained by NERC-LV with the Nevada Fish and Wildlife on their wildlife studies. The NERC-LV also maintains a liaison with the Bureau of Sport Fisheries and Wildlife of the Department of Interior in connection with the veterinary program conducted by NERC-LV around the NTS.

The NERC-LV also has the responsibility under the AEC memorandum of understanding to carry out precautionary programs to prevent injuries to members of the public from rocket firing activities at the Tonopak Test Range and from the seismic effects of test detonations at any location. A cooperative program with the U.S. Coast and Geodetic Survey and the U.S. Bureau of Mines is necessary to conduct this program.

Intragency

Coordination is necessary between the Office of Radiation Programs (ORP) and the Office of Research and Monitoring (ORM). The ORM has the administrative authority for all research activities. Formal research requirements are developed by the ORP and submitted to ORM in addition to those developed by ORM. The actual radiation surveillance and monitoring activities are technically managed by ORP. The ORM is kept informed of the scope and nature of radiation surveillance and monitoring activities so that they can properly carry out their overall functions.

Within the ORP, coordination is necessary between all Divisions. The Technology Assessment Division (TAD) has reviewed Environmental Impact Statements related to the testing activities at NTS in the past and has commented on their potential adverse environmental effects. TAD is the group within ORP that is coordinating all the comments on Environmental Impact Statements from the various offices within EPA such as the Office of Air Programs and the Office of Water Programs. The Field Operations Division is the primary contact between NERC-LV and ORP and has planned special studies at the NTS and has coordinated activities of the monitoring networks both nationally and in the immediate environs of NTS.

ALTERNATE APPROACHES

There are several other approaches which could be employed to accomplish EPA's objectives in this problem area. They are as follows:

- Some other agency, such as HEW or the AEC itself could perform the work.
- The work could be performed under contract by private industry.
- The work could continue to be performed by EPA and be funded directly by EPA.

An action memorandum has been written by ORP to the Office of Categorical Programs (OCP) concerning the possibility that EPA initiate action with OMB to transfer funds from the AEC to EPA for conduct of the Offsite Radiological Safety Program in support of test activities at NTS. It has been recommended by ORP to OCP that the present reimbursable arrangement with the AEC be maintained.

OPTIMUM PROGRAM

The optimum program is the same as the proposed programs because the scope of work is defined by the AEC under the memorandum of understanding.

PROPOSED PROGRAM

The proposed program involves basically the continued funding support from AEC for the NTS related activities at NERC-LV and the overseeing of these activities by the Assistant Director for Radiation Operations, ORP.

External Needs

Legislative

None

Knowledge

It is necessary that NERC-LV continue to be informed by the AEC of all plans to conduct weapon testing programs.

Research and Development Needs

The research program proposed for the Offsite Radiological Safety Program, the Radiation Effects Program, and the Animal Investigation Program as submitted by NERC-LV to the AEC are required. This program is outlined below.

Enforcement and Control Requirements

None

Interagency Implementation

The AEC will fund the required NERC-LV activities and will continue to keep NERC-LV personnel informed of test plans.

Internal Needs

In ORP the proposed program requires the assignment of one man-year effort and the funds necessary to support his personnel costs and travel expenses. At NERC-LV, the necessary funding and positions are furnished on a reimbursable basis by the AEC.

Milestone Chart

See Figure C-42.

The program to be conducted by NERC-LV has been adapted from a proposal by the NERC-LV to the AEC of the continuing and new projects

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that they plan to conduct during FY 1973. Since this has not been approved, changes may have to be made in the future.

Off-Site Radiological Safety Program

- The routine environmental monitoring program will continue to document the environmental radioactivity levels around the NTS. As required, methods will be improved and additional nuclides measured.
- After each event an extensive program of sampling various ground media aerial tracking and surveillance will be conducted. Samples collected on and around the NTS will be analyzed for xenon, krypton, and tritium as methane hydrogen gas and water vapor.
- Analysis of soil, air filters, urine, vegetation, and animal tissue for plutonium samples collected through the NTS surveillance network will continue.
- Computer programs will be written for performing additional dose calculations from the data stored in the storage and retrieval system. This is an extension of the project to tabulate doses which might have accrued to an individual in the off-site area due to nuclear testing. Programs will also be written to provide dose contour plotting from surveillance data.
- A complete evaluation and update of the gamma spectral analyses computer programs will be conducted.
- A system utilizing a solid state counting system will be developed to analyze samples that contain complex mixtures. Computer

programs will also be developed to analyze this data.

The program to document the radioactivity levels in hydrological test wells at various off-NTS test sites such as Gnome and Shoal will be continued.

Bio-Environmental Program

- After the excretion of plutonium studies on goats and rats, four different ~~metabolism~~ studies in dairy cows will be conducted. This project will encompass oral and intravenous intakes, excretion, and tissue distribution studies.
- A study will be conducted on the in vitro solubility of plutonium compounds using a simulated rumen.
- The laboratory studies of plutonium assimilation by micro-organisms will be continued.
- The effect of various fertilizers, soil cations and colloids on plant uptake of plutonium will be studied.
- A study of plutonium movement in various soil types will be initiated to determine the influence of soil salinity, cation exchange capacity, texture, and structure of each soil.
- The mechanisms for foliar absorption of plutonium in forage plants will be studied.
- Tissue concentrations of fresh and/or aged fission products will be determined in bovine, mule deer, and other wildlife which range on the NTS with increased emphasis on plutonium-239 and tritium.

- The veterinary or animal investigation program will be continued. Investigations of alleged damage to domestic animals from AEC activities will be conducted in addition to the routine program of surveillance on the radionuclide content of edible species.
- The investigation of plutonium concentrations in the tissues of beef animals grazing the Roller Coaster site will continue.
- A study will be initiated to determine the possible hazards of plutonium-239 by grazing pregnant beef animals, pregnant goats, and fistulated steers on contaminated range in Area 13 of the NTS.
- A workable study of deer migration patterns on the NTS related to the season and preferred area will be developed. One method to be investigated is the use of aerial photography with infrared scanning equipment or the use of telemetry devices.
- Cooperation will be maintained with the Nevada Fish and Wildlife on wildlife studies, and the NERC-LV will supply veterinary support for the Desert Bighorn Range as part of its liaison with the Bureau of Sport Fisheries and Wildlife of the Department of Interior.
- The NTS farm will continue to be utilized to evaluate the uptake of low quantities of mixed fission and activation products in locally grown truck vegetables. Dairy cows from the farm are used for various radioisotope ingestion and inhalation studies.

- A project to measure the distribution and biological magnification of tritium in animals was initiated.
- A final evaluation will be conducted on the high concentration of tritium in urine from volunteers who wore watches with tritiated luminous dials.

MEASURES OF GOAL ATTAINMENT

The expected accomplishments of the proposed program will be primarily: (a) monitoring/surveillance reports for specific testing activities presented to the AEC, (b) technical reports on the research studies published as EPA documents, and (c) routine monitoring/surveillance data from the ORP networks and NERC-LV networks published in ORP's Radiation Data and Reports. The measures of these goal attainments will be the quantity and quality of these reports, the increase in the knowledge of environmental pathways, and the development and dissemination of improved predictive methods and models applicable to future weapon testing operations.

The proposed program, which is primarily a continuation of the past program, will continue to provide documentation of the radiological impact of NTS weapon testing activities on the surrounding area to the AEC. It will also continue the ecological studies being performed by NERC-LV related to the evaluation of the potential impact of past, present, and future on the environment. The program will provide a focal point within ORP which can facilitate the incorporate of results of these NERC-LV/NTS programs into the activities of the three ORP division activities (Table C-24).

TABLE C-24

NERC-LV PROJECTS RELATED TO
ORP PROBLEM AREAS

New NERC-LV Procedures	Possible Utilization
Gas sampler to monitor noble gas	Plowshare Projects NRDS Fuel Reprocessing Operation - Plutonium Operation - Uranium Fabrication - Uranium
Air sampling and research for Tritium	Plowshare Projects NRDS Fuel Reprocessing Tritium - Thermonuclear Operation - Uranium Operation - Plutonium
Plutonium Procedures, Research and Surveillance Program	Operation - Plutonium Fabrication - Plutonium Weapons Testing
New developments in Environmental Monitoring including animal investigation program	Plowshare Projects Fuel Reprocessing Operation - Plutonium Operation - Uranium Weapons Testing Fabrication - Uranium
Computer Operations	All problem areas
Dose and Body Burden Studies	Accidents Fuel Reprocessing Plowshare Projects Tritium - Thermonuclear Construction Materials Fabrication - Plutonium Operation - Plutonium Operation - Uranium Weapons Testing Mining & Mill Tailings Fabrication - Uranium

PLOWSHARE

PROBLEM DESCRIPTION

Summary

The use of nuclear explosives in commercial and public engineering projects as proposed under the Plowshare program presents hazards of two kinds. First, it presents a potentially significant public health hazard from the radioactive contaminants released by the nuclear explosion or associated with the by-products from it. Because of the half-lives of the radionuclides involved and their point of injection, the hazards presented are both immediate and long-term. Second, use of large numbers of nuclear explosives in a relatively small area as proposed by Projects Rio Blanco and Wagon Wheel has the possibility of inflicting severe seismic, physical, and chemical damage to the surface and subsurface environments and natural resources contained therein. It is not possible, at this point, to accurately assess the total impact of these activities due to uncertainties in the development of the Plowshare program and to critical gaps in basic scientific knowledge.

The EPA/ORP program outlined here seeks to minimize the impact of this activity by: (1) filling scientific and economic voids, (2) developing guidance based on risk/cost/benefit balances, (3) making accurate pre-project environmental impact assessments, and (4) insuring compliance with safety guidelines.

Component Problems

The components of the EPA/ORP program correspond to the major program areas of Plowshare. Plowshare activities can be grouped in three broad areas: excavation, resource recovery, and scientific experimentation. The major components of the program are listed below together with an indication of the present activity in the United States. Soviet activities are also included, and are so marked in cases where they are unique.

<u>Excavation</u>

Surface

Canals, dams, harbors (inactive).

Aggregate production (inactive).

Subsurface

Terminal gas storage (inactive).

Deep disposal of radioactive waste - concept stage (active).

Deep storage of industrial and municipal waste (inactive).

Special applications - extinguish gasfield fires (USSR).

<u>Resource Recovery</u>

Stimulation (hydrocarbon)

Natural gas from low permeability formations (active).

Enhancement of oil well flow (USSR).

Mineral recovery

In situ leaching of ore bodies (inactive).

Removing overburden from shallow ore bodies (inactive).

Energy

Fracturing of dry, hot subsurface formations (with a geothermal anomaly) for steam production (inactive).

Scientific

Basic

Neutron cross section studies (inactive).

Fission symmetry studies (inactive).

Applied

Isotope production (inactive).

Background

Surface Excavations

The use of nuclear explosives in surface excavations has recieved considerable attention in the United States and abroad. Shallow nuclear excavations, such as Cabriolet, Buggy, Schooner, and the large 100 kt (kiloton) Sedan crater, have been conducted at NTS to obtain basic cratering and fallout data. Specific applications considered include the excavation of sea-level transisthmian canal and the Ogoturuk Creek Harbor in Alaska (Project Chariot). Interest in this area has declined sharply because of the potential for significant adverse environmental impact, and the present public reaction in the United States against uncontained nuclear detonations.

Subsurface Excavations

Underground excavation experiements in the United States have been limited to the AEC's NTS (Nevada Test Site). The Ketch "experiment," proposed by Columbia Gas System Service Corporation for a site in a State forest near Renovo, Pennsylvania, was dropped. This "experiment" was to have produced a cavity for natural gas storage. Although this particular site was dropped, the program area seems viable and other sites in the Appalachian area may be proposed. The AEC is currently considering the underground excavations as possible means of radioactive waste disposal. In this technique, a deep subterranean cavity is created by a nuclear explosive placed in a drill hole. This cavity is then filled with high level waste whose energy release of heat when added to the cavity heat generated by the nuclear explosion will theoretically seal the cavity and solidify as a stable immobile mass.

Gas Stimulation

The use of nuclear explosives to stimulate the production of reportedly large supplies of natural gas in low-permeability rocks in Rocky Mountain geologic basins has been under development by the AEC in cooperation with Industry. Two previous AEC-Industry experiments in New Mexico and Colorado have demonstrated that nuclear stimulation of gas in low-permeability reservoirs is technically feasible.

The AEC has proposed additional experiments at the Rio Blanco gas filed in Colorado and the Pinedale field in Wyoming with new types and configurations of multiple nuclear explosives designed to fracture thick sequences of low permeability rocks. If the tests are successful, the AEC contemplates the development of the Rio Blanco field with about 140 nuclearly stimulated wells, and the Pinedale field with about 300 nuclearly stimulated wells. Possibly other areas would be susceptible to large-scale nuclear stimulation also. The explosives for the two proposed tests would be detonated as depths greater than 5500 feet at Rio Blanco and greater than 9220 feet at Pinedale, and it is probable that much of the radioactivity from these tests would remain in the deep rocks. Nevertheless, the analysis of the potential environmental effects of the proposed tests is complex and critical because of the large amounts of radioactivity that will be released by the detonation of multiple devices in the 30-100 kiloton yeild range. An analysis of the effects of developing entire gas fields would be extremely complex and is not possible with existing information. The environmental considerations of large-scale nuclear gas stimulation can be assigned to two major categories: (1) effects on the local environment resulting from the nuclear detonations during and after well stimulation and production operations, and (2) the radiation exposure of the general public by widespread distribution and use of the proposed gas. The effects on the local environment that must be evaluated and judged include the effects of hundreds of detonations over a period of possibly 8-10 years. Potential local effects include seismic damage to man-made structures and terrain, contamination of large underground water resources and oil shale, and accidental and purposeful releases of radioactive gas and fluids to the land surface and air during testing and operations. A special problem is the disposal of relatively large volumes of tritium contaminated water that would be stripped from the gas during testing and production. After depletion of the gas fields significant quantities of radioactive materials would remain underground providing possible sources of contamination by slow migration in groundwater for many years.

Assessments of the environmental consequences to the local environment will depend not only on the above described geologic, hydrologic, and radiologic considerations, but also on risk/cost/benefit decisions. The alternatives to large-scale nuclear stimulation whereby the gas might be obtained by further development of chemical explosive and hydrofracturing techniques should be examined. The actual size of gas reserves that could realistically be developed by nuclear stimulation should be determined, and a determination should be made as to whether the increased production of a dwindling energy source will be significant enough, in terms of an overall national energy policy, to justify the radiation risk involved.

The question of radiation exposures from transmission and use of nuclear stimulated gas is central to the acceptability of the gas as a consumer product. In order to evaluate exposures of the general population from actual consumer use, it will be necessary to make projections of the amounts of gas that will be transmitted and used; the radioactivity of the gas at various stages of transmission, stroage, and use; and possible methods of achieving "steady-state" concentrations of radioactivity by diluting gas from newly stimulated wells with uncontaminated gas from other sources. Methods of survèillance and monitoring must be developed at various points in the production and distribution systems. Much of the above is currently being investigated and developed by AEC: nevertheless, the responsibility of EPA lies in examining the problems thoroughly and developing methods and expertise for evaluations, decisions, and recommendations relative to using nuclear stimulated gas as an energy source. The determination of "acceptable" or "permissible" concentrations of man-made radioactivity in natural gas for industrial and commercial use is difficult because this represents only one of many potential sources of radiation exposure and a large population is involved. The responsibility and needs of EPA relevant to nuclear gas stimulation are immediate because of the necessity for technically based decisions concerning Environmental Impact Statements, the necessity for providing technical assistance and consultation to State agencies, and risk/cost/benefit decisions related to the reported natural gas shortage.

Mineral Recovery

Several mineral recovery experiments have been proposed by industrial sponsors. The Bronco experiment was proposed by CER for oil recovery from shales, and the Kennecott Copper Corporation's Sloop experiment was to determine the feasibility of in situ copper leaching. To date, neither experiment has been implemented.

Scientific

Few scientific components of the Plowshare program have been carried out. These have been, in general, conducted as part of device tests at NTS. Two such experiments were a neutron cross-section experiment on the Persimmon Event, and an isotope production experiment on Hutch. An exception is the Gnome-Coach experiment, conducted at Carlsbad, New Mexico. Gnome-Coach was designed to measure the energy dependence of the neutron-activation cross-sections of several heavy elements and the resonance-fission characteristics of Uranium-235.

USSR

The Soviet Union is actively pursuing a program closely paralleling the U.S. effort. The level of Soviet activities is presently several times that of the U.S. and covers a somewhat broader range of applications. They are actively pursuing surface excavation, particularly as applied to water management. Experimentation is being conducted on a technique to stimulate oil flow from spent or low production wells.

Scope of Program

The major completed Plowshare experiments and their dates and sites are summarized in Table C-25.

At present, the only active Plowshare program is the stimulation of gas-bearing formations. This program is currently in an experimental phase in which nuclear stimulation technology, explosives research, and radiological problems are being investigated. It is conducted jointly by the AEC and an industrial sponsor. To date, the industrial sponsors have been Austral Oil Company, CER-Geonuclear, El Paso Natural Gas Company, and Equity Oil Company. As previously noted, two field experiments, Gasbuggy and Rulison, have been completed. Two additional experiments, Rio Blanco and Wagon Wheel, are in advanced stages of preparation. Rio Blanco now scheduled for early 1973, will test the capability of multiple (3) explosives, fired simultaneously, to successfully stimulate a 1400 foot section of thin, low-permeability gas-bearing sand. The Wagon Wheel experiment, tentatively set for 1974,

TABLE C-25

PLOWSHARE EXPERIMENTS

1. Gnome, Carlsbad, New Mexico (12/10/61)[1]	14. Vulcan, NTS (6/25/66)[4]
2. Sedan, NTS (7/6/62)[2]	15. Saxon, NTS (7/28/66)[4]
3. Anacostia, NTS (11/27/62)[3]	16. Simms, NTS (11/5/66)[3]
4. Kaweah, NTS (2/21/63)[3]	17. Switch, NTS (6/22/67)[3]
5. Tornillo, NTS (10/11/63)[3]	18. Marvel, NTS (9/21/67)[5]
6. Klickitat, NTS (2/20/64)[3]	19. Gasbuggy, Farmington, N.M. (12/10/67)[6]
7. Ace, NTS (6/11/64)[3]	20. Cabriolet, NTS (1/26/68)[2]
8. Dub, NTS (6/30/64)[3]	21. Buggy, NTS (3/12/68)[7]
9. Par, NTS (10/9/64)[3]	22. Stoddard, NTS (9/17/68)[3]
10. Hancar, NTS (11/5/64)[1]	23. Schooner, NTS (12/8/68)[2]
11. Sulky, NTS (12/18/64)[2]	24. Rulison, Grand Valley, Col. (9/10/69)[6]
12. Palanquin, NTS (4/14/65)[2]	25. Flask, NTS (5/26/70)[3]
13. Templar, NTS (3/24/66)[3]	26. Miniata, NTS (7/8/71)[3]

[1]Contained underground experiment.

[2]Cratering experiment.

[3]Device development experiment.

[4]Heavy element production experiment.

[5]Emplacement technique experiment.

[6]Gas stimulation experiment (industrial participation).

[7]Row charge cratering experiment with five simultaneous detonations.

will involve sequentially firing five (5) nuclear explosives in a 2700 foot section of thin, low-permeability formation. In addition to gas stimulation experiments, test detonations involving advanced concepts are being conducted at the Nevada Test Site. One such experiment "Yacht" will test the explosive devices and timing and firing system to be used at Wagon Wheel.

The gas generated in Rulison and Gasbuggy (the two stimulation experiments) has relatively low levels of radioactivity, due primarily to the nuclides H-3, Kr-85, Ar-39, and C-14. Significant fractions of these nuclides have been released to the atmosphere during post stimulation testing.

While none of the gas produced in these experiments has been sold commercially, the Rocky Mountain Natural Gas Company will in early 1973 seek clearance from the AEC to allow the sale of Rulison gas in Colorado.

The present EPA/ORP program is devoted primarily to gas stimulation. This program is conducted primarily by EPA's NERC (National Environmental Research Center), ORP, and regional offices. Support is given in the following areas:

- Off-site surveillance of test areas (NERC).
- Analyses to determine health impact from radionuclide releases (NERC).
- Environmental impact statement review (ORP).
- Development of monitoring instrumentation (NERC).

- Basic radiobiological research on tritium transfer (NERC).
- Continuing review of old and new Plowshare concepts and programs (ORP).
- Review and promulgation of radiation standards and protective action guides (ORP).

Activities at NERC are funded by the AEC. In FY 1972 the program was funded to 16.3K for a 1.5 man-year effort. The FY 1973 budget is for 30.0K with a 2.0 man-year level of effort. No funds are currently budgeted for FY 1974. Activities at ORP have been conducted by personnel from the Technology and Impact Review Branch without special Plowshare funding to date.

If the experimental phase shows the gas stimulation program to be safe and economically and technically feasible, a full field development phase may follow. This may include development of gas fields throughout the Rocky Mountain area where it is currently estimated there are 300 trillion standard cubic feet of potentially recoverable gas in place. Assuming full field development is initiated in the 1970's, stimulation activities could continue through this century with the stimulated wells producing for 50 or more years.

It is not possible at this point to accurately assess the impact of full field development due to uncertainties in its growth rate and to serious voids in scientific and technological data. All proposed uses of the gas, whether in domestic heating or in commercial electric generators, would result in atmospheric releases of the radionuclides

H-3 and Kr-85. These releases would not be large in relation to the total atmospheric inventories of these nuclides. A program of 1,000 wells would, however, involve the use of hundreds of megatons of nuclear explosives and leave a vast inventory of nonvolatile radionuclides. In addition, these same explosives could cause serious physical and seismic damage to the surface and subsurface environment. The ultimate fate of these nonvolatile radionuclides is not yet known with certainty, and they represent, because of possible communication with overlying aquifers, a potential long-term environmental hazard.

Other Plowshare programs could become active in the future, and some would involve the deep detonation of nuclear explosives. In particular, activity is anticipated in the areas of deep well disposal of radioactive waste, in in situ oil shale retorting and in in situ leaching of ore bodies. The environmental impact of these activities is as yet undefined.

It has been estimated that under conditions of uninhibited growth the full Plowshare program would involve as many as 2000 detonations in the present decade.

To limit the environmental impact of these activities, EPA must increase its present activities and initiate new activities. Particularly prominent in this latter group will be efforts in the area of criteria and standards. To support these activities, efforts will be made to fill present voids in technological, scientific, and economic data.

Efforts will be directed primarily toward providing a basis for EPA policy and guidance in the area of gas stimulation. Background for these judgments must reflect careful consideration of the benefits and risks of the total stimulation problem, including its relationship to the U.S. energy policy.

LEGISLATIVE STATUS

The basic legislation controlling this activity is the Atomic Energy Act of 1954 (AEA-1954). It is believed that this Act restricts the AEC to participate only in research, development, or demonstration programs. If this is correct, full commercial use of the stimulation technique must await an amendment to the 1954 AEC act. (Hosmer Bill, HR-12919). EPA can, in principle, influence the development of the Plowshare program by taking part in the Hearing on this Bill.

The gas produced by the stimulation technique is considered a by-product material by the AEC. Since present AEC exempt classifications do not include this product, changes in 10 CFR Part 30 will be required. Rocky Mountain Natural Gas Company is expected to file an application with the AEC by January 1, 1973, for the sale of Rulison gas, and thereby force a decision regarding this regulation.

The statutory basis for EPA activity in this area rests with authority transferred in Reorganization Plan No. 3. Authority transferred from the AEC permits EPA to "set generally applicable environmental standards." Authority transferred from FRC permits EPA to recommend to the President guidance for all Federal agencies in the formation of radiation standards. Other transferred FRC functions include the establishment and execution of programs of cooperation with States.

COORDINATION

Interagency

State

The most basic and possibly most important coordination begins at the state level. Federal agencies may plan and industry may promote, but no Plowshare or nuclear gas stimulation project can be conducted without the consent of the state's legislature and governor. The state judiciary often reviews such projects to ensure compliance with state laws and regulations. Although significant roles in surveillance, monitoring, and radiation safety programs may rest with the AEC, its safety contractors, and with commercial safety contractors engaged by industry, the principle radiation safety programs will in many cases remain under state health authroities. Coordination on technical affairs is often required with many specialized state agencies such as the state geological survey, state bureau of mines, and the state office of oil and gas.

Federal

Coordination with the federal government on Plowshare and nuclear gas stimulation projects can run the gamut from the President and Congress to any one of approximately forty executive departments, independent agencies, and special offices and councils of the executive branch. Decisions by the National Security Council or the Office of Science and

Technology can determine whether the nuclear stimulation of gas is in the national interest. EPA/ORP's coordination on Plowshare will be most extensive, however, with the AEC and the Department of the Interior.

Coordination with the AEC occurs from beginning to end of all Plowshare projects. The AEC acts as the official sponsor and technical expert on nuclear affairs to the public and industry for the federal government. From project design to environmental impact statement preparation to post-shot safety evaluation to sale of gas, EPA/ORP will be in constant contract with the AEC.

Coordination with the Department of the Interior may occur at all levels and can occur from shortly after project design to project end. Part of this close interrelationship is based on Interior's control of land; part is based on the "enviro-technical" agencies within Interior. Most of the gas-bearing formations considered suitable for nuclear stimulation underlie government-owned land in the western United States which is controlled or administered by the National Park Service, Bureau of Land Management, Bureau of Reclamation, or Bureau of Indian Affairs -- all of Interior. Many of the environmental and technical assessments and studies necessary before any Plowshare project can be executed may be made by services or bureaus within Interior such as Bureau of Sport Fisheries and Wildlife, Office of Coal Research, U.S. Geological Survey, and Bureau of Mines.

<u>Other External Organizations</u>

EPA/ORP's coordination and contact with other external organizations is wide and varied. The United States, in its "Atoms for Peace" program, has promised to help promote the peaceful uses of nuclear energy. EPA/ORP's coordination with the International Atomic Energy Agency and other United Nations organizations will be required in establishing international radiation release standards, in making benefit/risk assessments of proposed Plowshare projects, dose assessments, and environmental and geological impact assessments for Plowshare projects of international scope or for developing countries. EPA/ORP may engage universities, private laboratories, or industrial contractors on a contractural basis to collect data, assess certain problems, to conduct surveillance and monitoring, or to make laboratory analyses. In addition, EPA/ORP are often contacted by and must react with private citizens' groups, such as the Sierra Club and Colorado Committee for Environmental Information, on matters pertaining to safety and environmental impact of certain Plowshare projects. Coordination with the industrial sponsor of a Plowshare project is continuing and may include: furnishing guidance on safety criteria, radiation release standards, and data which will be required for safety analyses; making impact and safety reviews; and following project development and data acquisition.

Intra-Agency

Present EPA Plowshare efforts require intra-agency coordination between ORP, ORM, and the Regional Offices. This coordination, to date, has been related primarily to the review of EIS (Environmental Impact Statements). Coordination is required between ORP and ORM/NERC so that EIS reviews reflect current monitoring data and research results. ORM personnel have also directly participated in the preparation of EIS's.

Future EPA programs will require an expansion of coordination efforts, and particularly with ORM. Research and development programs sponsored by ORP will require close coordination with ORM to insure a timely development of data. Coordination in the development of standards will be treated mainly through the existing mechanism of working groups and steering committees. Particular attention in the standards area must, however, be given to the coordination of activities with those of Air and Water Programs. The development and implementation of an expanded surveillance and monitoring program will necessitate greater ORP-Regional coordination. Regions VIII and IX will be involved most directly.

Within ORP, continuing coordination of the Plowshare Program activities with other Divisional commitments will be required to meet manpower requirements.

ALTERNATIVE APPROACHES

Seceral alternatives are available that will permit EPA/ORP to achieve (in varying degrees) its objective of limiting the impact of Plowshare activities. These alternatives and their consequences are described briefly in the following paragraphs. Two of the alternatives are developed in detail in previous sections of this document.

Alternative I (Status Quo) is a continuation of the present, largely passive, EPA effort in this area. The program is confined in scope to gas stimulation and limited in activity to EIS reviews and in the conduct of an AEC funded site monitoring program. The program represents the absolute minimum of effort that EPA can expend and meet its delegated responsibilities. The program offers weak control over the impact of present Plowshare activities. The program would be incapable of maintaining control if planned Plowshare expansions take place.

Alternative II is for EPA/ORP to gain, through an unrestricted commitment of its resources, total control over the impact of the entire Plowshare program. This alternative implies that all existing voids in knowledge be filled in the minimum time. To accomplish this, the bredth, depth, and schedules of the data base would be controlled by EPA/ORP. The degree of control sought here would also require that EPA gain direct control over compliance assessment and the enforcement of its radiation standards. This alternative not only allows the EPA to meet its delegated responsibilities but to do so through policies based on a minimum of uncertainties.

Alternative II is for EPA/ORP to embark on a program to gain positive control over the impact of Plowshare activities in a way designed to minimize the commitment of ORP personnel. As a minimum this would require EPA to fill existing information voids and control compliance assessment. The commitment of EPA personnel would be minimized by (1) relaxation of time schedules for accumulation of the information base and (2) through the use of outside agencies and contractors where possible to collect data.

Alternative IV would be for EPA to gain its objectives through largely legislative channels. Specifically, EPA would seek legislative authority to halt proposed Plowshare programs until all questions regarding justification and impact of a given program were resolved to the Agency's satisfaction. This alternative shifts the burden of proof to the AEC and the industrial sponsors. Under such an approach ORP would be required to maintain expertise in the program area to evaluate programs and to produce radiation guidance for approved activities.

OPTIMUM PROGRAM

Introduction

At this time, EPA is actively improving its policy positions, knowledge, and functional capabilities on Plowshare and the nuclear stimulation of gas in response to growing development within these fields. Having just completed the preliminary program phase, EPA/ORP's next moves include: (1) completing a detailed program plan; (2) implementing required operating, legislative, coordinating, and other continuing functions; (3) implementing data acquisition and technical assessment studies required as input for making policy decisions, setting criteria and standards, and maintaining current levels of knowledge; and (4) making necessary internal studies and assessments and arriving at certain policy decisions.

Clearly defining EPA/ORP's Plowshare program, completing the detailed program plans, and issuing guidelines should have first priority, whether the "Optimum" or "Proposed" program is chosen. Responsibility for completing guidelines and detailed program plans for each functional area would be assigned to the branch, division, or laboratory with the greatest competence. On completion, the separate documents would be collated and edited at ORP. Firm realistic deadlines are essential at each step, for a timely completion of the plans and guidelines. Even so, the date of completion is governed somewhat by the editorial processes (higher, lower, and external reviews) and the post. Presuming a beginning date in Second Quarter, FY 1973, a realistic time table would include completion of, and issuing guidelines by First Quarter, FY 1974, and all EPA/ORP organizations assigned to the Plowshare program being operational by the end of FY 1974. The above would not preclude concurrent development of special studies, development of standards, legislative needs, coordination, etc., for which the need is already obvious at this time.

The elements of EPA/ORP's program for Plowshare and nuclear stimulation of gas have been generally categorized as continuing data acquisition, and data analysis/decision making functions. In several cases, these general categories overlap. The program elements which fall under these three categories are discussed briefly below. Because it is necessary to perform the routine functions and often gather data before arriving at decision-making, these are discussed first.

The program elements within EPA/ORP's Plowshare/nuclear gas stimulation program, the milestones which have been identified for each element, its general functional category, and the time frame for each milestone, are shown in Figure C-43. Several nuclear gas stimulation projects have been or soon will be fielded and may to some degree influence any scheduling by EPA/ORP during their program planning.

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Certain continuing functions are dual in that they are routine but also involve "data acquistion" or "policy/decision making." In example, monitoring is a continuing EPA/ORP function, but it also is a data gathering function. Assessment of new Plowshare concepts and review of EIS's involve "policy/decision making," but EPA/ORP must be preapred to perform both on a continuing "routine" basis. The "data acquisition" and "policy/decision making" functions are relatively straight forward and need little explanation. The category(s) of each function or milestone is given in Figure C-43.

Because of the importance of the issues, a "shortest practicable" time table was chosen to complete all major milestones. The time table is shown in Figure C-43 and on the accompanying Milestone Chart. Most milestones are completed within a two-year time frame - by FY 1975. However, several milestones cannot be completed so quickly. Construction, engineering, and technical problems could prevent completion of the devitrification study before FY 1979. Policy decisions on full field development and benefit/risk analysis require evaluated data from Rio Blanco and may accordingly be delayed beyond FY 1975. Several other milestones require data from Rio Blanco, and their completion dates will necessarily be delayed if Phases I or II of Rio Blanco are delayed.

External Needs

Legislative

Legislative authority will be sought to enable EPA to enforce its gas standards. Additional legislation will be required to allow EPA to indicate Protective Action Guides. EPA policy with respect to the Hosmer Amendment (HR-12919).

Knowledge

EPA/ORP will rely on external sources for the following information:

- Gas stimulation test results (AEC-Sponsors).
- Device test results (AEC).
- Geological and Hydrological data (AEC, USDI, and States).
- Gas Resources - gas amenable to stimulation and total reserves (USDI, FPC, States).
- Plowshare schedules and test results (AEC, laboratories, industrial sponsors).
- Plans for new Plowshare applications (AEC, laboratories, industrial sponsors).
- Radioactive-waste disposal plans for tritiated water and test results.

Research and Development

A number of tasks have been isolated for study by ORM in the Recommended Optimum Program. They are:

- Investigate the devitrification of resolidified molten rock containing nonvolatile radionuclides
- The transport of nonvolatile radionuclides from well cavities and chimneys to aquifers
- An independent assessment of the nuclear stimulation technique
- An independent assessment of present and planned non-nuclear stimulation techniques
- Investigation of gas to man exposure pathways for CH_3T and dose models for tritium

- Development of improved instrumentation for tritium monitoring
- Investigate reconcentration mechanisms for tritium
- Investigation of the biological half life of C-14.

Enforcement and Control Requirements

Enforcement of gas standards and initiation of PAG by EPA Office of General Enforcement.

Interagency Implementation

General interagency implementation and coordination will be required in this program and would include:

Agency	Area of Implemenation or Coordination
Congress	House hearing on Hosmer Amendment.
AEC	All phases of Plowshare activities. New Plowshare programs Old Plowshare programs EIS review Gas standards and gas sale Benefit/risk analysis.
Dept. of Interior	Geologic and hydrologic assessment of sites. EIS review.
Federal Power Commission	Gas-in-place studies. Benefit/risk analysis.
Council on Environmental Quality	EIS review.
Office of Science and Technology	Benefit/risk analysis.
National Academy of Science	Benefit/risk analysis.
Bureau of Mines	Benefit/risk analysis. Environmental impact (oil shale).

Agency (Cont'd)	Area of Implementation or Coordination
Bureau of Sport Fisheries and Wildlife	Environmental impact criteria.
States	Surveillance and monitoring. Geologic and hydrologic data. Environmental data.

In addition, the following existing programs also require interagency implementation:

- The joint AEC/NERC (interim) off-site monitoring program and,
- the on-site surveillance and monitoring activities associated with Plowshare detonations. Efforts in both of these areas are expected to be coordinated with the ORP program related to Nuclear Explosives Testing.

Internal Needs

The program requires ORP personnel for the following tasks:

- benefit risk rationales for Plowshare components
- expansion of Protection Action Guides
- EIS reviews
- coordination of research projects
- collation of research results
- development and management of surveillance program and,
- continuing review of technological and scientific base.

In FY 1974, the required ORP level of effort is estimated to be 16 man-years. An estimated 10 man-year level of effort is required in research and study programs.

PROPOSED PROGRAM

Introduction

The objectives of the Proposed Program like those of the Optimum Program are to evaluate and ultimately provide guidance to limit the adverse impact of Plowshare activities. This program has as major areas of emphasis data acquisition and technology assessment, collation and analysis, standards development, and compliance assessment. The major thrust in the areas will be prefaced by a detailed program analysis. This analysis will provide documented scopes for the research and study programs, accurate budget estimates and Request for Proposal documents. During this phase specific task assignments will also be made. An outline of the sequence of these events is shown in Figure C-44. Work on this analysis will not preclude activity required to meet such commitments as the Rulison Gas Problem.

The Proposed Program differs from the Optimum in the depth to which certain problems are pursued, the means by which information is gained, and the approach to compliance assessment and enforcement.

Voids in scientific and technological data, once isolated, will be filled primarily through research and study contracts with outside agencies or contractors. Specific problem areas which have been isolated are indicated in Figure C-44. In general, these will not be pursued in the same time frame as in the Optimum program. The information base serves the two-fold purpose of providing a basis for policy decisions and a background for standards.

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The compliance assessment-enforcement area has two major elements, (1) a State surveillance and monitoring program and (2) AEC-State based enforcement. The State surveillance program will be developed by EPA/ORP with ORM and regional assistance and will be EPA funded. On-site monitoring connected with stimulation detonations will be the responsibility of the ORP Surveillance Program for Nuclear Explosives Testing. The present off-site AEC/WERL program will be examined to determine if additional doverage with respect to radioisotopes and pathways is required. If additional doverage appears to be warranted an expanded program will be developed and presented to the AEC.

Paralleling these activities will be the development of benefit-risk rationales for the Plowshare components. Of immediate concern will be the basis for gas standards. The issue of an interim standard for Rulison gas will be addressed during FY 1973. Decisions on this standard will be based largely on existing data. Benefit-risk balancing for full commercial use of the stimulation technique will, however, reflect inputs from research and study contracts and field experiments.

External Needs

Legislative

Apart from having EPA policy reflected in the Hosmer Amendment, no legislative requirements have been identified.

Knowledge

EPA/ORP will require the following external knowledge:

- Gas stimulation test results
- Device test results

- Geological and hydrological test results
- Gas resource data
- Plowshare schedules
- Plans for new Plowshare applications
- Radioactive-waste storage-disposal plans (particularly tritiated water) and test results

Research and Development

The R&D requirements of this program together with the groups designated to fill them are as follows:

- The devitrification of resolidified molten rock containing nonvolatile radionuclides (by contractor)
- The transport of nonvolatile radionuclides from well cavities and chimneys (by contractor)
- An independent assessment of the nuclear stimulation technique (by contractor)
- An independent assessment of existing and proposed non-nuclear stimulation techniques (by contractor)
- Investigation of gas to man exposure pathways for CH_3T and tritium dose models (by ORM)
- Investigate reconcentration mechanisms for tritium (by ORM)
- The development of improved instrumentation for tritium monitoring (ORM)

Enforcement and Control Requirements

Enforcement of EPA standards will rest primarily with the AEC and States. Detailed programs for enforcement with authority designations will be required.

Interagency Implementation

In addition to the general implementation noted in the Optimum Program, the Proposed program calls for State implementation of an off-site surveillance and monitoring network. This portion of the program will be coordinated through Regions VIII and IX.

On-site surveillance during the detonation will continue to be implemented by the AEC. The interim off-site monitoring program will also be implemented by the AEC. In both cases these efforts will be conducted through interfacing with the ORP Surveillance Program for Nuclear Explosives Testing.

Internal Needs

The proposed program requires the commitment of ORP personnel for the following:

- Establishment of benefit rationales for Plowshare components.
- The preparation of EIS reviews.
- The development and coordination of an ORP/State surveillance and monitoring program.
- The monitoring of research/study contracts and the collation of results.
- The development of standards.
- A continuing review of Scientific and Engineering literature.

The Proposed Program requires direct ORP participation in six functional areas. It is estimated that a 10 man-year level of effort will be required within ORP during FY 1974. Funding to support a 7-8 man-year reserach and development effort in FY 1974 will also be required. In FY 1975 the ORP manpower commitment is expected to remain at 10 positions although increased research funding will be required.

COMPARISON OF THE OPTIMUM AND PROPOSED PROGRAMS

The relative impact of the Proposed Program is measured in terms of the depth, timeliness, and EPA control available in the program's milestones. The same data base is sought in both programs. The Proposed Program will accumulate data more slowly and will attack certain problems in less depth. The Proposed Program will have, therefore, at any given time a less extensive data base. The existence of greater uncertainties resulting from this could lead to more conservative EPA/ORP positions and standards. This will also lead to some decisions being delayed relative to their schedules in the Optimum Program. In particular the policy decision regarding an interim standard for Rulison gas will be delayed several months. This delay will reduce the amount of time available for EPA/ORP to influence possible 10 CFR 30 changes.

The relative impact of the State surveillance and monitoring program can be expected to manifest itself primarily as a loss in the uniformity of compliance assessment. The absence of enforcement authority in the Proposed Program can be expected to lead to reduced effectiveness in gaining compliance with EPA standards, particularly in terms of the time required. The relatively low EPA profile in this portion of the program which interfaces most directly with the public could lead to some loss of public confidence in whether environmental considerations are being adequately addressed.

MEASURES OF GOAL ATTAINMENTS

The overall objective of the Proposed Program is to control the environmental impact of Plowshare activities. Specific milestones that will be accomplished are:

1. An improved model for the gas-man exposure pathway for CH_3T.
2. Hydrological data regarding the transport and ultimate disposition of nonvolatile radionuclides.
3. Development of improved instrumentation for monitoring tritium.
4. An independent assessment of the nuclear stimulation technique.
5. Independent assessment of methods of HTO disposal.
6. An EPA/State surveillance and monitoring program.
7. EPA guidance for the use of nuclearly stimulated natural gas.
8. A technically sound EPA policy regarding gas stimulation.
9. EPA policy reflected in modification to 10 CFR 30 and amendments to the Atomic Energy Act.
10. An expanded data base regarding the effects of Nuclear Explosives Testing.

The accomplishment of the overall objective of the program will be measured by the degree of compliance with EPA/ORP standards and guidelines that is achieved. The accomplishment of the scientific and technological programs can be measured by their acceptance by the scientific and engineering communities.