DOE/EDP-23

Environmental Development Plan (EDP)

ENHANCED GAS RECOVERY FY 1977

March 1978

U.S. Department of Energy
Assistant Secretary for Energy Technology
Assistant Secretary for Environment

DISCLAIMER

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U.S. Department of Energy
Assistant Secretary for Energy Technology
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Washington, DC 20545

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FOREWORD

Environmental Development Plans (EDP's) were conceived and prepared as basic documents for planning and managing environmental requirements of energy technology development. Approximately 30 EDP's covering major developing energy technologies were prepared prior to the establishment of the Department of Energy (DOE). Elements of various organizations were involved in the preparation and review of these plans but reorganization of program responsibilities has made it impossible to complete the formal review and concurrence process as originally planned.

These EDP's are now being distributed so that all having interests and responsibilities may assist in a revision and update which we plan to initiate in DOE along with preparation of EDP's covering environmental aspects of additional DOE programs.

James L. Liverman
Acting Assistant Secretary
For Environment

Robert D. Thorne
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ENVIRONMENTAL DEVELOPMENT PLAN

ENHANCED GAS RECOVERY PROGRAM

SEPTEMBER 1977

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

Technology Program Office:	Division of Oil, Gas, and Shale Technology
Technology Program:	Enhanced Gas Recovery
Coordinated by:	Cynthia B. Wilson Division of Environmental and Socioeconomic Programs
	Robert Jimeson Division of Technology Overview

This Environmental Development Plan is used for planning the environmental health, and safety research and development activities for the ERDA Enhanced Gas Recovery Program. The plan is subject to changes and will be updated annually.

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1. INTRODUCTION

1.1 LEGISLATIVE BACKGROUND

The Energy Research and Development Administration (ERDA) was created on January 19, 1975, by the Energy Reorganization Act of 1974.[1.1] It was assigned the responsibility of researching, developing, and demonstrating new energy technologies. Inseparable from this responsibility is the need to identify and characterize environmental impacts and analyze control technologies needed to mitigate the potential environmental impacts of the energy technologies being developed. Environmental concern is a crucial part of ERDA's decision making at all stages of technology development.

The Federal Nonnuclear Energy Research and Development Act of 1974.[1.2] emphasizes the importance of environmental issues as decision-making factors and requires that energy technologies developed by ERDA be environmentally acceptable.

The National Environmental Policy Act of 1969[1.3] requires that all Federal agencies consider the potential environmental effects of their proposed actions at the earliest possible time. This consideration, or environmental analysis, must be "a systematic interdisciplinary approach" and is used "in planning and in decision making which may have an impact on man's environment."

1.2 ROLE OF THE ENVIRONMENTAL DEVELOPMENT PLAN (EDP)

To meet its responsibility under the Energy Reorganization Act and to be in compliance with NEPA, DOE established an environmental planning process. On December 14, 1976, DOE issued Immediate Action Directive (IAD) #0500-4 initiating the Environmental Development Plan (EDP) process. The EDP is intended to be the basic DOE document to plan, budget, manage, and review the broad environmental implications of each energy technology alternative. The EDP provides the framework for: 1) incorporating environmental consideration into departmental planning processes *at the earliest stages;* 2) resolving environmental issues concurrently with energy technology development; and 3) assuring that environmental issues are considered equally in decision-making with technological, economic, and institutional issues.

For each developing energy technology, including the present Enhanced Gas Recovery (EGR) technologies, the EDP should identify environmental issues in such areas as the physical environment, ecology, health and safety, and socioeconomics. Other functions of the EDP include:

- A summary of objectives and current status of environmental research
- The identification of additional research requirements
- The proposal of a research strategy
- A designation of significant milestones for research and environmental analysis
- An annual review and update to the document, by incorporating environmental research completed that identifies new issues or addresses known issues by acquisition of new data developed during the testing of EGR technologies.

1.3 SCOPE OF THE ENHANCED GAS RECOVERY (EGR) EDP

The EDP addresses planning in two basic areas: environmental research and environmental assessment.

Environmental research can be categorized as follows:

- Characterization of pollutants from EGR processes
- Selective application of monitoring and measuring techniques
- Evaluation of control/mitigation techniques
- Evaluation of the synergistic impacts of the development of EGR techniques.

Environmental assessment activities scheduled by EDP include:

- Assessment of ecological impacts
- Assessment of socioeconomic effects
- EIA/EIS preparation
- Evaluation of control technology needs
- Analysis of applicable and proposed emission, effluent, and health and safety standards.

The EDP schedules and manages environmental assessment activities which include Environmental Impact Assessment (EIA), Draft Environmental Impact Statement (EIS), Environmental Impact Statement (EIS) and the Federal Nonnuclear Energy Research and Development Act (water resource assessment). The most important aspect of scheduling is to assure that the findings and conclusions of the environmental assessments and impact statements be available when program development decisions must be made.

This Enhanced Gas Recovery EDP addresses the environmental impacts of enhanced gas recovery processes in shale and sandstone, methane drainage from coalbeds, and methane recovery from geopressured aquifers.

1.4 ORGANIZATION OF THE EGR EDP

The EGR EDP includes an EGR technology overview (Section 2), a discussion of EGR environmental issues and requirements (Section 3), an environmental action plan (Section 4), an environmental management strategy for the EGR program (Section 5), and supporting appendices which present information on Federal legislation applicable to EGR technology, a summary of ongoing and completed research, and future research and assessment projects.

The technology overview (Section 2) discusses the geologic formations which contain the potential gas resources, the enhanced gas recovery techniques used to produce these resources, and the programs that ERDA is conducting to characterize the various resources and to test the EGR processes.

Section 3 discusses the establishment of environmental goals and describes project issues and impacts in detail. These issues and impacts are the basis for the research requirements which are also discussed in Section 3.

Section 4 is the Environmental Action Plan. This section presents the criteria for setting priorities for research requirements and the criteria for the selection of specific research options. Ongoing and completed research, as well as future research and assessment projects, are discussed.

The Management Strategy of the Environmental Development Plan is presented in Section 5. The EDP implementation responsibility of ERDA's Administrators for Environment and Safety and for Fossil Energy is defined. The interaction of other Federal agencies and the public during EGR technology development is also discussed in this section.

2. TECHNOLOGY OVERVIEW

2.1 BACKGROUND

Natural gas currently supplies approximately 37 percent of the total U. S. domestic energy. The proved natural gas reserves currently stand at 216 trillion cubic feet. The bulk of the proved reserves is contributed by conventional reservoirs underlying the Gulf Coast and the southwestern part of the United States. The development and exploitation of the conventional reservoirs are competitively pursued by the private sector because their high recovery efficiencies (up to 80 percent of the original gas-in-place can be produced with commercially available methods) provide attractive profit incentives.

The main objective of the EGR subprogram reviewed here is to increase the recoverable natural gas reserves of the United States by developing and demonstrating new gas recovery methods which will make it possible to produce gas resources that are currently uneconomic. There are four such resource targets for future development within the EGR subprogram. These are:

1) The gas-bearing Devonian shales of the eastern United States

2) The low-permeability (tight) sandstones of the Rocky Mountain region

3) The non-surface coalbeds (minable and unminable) containing methane

4) The high-pressure, methane-saturated aquifers of the Gulf Coast region (geopressured aquifers).

The latest estimates[2.1] of potentially recoverable reserves associated with these four resources are as follows:

- Devonian Shales — 10 to 250 trillion cubic feet potentially recoverable
- Tight Gas Sands — 53 to 323 trillion cubic feet potentially recoverable
- Methane from Coal — 16 to 503 trillion cubic feet potentially recoverable
- Methane from Geopressured Aquifers — 150 to 200 trillion cubic feet potentially recoverable.

The EGR subprogram focuses on the extraction of the above resources, through the development and demonstration of three stimulation technologies: 1) advanced hydraulic fracturing, 2) chemical explosive fracturing, and 3) directional drilling.

Section 2.2 briefly describes the four geologic formations and the three enhanced gas recovery technologies as they relate to the current EGR projects. Table 2-1 presents all currently funded applications of EGR processes in the four gas resource areas.

2.2 RESOURCE DEFINITION

Four geological formations with natural resources of gas are being subjected to enhanced production through various stimulation techniques, within the scope of the EGR subprogram. A brief definition of these four resource formations is given below.

2.2.1 Devonian Shale

Devonian shale formations of primary interest underlie the Applachian, Illinois, and Michigan basins (see Figure 2-1). A comprehensive discussion on the geology of the Devonian shale and the origin and occurrence of natural gas in the shale of the above three basins is given in Reference 2.2.

A few studies have been made of the resource potential of Devonian shales.[2.3-2.10] Basic geologic resource definition studies are also limited.[2.11-2.13] Resource characterization research work in these areas is being funded by ERDA through the Eastern Gas Shales Project (EGSP).

2.2.2 Methane from Coalbeds

The historic background of the two major government programs aiming at the development of coalbeds as a methane resource can briefly be summarized as follows: The first of these programs was The Pittsburgh Mining and Safety Research Center (PMSRC), initiated by the U. S. Bureau of Mines in 1964 in the Bruceton, Pennsylvania, facilities of the Bureau. The program currently is centered around field demonstrations of the developed drainage methods. Many publications have documented the achievements of this program.

The main objectives of the Bureau of Mines program was enhancement of mine safety and productivity through reduction of methane in coal mines. This was to be achieved by predraining the gas from the coalbeds ahead of mining. Thus, the coalbeds primarily considered by the Bureau were the ones sustaining extensive underground coal mining activity. The most important of these coalbeds underlie the Appalachian and Illinois basins (see Figure 2-1).

Table 2-1. CURRENTLY FUNDED ERDA PROJECTS APPLYING EGR PROCESSES IN THE STIMULATION OF UNCONVENTIONAL GAS RESOURCES

EGR PROCESSES / EGR RESOURCES	ADVANCED HYDRAULIC FRACTURING			CHEMICAL EXPLOSIVE FRACTURING		DIRECTIONAL DRILLING	CONVENTIONAL GEOTHERMAL DRILLING
	MASSIVE HYDRAULIC FRACTURING (MHF)	FOAM FRACTURING (FF)	KIEL FRACTURING (KF) (DENDRITIC)	COUPLED-INJECTED LIQUID EXPLOSIVE	DYNAFRAC (STRIPPER WELL RE-COMPLETIONS		
Devonian Shales	• Columbia Gas System Service - Lincoln County, West Virginia (3 wells) - Ohio, W. Virginia, Virginia, Kentucky (13 wells, some of which FF and KF)	• Columbia Gas System Service - Ohio, West Virginia, Virginia, Kentucky (13 wells, some of which MHF and KF)	• Columbia Gas System Service - Ohio, West Virginia, Virginia, Kentucky (13 wells, some of which MHF and FF)	• Petroleum Technology Corporation - Kentucky, West Virginia (2 wells)	• Physics International Company - West Virginia, Pennsylvania, Kentucky (5 wells)	• Consolidated Gas Supply Corporation - Jackson County, West Virginia (1 well) • Kentucky-West Virginia Corporation - Perry County, Kentucky (1 well)	
Low-Permeability (Tight Gas Sandstones)	• CER Corporation - Rio Blanco Cy., Colorado (Piceance Basin, 1 well) • Gas Producing Enterprises, Inc. - Uinta Cy., Utah (Uinta Basin, 8 wells) • Pacific Transmission Supply Co. - Uinta Basin (1 well) • Mobil Oil Company - Uinta Cy., Utah (Uinta Basin, 1 well)			• Petroleum Technology Corporation - South Texas (1 well)			
Non-Surface Coalbeds Containing Methane as a Free Intergranular Gas	• MERC[2]	• MERC[2]	• MERC[2]		• MERC[2]	• MERC[1] - Smithfield, West Virginia (1 well)	
Geopressured Aquifers Containing Methane in Solution							• ERDA/Geothermal Division - Louisiana (1 well)

1. See Ref. 2.123
2. See Ref. 2.125

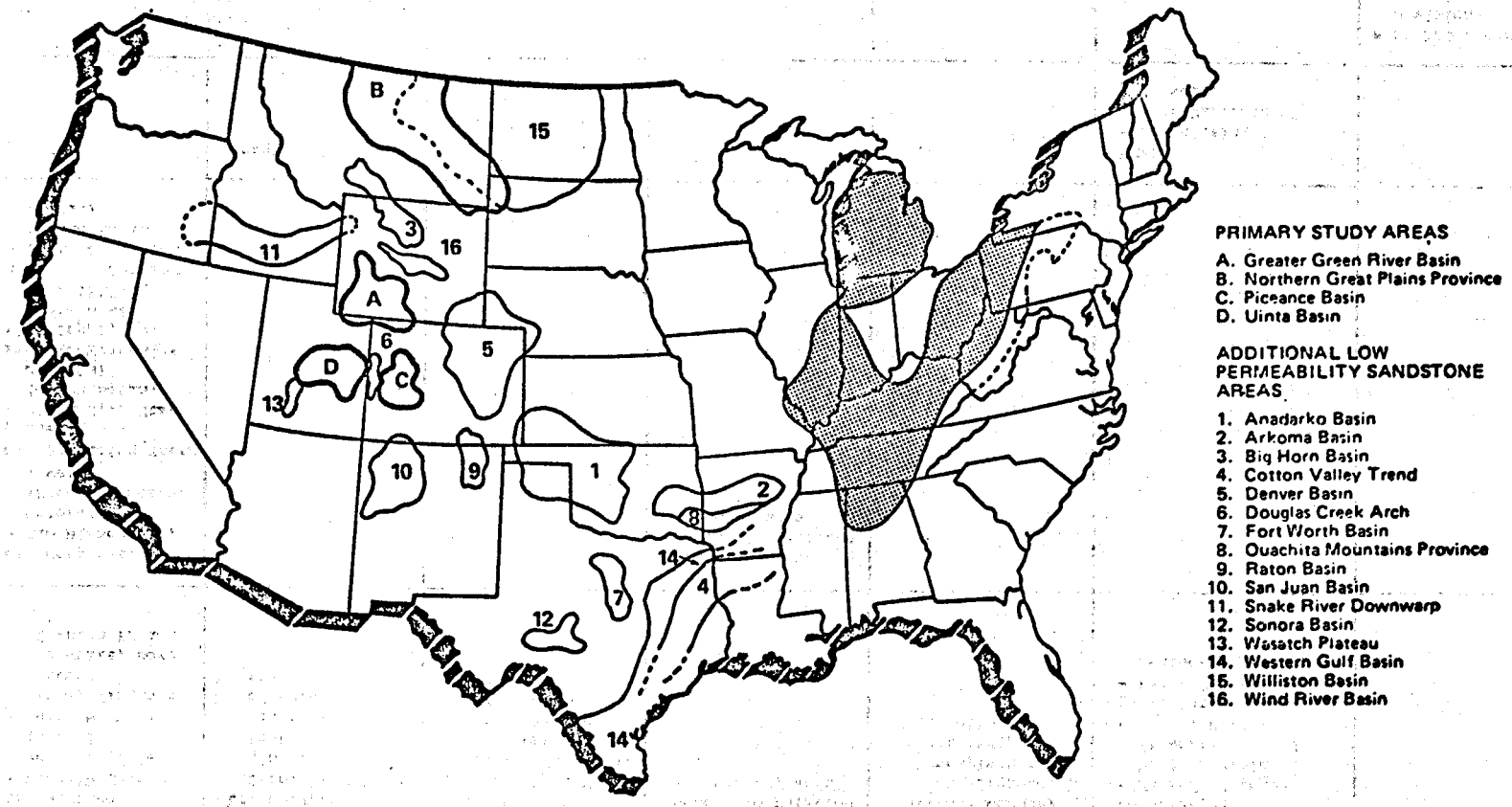


Figure 2-1. GEOGRAPHIC LOCATION OF DEVONIAN SHALE FORMATIONS IN APPALACHIA, ILLINOIS, AND MICHIGAN BASINS; AND OF THE MAJOR WESTERN TIGHT SANDS GAS RESERVOIRS

The Bureau of Mines program lately incorporated within its objectives methane utilization considerations.[2.14] This was the first major study of the Bureau program where the emphasis of methane extraction was shifted from safety and coal productivity enhancement to conservation and utilization of a new gas resource.

The second major national program on the subject is being administered currently by Morgantown Energy Research Center (MERC). During the initial phase of the program, directional well drilling technology was field tested. During the second phase, systems studies of energy conservation involving methane produced from coalbeds were performed.[2.15] A third phase, procuring gas extraction-utilization field demonstrations, was recently launched. These demonstrations will initially be restricted to the Applachian basin.

2.2.3 Western Tight Gas Sands

An immense resource of natural gas is contained in the low-permeability or "tight" sand reservoirs scattered throughout several western basins. These sand formations are interbedded with shales over intervals as thick as 15,000 feet. In some western basins, more than 100 tight sand reservoirs can be penetrated by one well. The thickness of these reservoirs varies from a few feet to over 100 feet. The shape of the sand formations is either planar or lenticular.

Figure 2-1 illustrates the geographic location of some of the major tight sand reservoirs in the western United States. Current ERDA projects are mostly confined in the Piceance and Uinta basins. The Greater Green River basin and the Northern Great Plains province are the next developmental targets. These four areas are considered promising gas producers because they cover a large geographic area, contain a large percentage of all identified sand reservoirs, and have a substantial data base for resource definition. Additional resource definition data are presented in Reference 2.16.

2.2.4 Geopressured Aquifers

Geopressured aquifers underlie the coastal zone of Texas and Louisiana, and the northern margins of the Gulf of Mexico. The aquifers occur in tertiary sediments at an average mid-point depth of 14,800 feet and extend over an area northeastward of the Rio Grande in Texas, up to the delta of the Pearl River in Louisiana. The southern borders of the resource area are defined by the edge of the continental shelf and the northern boundaries are extended to the Eocene faulting (approximately 75 miles inland).[2.17] The major area defined above is illustrated in Figure 2-2.

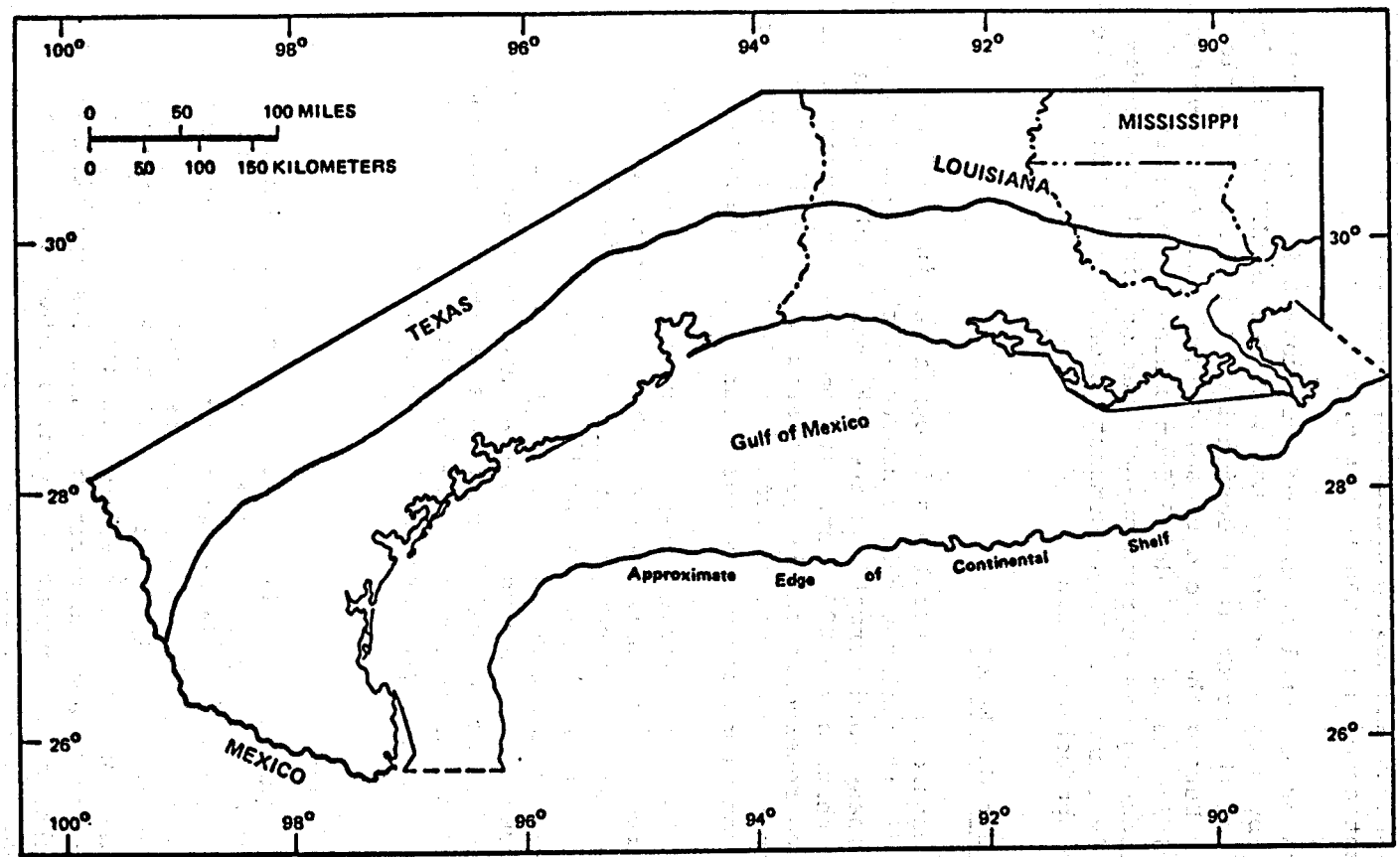


Figure 2-2. GEOGRAPHIC LOCATION OF MAJOR GEOPRESSURED AQUIFERS IN THE NORTHERN GULF OF MEXICO REGION

A second enormous resource was detected recently[2.14] beneath the previous one. It has been found that Cretaceous sediments in the Gulf Coast basin underlying the tertiary sediments at a nominal depth of 10,000 ft also contain vast geopressured zones; in fact, the latter resource is extended further inland, under an additional area of at least 20,077 sq. mi.

2.3 EGR TECHNOLOGY PROCESSES

Enhanced gas recovery processes are the production stimulation techniques applied by ERDA in the development of the gas resources described in Section 2.2. The three following enhanced recovery technologies are currently being developed by ERDA.

2.3.1 Advanced Hydraulic Fracturing

ERDA's Advanced Hydraulic Fracturing program is currently funding the development of four stimulation processes: 1) Massive Hydraulic Fracturing (MHF), 2) Foam Fracturing (FF), 3) Dendritic or Kiel Fracturing (KF), and 4) Cryogenic (Gas) Fracturing (CF). These four processes are described in the following sections.

2.3.1.1 Massive Hydraulic Fracturing (MHF)

Hydraulic fracturing is the process of creating fractures in oil- or gas-bearing formations by the application of sufficient hydraulic pressure from the surface (see Figure 2-3). There is no clear-cut definition of "massive" hydraulic fracturing; however, for the purposes of this discussion, any fracture treatment in excess of 300,000 gallons of liquid is considered "massive."

The induced fractures are kept open by proppants such as sand, glass beads, or walnut hulls that are transported into the formation suspended in the fracturing fluid. At the end of the fracturing treatment, the fluid pressure is released and the fracturing fluid is allowed to flow back into the well and return to the surface. Most of the proppant remains trapped between the fractures, thus keeping them open.

The fractures induced in the reservoir matrix allow for the flow of gas from the intergranular pores into the wellbore, instead of migration through the matrix, which is a much slower process. Thus, gas production rates are increased after a successful hydraulic fracturing.

Basic mechanical equipment involved in MHF includes pumping units, liquid/propping-agent proportioners, bulk-handling equipment, surface piping and wellhead equipment, downhole tools, etc. Figure 2-4 provides a schematic presentation of the equipment configuration around the wellhead.

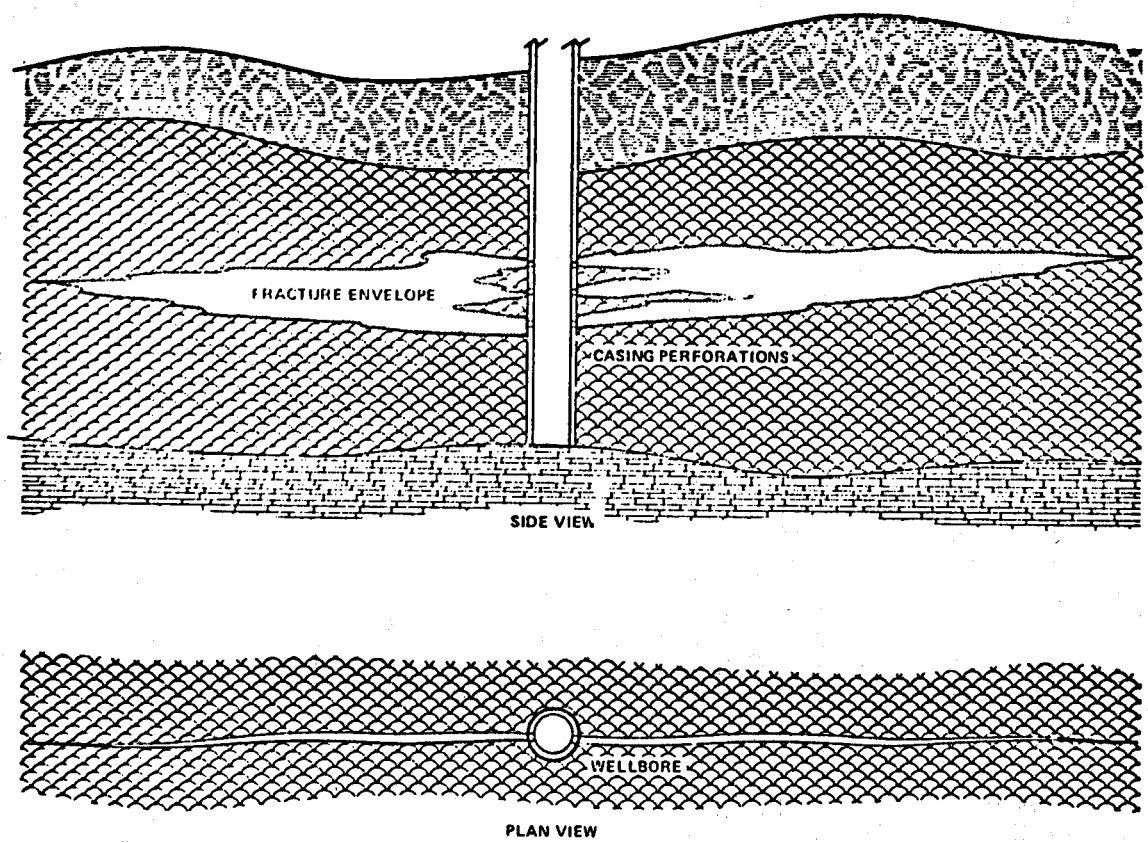
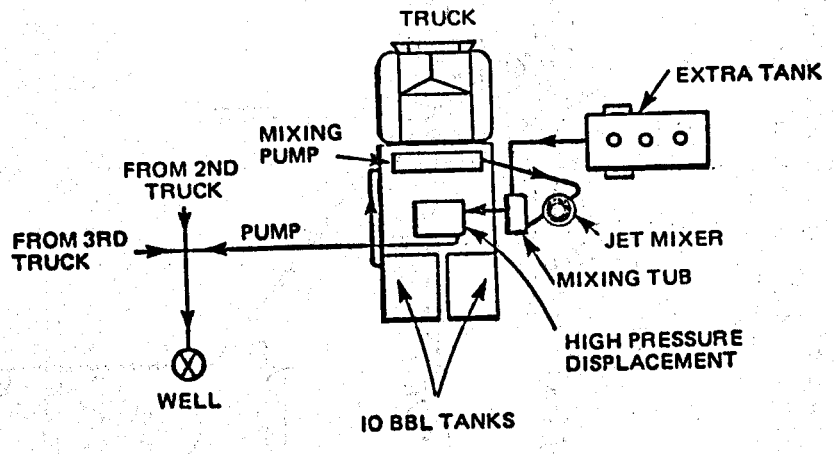


Figure 2-3. PLAN AND SIDE VIEW OF A WELL STIMULATED BY MHF



(from "Hydraulic Fracturing" by G.C. Howard & C.R. Fast, AIME Monograph Vol. 2, H.L. Doherty Series, 1970)

Figure 2-4. SURFACE EQUIPMENT FOR MHF

2.3.1.2 Foam Fracturing (FF)

Foam fracturing and MHF use different fluids. Foam fracturing fluid consists of a base liquid (treated water, gel or acid), and a foaming agent (surfactant).[2.18-1.19] A major advantage of foam is that it can seal minor, side fractures, and thus prevent propagation of irregular, small fractures at the expense of the main fracture along the plane of weakest stress. Sealing the small (almost capillary) side fractures is achieved through plugging with stationary foam bubbles (see Figure 2-5). Experiments by Halliburton Company have indicated[2.20] that using foam increases the fracture surface area by threefold, mainly because side leakoff is avoided. A second advantage of foam fracturing over MHF utilizing gelled potassium chloride in water solution is that it requires a shorter cleanup time. It was found during FF jobs on shales that 50 percent of the fluid returns to the wellbore within 48 hours and gas production can start shortly thereafter.

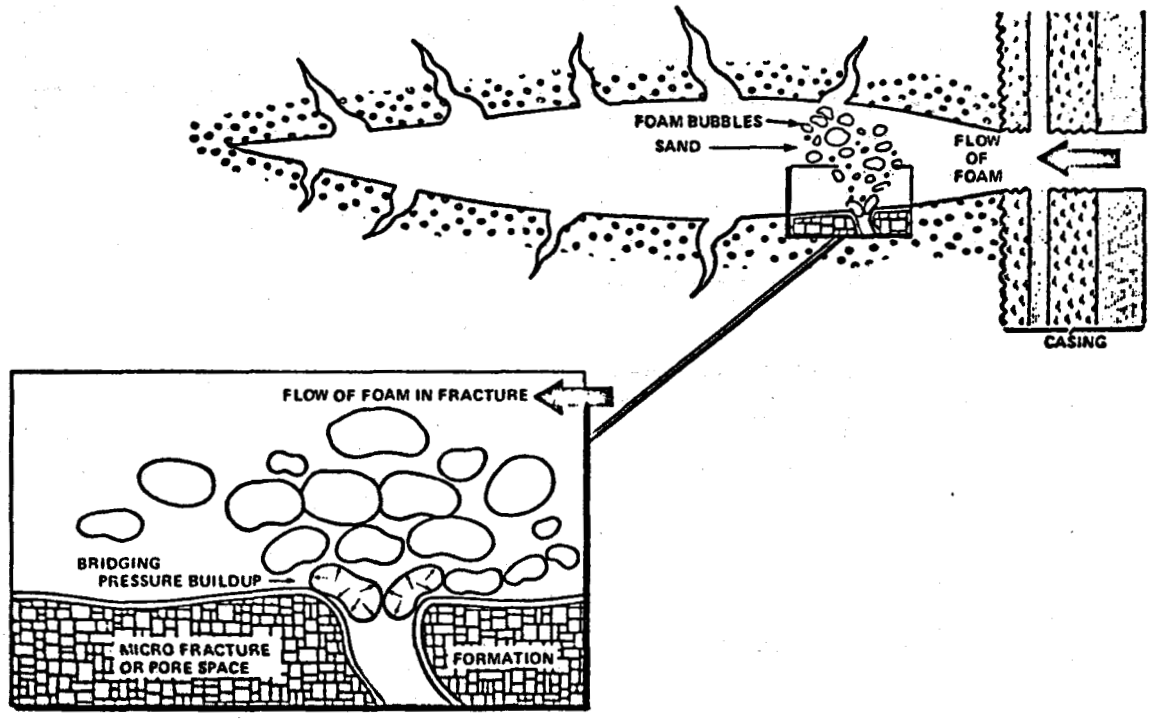


Figure 2-5. SCHEMATIC ILLUSTRATION OF FOAM BEHAVIOR IN FF STIMULATION

2.3.1.3 Kiel Fracturing (KF)

In this process, the hydraulic pressure is applied in varying stages. This staging is expected to create a dendritic fracture pattern instead of a linear pattern postulated for other fracturing processes. The dendritic fracture system covers a much greater surface area than the linear fracture systems (per running foot of fractures). It has been theorized that the Kiel process produces the fracture pattern as illustrated in Figure 2-6. However, physical models or extensive field testing have not as yet substantiated this claim.

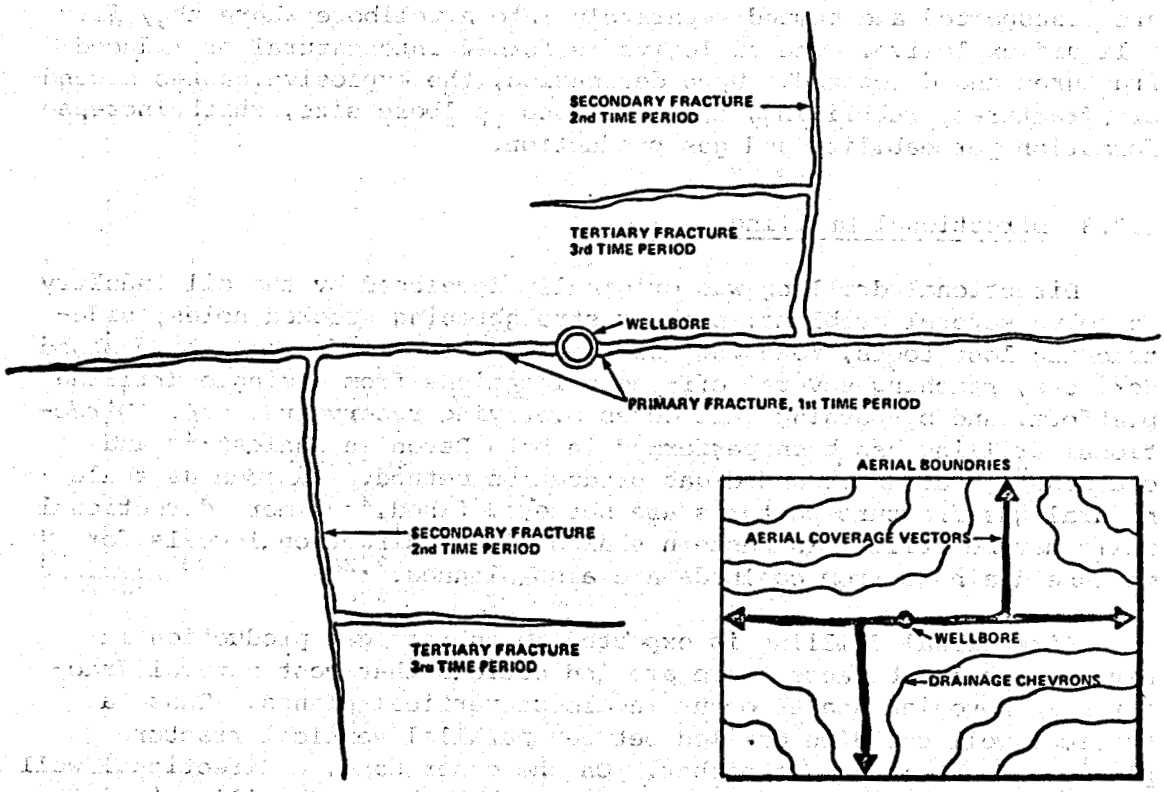


Figure 2-6. DENDRITIC FRACTURING PATTERN OF KIEL PROCESS

2.3.1.4 Cryogenic (Gas) Fracturing

Cryogenic fracturing involves using a mixed fluid, such as gelled water or methanol and liquid CO_2, to carry a proppant (sand) into the formation. The CO_2 aids in the flow-back of the injected fluid.

2.3.2 Chemical Explosive Fracturing (CEF)

Chemical explosive fracturing (CEF) is currently being applied in the enhanced gas recovery field demonstrations. The Coupled-Injected-Liquid Explosive Method is described below.

The mobile surface equipment used in CEF consists of: a semi-trailer mounted oxidizer mix and pump unit, a truck-mounted fuel pump unit, a wellhead assembly operated by remote control, a mobile data control unit, and a downhole mixer.

The non-explosive chemicals, an oxidizer and a hydrazine fuel, are transported and pumped separately into a wellbore where they form a liquid explosive. The explosive is forced into natural or induced fractures and detonated. Upon detonation, the explosive causes secondary fractures, rubblizing, and increased wellbore size, which increase formation permeability and gas production.

2.3.3 Directional Drilling

Directional drilling was originally developed by the oil industry to solve several problems, such as straightening crooked holes, side-tracking lost tools, reaching off-shore reservoirs from on-shore based derricks, reaching several off-shore locations from a single drilling platform, and by-passing salt domes overlying reservoirs, etc. Directional drilling has been performed in both Devonian shales[2.21] and coalbeds[2.22] as an enhanced gas production method. As soon as shale natural gas fracture patterns are better defined,[2.23] more directional wells may be drilled in Eastern shales. More directional wells for methane drainage from coalbeds are also planned.[2.24]

Directional drilling is expected to enhance gas production in Devonian shales because there are indications that most natural fractures in Devonian shales occur in almost vertical planes. Thus, a vertical well could be drilled between parallel vertical fracture planes and not intersect either. On the other hand, a directional well penetrating almost horizontally has a much higher probability to intersect a great many vertical fracture planes, as illustrated in Figure 2-7. Connecting the wellbore with a great many systems of natural fractures increases probability of high gas flow rates and reduces substantially the need for induced fracturing. Successful application of directional drilling, however, requires a knowledge of the exact location and orientation of the natural fracture systems. Numerous geological studies[2.25] have already identified several Appalachian areas of high natural fracture density and additional studies are currently being funded by EGSP.

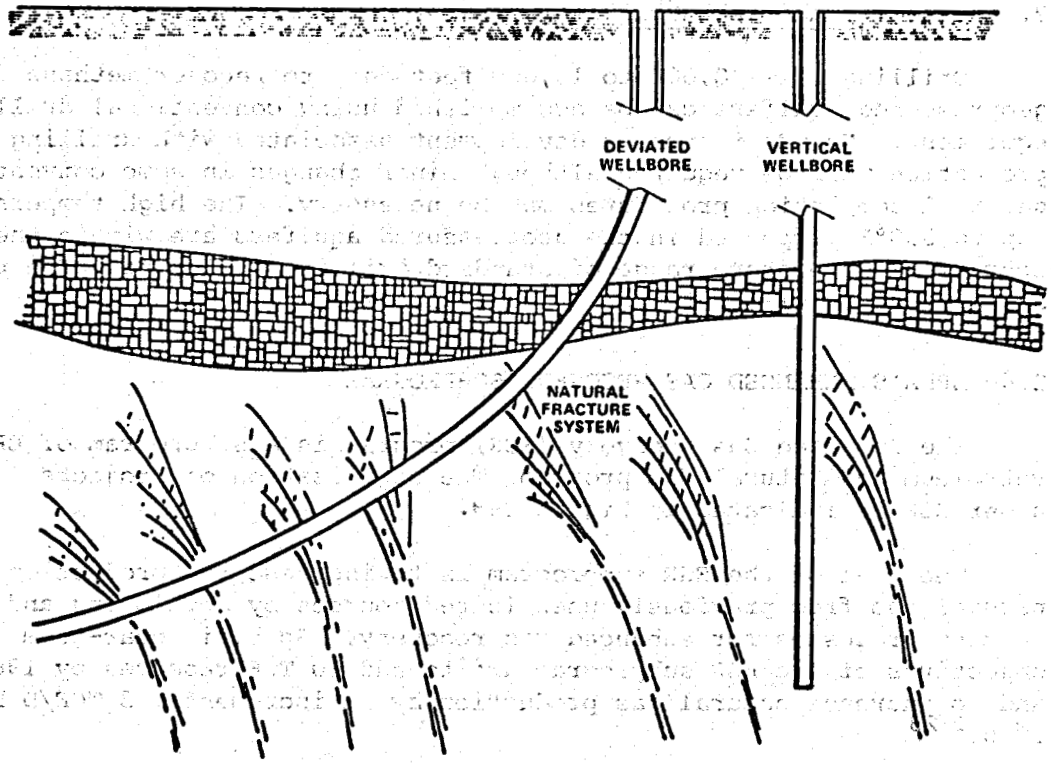


Figure 2-7. INTERSECTION OF ALMOST VERTICAL PLANES OF NATURAL FRACTURES IN SHALES BY DIRECTIONAL AND VERTICAL WELLS

The rationale for using directional wells to enhance methane drainage from coalbeds is illustrated by Figure 2-8. A directional well can penetrate a horizontal coalbed up to 1,000 feet (with current controls of drilling technology).

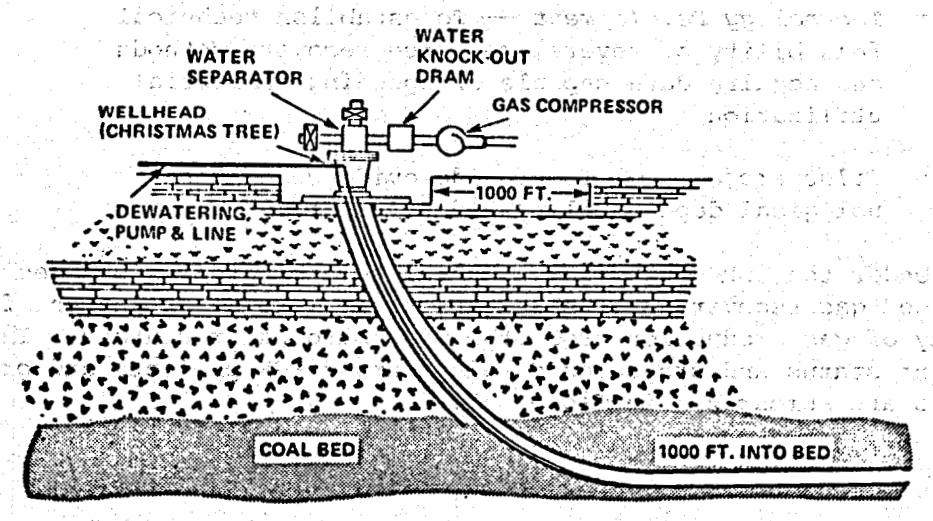


Figure 2-8. APPLICATION OF DIRECTIONAL DRILLING IN METHANE DRAINAGE FROM COALBEDS

2.3.4 Geothermal Well Drilling

Drilling wells 8,000 to 15,000 feet deep to recover methane from geopressured aquifers can be accomplished using conventional drilling equipment. No major process development associated with drilling and production will be required although minor changes in some conventional gas well completion procedures may be necessary. The high temperatures (up to 350°F) expected in the geopressured aquifers are within the operating temperature range of standard drilling equipment. The pressures expected will not pose unusual problems.

2.4 ERDA'S ENHANCED GAS RECOVERY SUBPROGRAM

The Enhanced Gas Recovery (EGR) program is a subprogram of ERDA's Petroleum and Natural Gas program. The organization of projects under EGR is indicated in Figure 2-9.

The goal of the EGR subprogram is to increase the production of natural gas from previously unexploited sources by developing and testing processes for enhanced gas recovery. Specific near-term objectives of the EGR subprogram are to add 10 TCF reserves by 1985 and to increase natural gas production by an incremental 3 TCF/D by 1985.[2.29]

ERDA generally develops a technology through several stages, beginning with process conceptualization and carrying through to commercialization. For EGR, the purposes of these development stages are:

- *Resource Characterization* — To supply information on the extent of the resource, its availability for recovery, and its quality
- *Technology Development* — To establish technical feasibility of several resource recovery methods and acquire data capable of speeding commercial utilization
- *Pilot Projects* — To provide evidence of technological dependability and viability.

Under the EGR subprogram, several technological processes for enhanced gas recovery are being investigated to determine the feasibility of gas production from otherwise marginal resources. The present status and projected development of EGR projects and processes are summarized in Table 2-2.

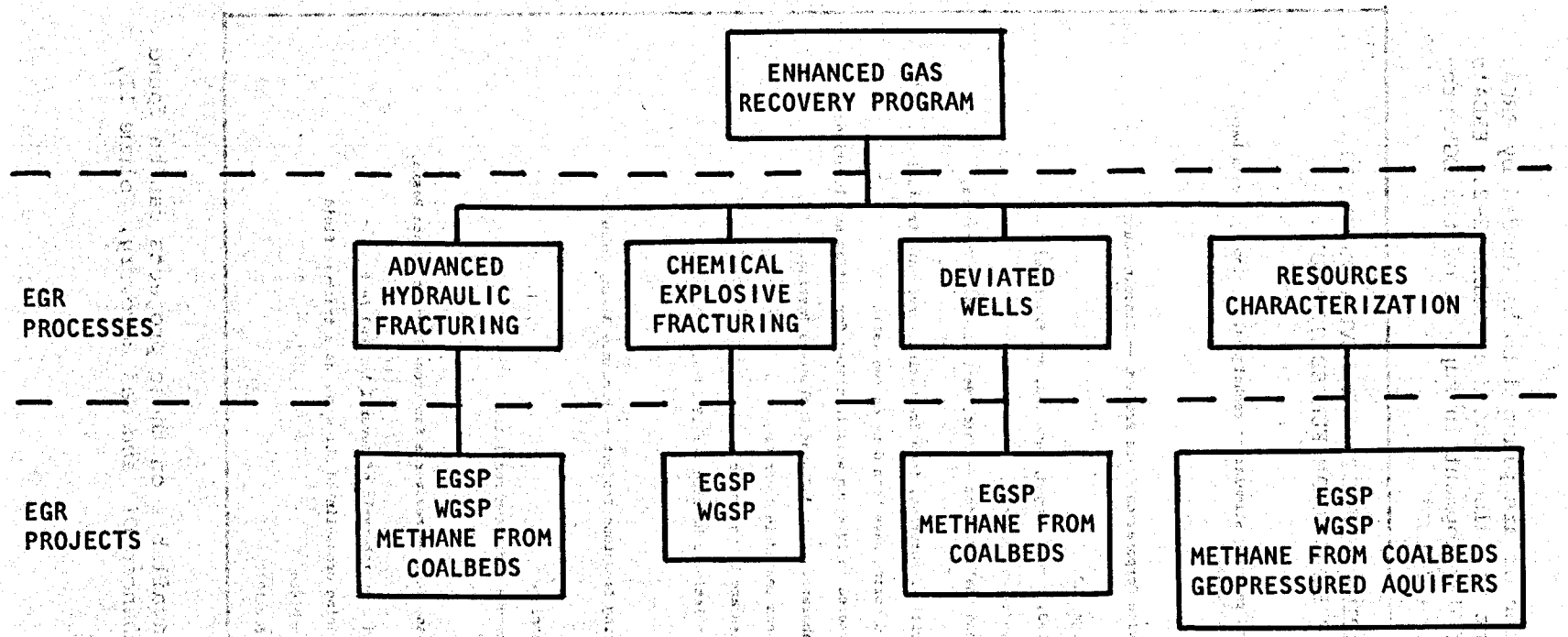


Figure 2-9. ENHANCED GAS RECOVERY (EGR) SUBPROGRAM

Projects which have been or are planned to be funded by ERDA in support of its R&D effort are also listed in Table 2-2. ERDA's milestones for research and development in support of the EGR program are summarized in Figure 2-10.*

Table 2-2. SUPPORTING RESEARCH AND DEVELOPMENT FOR THE EGR SUBPROGRAM FUNDED BY ERDA

ADVANCED HYDRAULIC FRACTURING

The current direction is toward refining stimulation techniques, developing a data base, and supporting demonstration projects.

EGSP

- Columbia Gas System Service Corporation Shale Project — Lincoln County, West Virginia
  - Three wells, four-stage MHF
  - All three wells drilled, cored, logged, cemented, and fractured
  - Reservoir tests and modifications being made
- Columbia Gas Sandstone and Shale Project — Ohio, West Virginia, Virginia, Kentucky
  - Thirteen wells, dendritic fracturing, foam fracturing, cryogenic fracturing
  - Drilling, logging, and coring have been done on two wells
  - Three wells were fractured in 1976 and work initiated for siting new locations
- Los Alamos Scientific Laboratory Shaped-Charge Explosives Testing
  - Shaped charges have been tested in concrete
  - Laser pyrolysis studies are being conducted
  - Started FY 1977 — Completion scheduled for FY 1979.

WGSP

- CER Corporation Gas Bearing Sandstone Project — Piceance Basin, Colorado
  - One well, MHF
  - Coring and logging complete
  - Four fracturing treatments have been completed
  - Project complete
- Gas Production Enterprises, Inc. — Mesaverde Sandstone Project, Uinta Basin, Utah
  - Eight wells, fractured over intervals of several hundred feet
  - Initial testing done using cross-linked KCl water as a fracture fluid
  - Five MHF treatments complete
  - Completion scheduled for 1978

* Much of the current data available on these projects can be found in ERDA's *Symposium on Enhanced Oil and Gas Recovery*, Volume II, 1976.

Table 2-2. SUPPORTING RESEARCH AND DEVELOPMENT FOR THE EGR SUBPROGRAM FUNDED BY ERDA (Cont'd)

WGSP (Cont'd)

- Mobil Oil Corporation — Low Velocity Fluid Project, Uinta Basin, Utah
  - One well project
  - Well has been cored, production testing is under way
  - Two frac treatments complete
- Sandia Laboratories Electropotential Technique for Fracture Orientation, in process of development
  - Mine back work on MHF and CEF in progress

CHEMICAL EXPLOSIVE FRACTURING (CEF)

Efforts are currently being directed toward investigating technical feasibility, costs and effectiveness of chemical explosive techniques, including demonstration projects in both the Eastern Gas Shales and Western Tight Gas Sands Projects.

EGSP

- Petroleum Technology Corporation (PTC)
  - Four wells, Devonian Shales
  - Lineament analysis from remote sensing imagery in progress
  - One well is being reworked and tested
  - One well shot and tested

WGSP

- Petroleum Technology Corporation (PTC)
  - Two wells, tight gas sandstones of south Texas
  - Drilling, treatment and short-term production tests in progress, although running behind schedule

DIRECTIONAL WELLS

The feasibility and effectiveness of drilling directional wells to intersect the maximum number of natural fractures containing natural gas in the eastern gas shales is currently being investigated.

EGSP

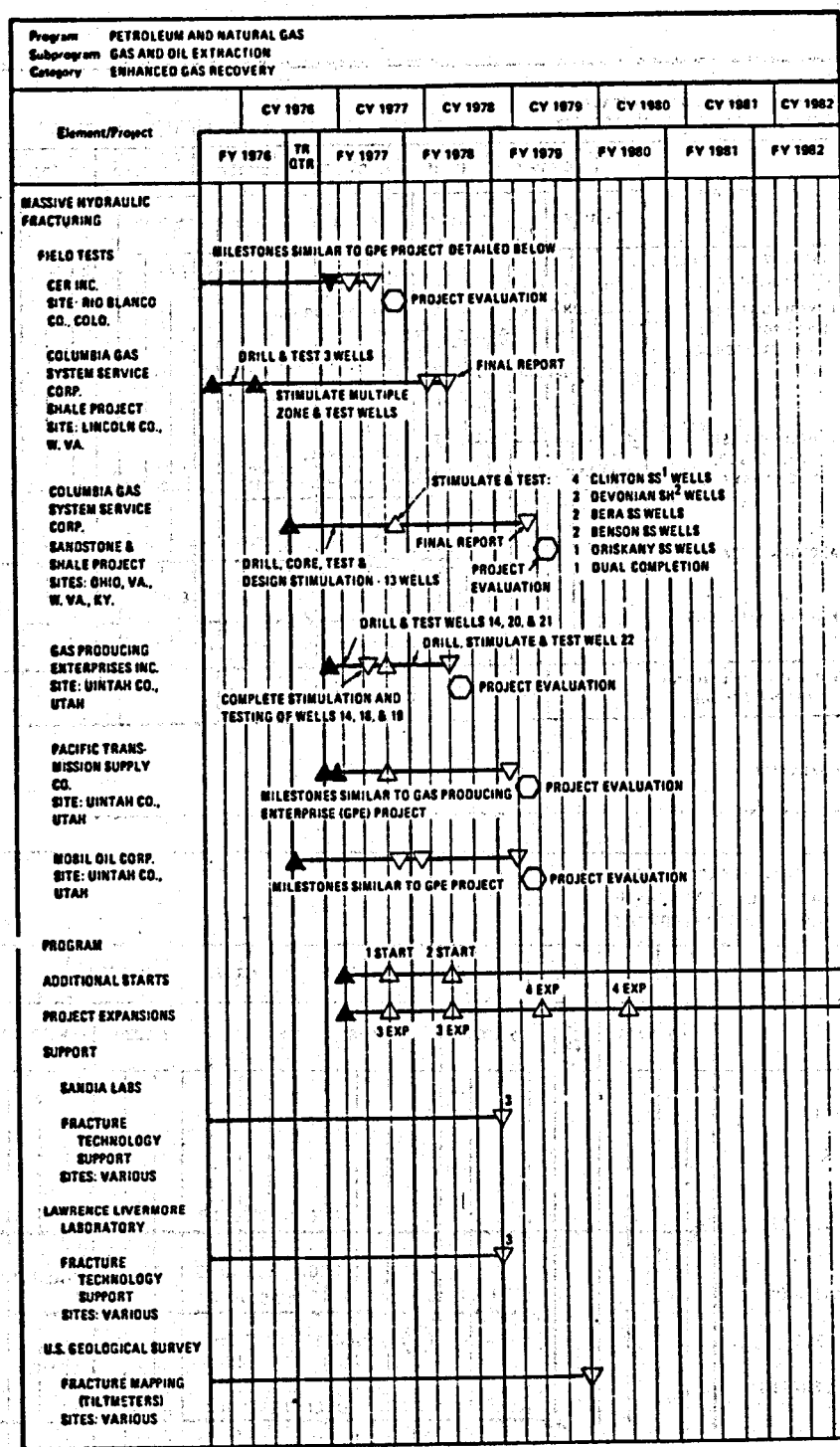
- Consolidated Gas Supply Corporation Test Well — Jackson County, West Virginia
  - One well is to be directionally drilled and hydraulically fractured
  - Exploration R&D package to be completed by March 1977
  - Geophysical work is in progress and remote sensing imagery has been analyzed

Table 2-2. SUPPORTING RESEARCH AND DEVELOPMENT FOR THE EGR SUBPROGRAM FUNDED BY ERDA (Cont'd)

RESOURCE CHARACTERIZATION

Research efforts are being made to determine the magnitude, distribution and characteristics of unconventional natural gas resources.

- Eastern Gas Shales Project
  - USGS is the coordinating agency for 18 contracts to perform resource characterization studies
- Western Gas Sands Project
  - USGS is the sole agency for resource characterization studies
- Methane from Coalbeds
  - ERDA, in cooperation with the U. S. Bureau of Mines, contracts with institutions and private research firms to provide geologic and engineering data base
- Geopressured Aquifers
  - Contracts for data base expansion for gas bearing, high temperature and pressure saltwater aquifers of the Texas/Louisiana coast.

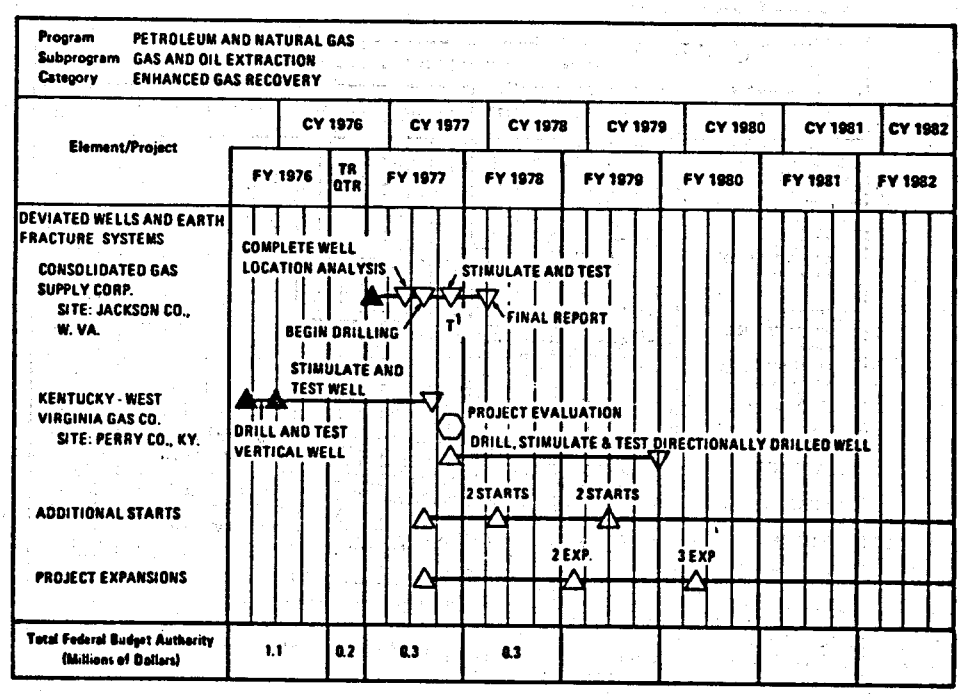


MILESTONE SYMBOLS ARE DEFINED ON LAST PAGE OF THIS DOCUMENT.

[1]SS = SANDSTONE
[2]SH = SHALE

[3]RESEARCH PROJECTS AT NATIONAL LABS ARE SUBJECT TO INCREMENTAL ANNUAL AUTHORIZATION BY ERDA(FE). THEREFORE, THIS WORK MAY BE EXTENDED BEYOND FY 1978.

Figure 2-10. EGR SUBPROGRAM SUPPORTING RESEARCH, PROJECT MILESTONES



[1] T = WELL TEST

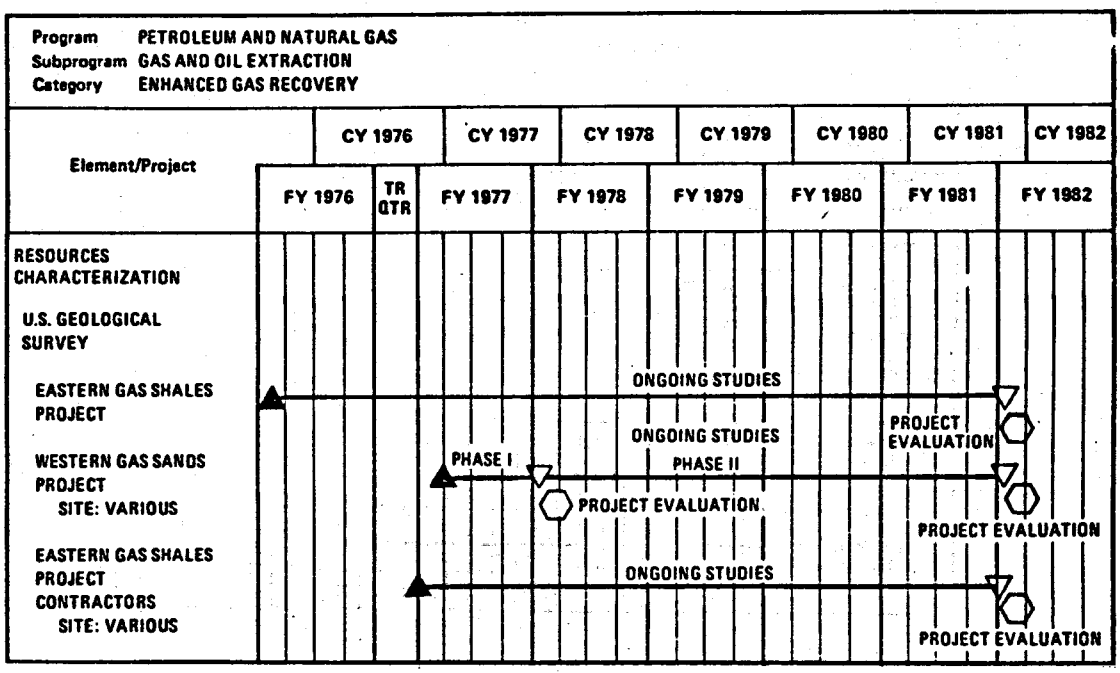


Figure 2-10. EGR SUBPROGRAM SUPPORTING RESEARCH, PROJECT MILESTONES (Cont'd)

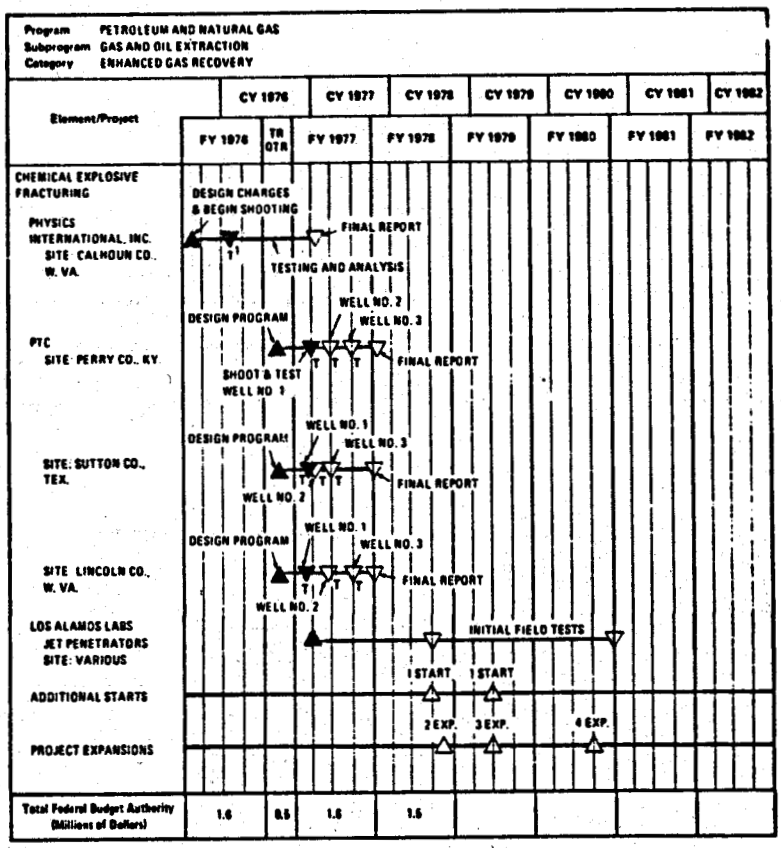


Figure 2-10. EGR SUBPROGRAM SUPPORTING RESEARCH, PROJECT MILESTONES (Cont'd)

3. ENVIRONMENTAL AND HEALTH AND SAFETY ISSUES AND REQUIREMENTS

3.1 INTRODUCTION

The Federal regulations and some State regulations which are applicable to EGR technologies are listed in Appendix A. NEPA requires that all Federal agencies consider the environmental impact of all major Federal actions significantly affecting the environment. The Energy Reorganization Act of 1974 requires that ERDA consider environmental factors equally in conjunction with technological and economic factors influencing the decisionmaking elements of energy development plans.

Table 3-1 identifies potential environmental problems associated with four EGR resource bases — Eastern Gas Shales, Western Gas Sands, Methane from Coalbeds, and Methane from Geopressured Aquifers (Geopressured Methane). Each technology is analyzed by principal operations, as follows:

- *Drilling Operations* — including site preparation and site restoration activities, as well as drilling, coring and logging activities
- *Stimulation and Production Operations* — including multiple stimulation and production activities.

The six impact areas discussed in this section are as follows:

1) *Air Quality* — Air emissions/atmospheric transformations
2) *Water Quality* — Liquid pollutants, solid waste leachates
3) *Geology and Land* — Landslides, subsidence, seismicity, land use, surface disturbance, waste disposal
4) *Ecology* — Ecosystem dynamics, endangered species
5) *Health and Safety* — Occupational hazards, community impacts
6) *Socioeconomic* — Employment, noise impacts.

Table 3-1. POTENTIAL ENVIRONMENTAL PROBLEMS ASSOCIATED WITH EGR PROCESSES

ISSUE	ENVIRONMENTAL CONCERNS OR POTENTIAL PROBLEMS
Air	Air emissions from construction and drilling equipment Fugitive dust from access roads and site preparation activities Cooling tower drift from geopressured methane recovery
Water	Disposal of liquid effluents from drilling and production operations Potential leakage of brine from production and stimulation activities Potential erosion and siltation from site preparation activities
Geology and Land Use	Disposal of drill cuttings and spent mud Potential land slide/mud slide from construction activities
Ecology	Temporary disruption of local biota Potential accidental spills Potential impacts on flora from cooling tower drift from geopressured methane recovery
Health and Safety	Potential noise impact on workers at the site Steam or hot water scalds on workers

If the EGR processes being developed are to be environmentally acceptable, it is essential to identify and discuss both generic issues and EGR technology-specific issues. A generic impact is defined as an impact common to a wide range of activities. For example, many similar site preparation impacts may occur during the construction of a pipeline, a highway, or a building. Detailed attention will be given to generic issues in the EIA and EIS process. Most of these generic impacts have been researched and information concerning mitigation and environmental controls is available. Only when this is not the case will a field or laboratory research program be suggested as part of the EGR environmental action plan.

EGR processes rely principally on established techniques for well drilling, pipeline construction, site preparation and restoration. Control technology exists for these conventional operations and it is anticipated that a majority of the environmental impacts which can result from EGR development can be successfully avoided or mitigated by careful use of this standard control technology.

3.2 AIR QUALITY ISSUES

The development of EGR technologies is not expected to lead to significant air quality deterioration. Emissions will be temporary and, in most cases, will not be different than emissions from general construction, drilling and gas production activities. Air pollutant emissions will stem mainly from site preparation, drilling, and stimulation activities.

Site clearing and preparation will cause temporary increases in ambient levels of particulates due to fugitive dust in the immediate vicinity of the site. Techniques for controlling fugitive dust emissions have been developed and, when properly implemented, will result in the lowering of particulate concentrations below applicable standards in most cases.

The majority of the equipment used for site clearing and well drilling will be diesel-powered equipment such as bulldozers, air compressors, and prime movers on drill rigs which emit carbon monoxide, hydrocarbons, nitrogen oxides, and small amounts of sulfur oxides and particulates. These emissions are common to many construction and/or drilling operations. The U. S. EPA has published emission rates for these types of equipment.[3.1] In most cases, the use of modern equipment, with properly operating pollution controls, will reduce emissions below applicable standards.

The extraction of gas from geopressured sources may involve the control of hydrogen sulfide (H_2S). Geopressured methane can also

involve the use of cooling towers which can create atmospheric thermal plumes or fogging.[3.2] A great deal of research has been carried out on the subject of cooling tower drift, especially in regard to power plant cooling systems.

Table 3-2 lists air quality issues and requirements relevant to ERDA's Enhanced Gas Recovery (EGR) Programs. The interpretive key to the level of specificity appears in Table 3-3.

3.3 WATER QUALITY ISSUES

The development of EGR processes will not lead to significant impacts on water quality. Water quality impacts from EGR development projects will be site-specific and regional water quality impacts are not anticipated. The majority of the potential impacts can be mitigated by using standard control technology and environmentally sound engineering practice.

The EGSP, WGSP, and Methane from Coalbeds Projects will involve the recovery of drilling and fracturing fluids. These effluents are stored in lined pits. Usually, the effluent remains in the pit until the aqueous portion evaporates. The remaining material is buried or disposed of in accordance with local regulations. Several operators maintain that this interim storage of effluents in pits does not represent a water quality issue because of the impermeable nature of the liner. Use of these lined pits has been extensive and data exist concerning environmental acceptability. In most cases, the nature of these effluents has been determined because of extensive commercial application.

Another water quality issue stems from site construction and the construction of access roads and drilling pads. Such activities may cause temporary erosion and siltation problems, but they are usually of limited areal extent if standard control techniques are used. However, clearing the natural vegetation can have long-term impacts depending on the site; in particular, erosion from such denuded areas and subsequent siltation in surface streams. This problem can usually be controlled by use of standard engineering techniques. It may be useful to conduct site-specific studies as part of the EIA preparation process.

In the case of methane recovery from geopressured reservoirs, the composition of the geopressured fluids varies from relatively fresh to highly saline waters and may vary in temperature from about 175° to 375°F (80 to 190°C).[3.3] Even after extraction of the thermal energy and methane, the water is still at sufficiently high temperatures to cause thermal pollution if discharged into surface bodies of water. This can be controlled by cooling before surface discharge or by underground disposal through injection wells.

Table 3-2. LIST OF AIR QUALITY ISSUES AND REQUIREMENTS RELEVANT TO ERDA'S ENHANCED GAS RECOVERY (EGR) PROGRAMS[a]

AIR QUALITY RESEARCH REQUIREMENTS	TASKS	EGR PROCESSES AND OPERATIONS	RELEVANT PROGRAMS	LOS[b,c]
1.1 Assess ambient air quality data, existing standards or proposed goals.	1.1.1 As preparation for NEPA process, collect existing air quality data for sites which will be developed by EGR processes. Identify gaps in this data base. (A-1, A-3)	Applicable to all EGR processes except where noted	Applicable to all EGR programs	5/6
	1.1.2 When existing data are insufficient, acquire baseline data at EGR sites prior to development.(A-3, J-1)			5/6
1.2 Determine the potential impacts from EGR site preparation and construction and drilling equipment.	1.2.1 If emission rates for construction or operational equipment have not been established, conduct measurement tests at selected sites. (A-1, A-3, A-4, J-1)	Construction, site-clearing and drilling		3
	1.2.2 Complete data to predict fugitive dust emissions from access roads, drilling pads and construction activities. (A-3, J-1)			3

[a] The generic list of issues and requirements appears in Appendix D.

[b] LOS = Level of Specificity.

[c] The interpretive key to the level of specificity appears in Table 3-3.

Table 3-3. ENVIRONMENTAL R&D CLASSIFICATION SYSTEM APPLICABLE TO ENHANCED GAS RECOVERY

Level of Specificity	General Description
1	Research on general environmental problems (effects, environmental chemistry, measurement methods, and ambient modeling) of importance to the technology of interest but also of value in understanding impacts of a wide range of energy and non-energy uses.
2	Research specific to environmental problems of energy covering the range of energy technology impacts including the ones of interest.
3	Projects aimed at the general impacts of natural gas development and use and problems distinctive to natural gas.
4	R&D covering the overall impacts of Enhanced Gas Recovery.
5	Studies of impacts specific to EGR processes but not specific to an ERDA project site.
6	Environmental R&D directly associated with operation of an ERDA test facility or demonstration project.

It should be noted that the development of geopressured resources is the overall responsibility of ERDA's Division of Geothermal Energy.

Although potential subsidence of land in regions of excessive geopressured water or groundwater withdrawal is primarily a geologic hazard (treated in the discussion of geological hazards, Section 3.4), the potential damage to groundwater aquifers produced by such subsidence is a water-related impact. It may be necessary to monitor potential subsidence in the vicinity of selected geopressured wells and conduct studies in order to evaluate or quantify any impacts.

The water resources issues, requirements, and tasks are listed in Table 3-4.

3.4 GEOLOGY AND LAND ISSUES

The potential geologic impacts related to EGR processes are landslides and mudslides which may be caused by clearing and road construction activities at some EGR sites; seismic or microseismic events which may be induced by fracturing or subsurface waste injection; and potential land subsidence caused by withdrawal of gas or geopressured water.

Clearing is involved if construction of access roads and drilling pads for drilling operations is necessary. Geomorphological impacts such as landslides and mudslides can be associated with denudation and earth removal, especially in the rugged terrain of the Applachian regions. Sensitive mudstones and clays underlying heavier sandstone beds are normally the main formation likely to be impacted by removal of vegetation and surface soil cover and subsequent exposure to heavy rain. The impacts can be mitigated or avoided by properly planned and executed engineering design. If not previously carried out, tests to determine soil strength and slope stabilities in the vicinity of sites selected for EGR activities will probably be conducted as part of standard engineering practice. These tests can include soil boring and testing activities at a selected number of sites where previous experience indicates the presence of sensitive near-surface geological formations. These engineering tests and standard controls should be sufficient to avoid severe erosion and landslides.

Another important geologic issue focuses on land subsidence which may be caused by production of large quantities of water from geopressured aquifers. Land subsidence has been attributed to and caused by oil and gas or groundwater recovery operations in some areas of California and the Gulf Coast.[3.4] In some places, subsidence of up to 6 feet within a period of 50 years has been measured and documented.

Table 3-4. LIST OF WATER QUALITY ISSUES AND REQUIREMENTS RELEVANT TO ERDA'S ENHANCED GAS RECOVERY (EGR) PROGRAMS[a]

WATER QUALITY RESEARCH REQUIREMENTS	TASKS	EGR PROCESSES AND OPERATIONS	RELEVANT PROGRAMS	LOS[b,c]
2.2 Identify the potential water quality impacts of site preparation and drilling operations as part of the the NEPA process.	2.2.1 On a site-specific basis, identify any potential water quality impacts from erosion and siltation due to site preparation activities. (B-4, D-10, E-11, J-4)	AHF, CEF, DW, CW Site Preparation/ Stimulation	Applicable to all EGR Programs	6
	2.2.2 On a site-specific basis, evaluate plans for waste disposal (i.e., drilling mud and fracture fluid) to assure compliance with environmental requirements. (B-3, B-4)			6
2.3 Characterize, identify and quantify the chemical constituents of spent fracture fluids.	2.3.1 Sample the effluents of the CEF process at selected sites to identify and quantify any trace elements, gases, or heavy metals that may be present after contact with geologic formations. (B-4, D-10)	CEF Stimulation	EGSP, WGSP, Methane from Coal	5/6
2.4 Determine potential impacts from brine and thermal discharges	2.4.1 Conduct studies to determine salinity of brine from geopressured wells and assess the water quality impacts of releasing this brine in surface water or injecting it into subsurface geologic formations. (B-4, B-6, E-7, E-9, J-2, J-4, J-7, J-8)	Production	Applicable to Geopressured Methane	5

[a] The generic list of issues and requirements appears in Appendix D.

[b] LOS = Level of Specificity.

[c] The interpretive key to the level of specificity appears in Table 3-3.

Table 3-4. LIST OF WATER QUALITY ISSUES AND REQUIREMENTS RELEVANT TO ERDA'S ENHANCED GAS RECOVERY (EGR) PROGRAMS[a] (Cont'd)

WATER QUALITY RESEARCH REQUIREMENTS	TASKS	EGR PROCESSES AND OPERATIONS	RELEVANT PROGRAMS	LOS[b,c]
2.4 Determine potential impacts from brine and thermal discharges	2.4.2 Characterize the potential thermal effluents from geopressured production processes and predict the water quality impacts. (B-6, J-2, J-7, J-8)	Production	Applicable to Geopressured Methane	5
	2.4.3 Collect existing research data dealing with techniques of the disposal of hot saline water and initiate research as needed. (E-7, J-2, J-4, J-6, J-7, J-8)			4

[a] The generic list of issues and requirements appears in Appendix D.

[b] LOS = Level of Specificity.

[c] The interpretive key to the level of specificity appears in Table 3-3.

Subsidence might disrupt groundwater aquifers or cause surface water flow problems. The subsidence potential of sites selected should be identified and, if needed, studies conducted to provide data to develop suitable and adequate mitigation and control measures.

Land resource issues are non-technology-specific and are of minor significance in the development and implementation of EGR processes. The same impacts to land use, varying in degree only, would result from drilling conventional oil and gas wells. Analysis of these impacts can be conducted on a site-specific basis in future environmental impact assessment activities. The geology and land issues, requirements, and tasks are listed in Table 3-5.

3.5 ECOLOGIC ISSUES

Impacts to species and ecosystems are highly variable and are usually dependent upon primary impacts such as air, water, noise, and alteration in habitat. For EGR development, these parameters will be dependent upon project size, EGR technology, phase of the energy cycle and locations of activity. Ecologic impacts are best predicted and mitigated on a site-specific basis through the Environmental Impact Assessment process.

The development of EGR technologies is not expected to lead to severe or long-term ecologic impacts. Impacts may stem from two sources: 1) loss of habitat from site clearing and access road construction, and 2) the effects of EGR-related pollutants on local populations. None of the anticipated impacts are unique to EGR processes; most are common to other construction or energy production activities.

Site development for EGR processes may result in alteration of habitat by site clearing and preparation, water utilization, effluents, noise emissions, and other disturbances. These can cause immediate impacts such as emigration of species from the site, and interference with reproductive behavior. These disturbances can also result in secondary impacts such as alteration in species abundance and composition due to thermal effluents, and reduction in the capacity of soil to support native species by loss of topsoil, spills of chemicals, and acid waste.

Impacts on aquatic and terrestrial species can result from the accidental release of spent fracture fluid or brine. Discharge of thermal effluents, depending on temperature, can result in a sudden increase in productivity of aquatic species (for example, algae blooms).

Table 3-5. LIST OF GEOLOGY AND LAND ISSUES AND REQUIREMENTS RELEVANT TO ERDA'S ENHANCED GAS RECOVERY (EGR) PROGRAMS[a]

GEOLOGY & LAND USE RESEARCH REQUIREMENTS	TASKS	EGR PROCESSES AND OPERATIONS	RELEVANT PROGRAMS	LOS[b,c]
3.1 Determine the extent of subsidence and seismicity.	3.1.1 Conduct ground elevation surveys before and after production at GPA sites and correlate results with production rates and geologic conditions. (E-4)	Production	Applicable to Geopressured Methane	6
	3.1.2 Monitor seismicity at GPA production sites. (E-4)			
3.2 Determine the effects of stimulation and gas extraction on groundwater movement.	3.2.1 Accumulate existing data on aquifer production rates in the potential impact area of selected sites. (E-4, E-5)	Production Operations	Applicable to all EGR programs	6
	3.2.2 Test aquifer production in existing water wells before and after stimulation and characterize effect of stimulation. (E-5)		Applicable to EGSP, WGSP, Methane from Coal	6
3.3 Collect appropriate data to ensure successful site restoration to original conditions and determine success of site restoration.	3.3.1 Re-contour land to conform to preconstruction topography. (E-1)	AHF, CEF, DW, CW, Site Restoration	Applicable to all EGR programs	6
	3.3.2 Monitor the success of reclamation by field inspection and aerial surveys. (E-3)			

[a] The generic list of issues and requirements appears in Appendix D.

[b] LOS = Level of Specificity.

[c] The interpretive key to the level of specificity appears in Table 3-3.

Ecological issues, requirements, and tasks are listed in Table 3-6. These tasks have been formulated to characterize the potential impacts and help develop adequate techniques for mitigation and control of such impacts.

3.6 HEALTH AND SAFETY ISSUES

The major health and safety issues discussed in this section deal with potential injury or illness caused by accidents at well sites, the impacts of high noise levels on workers, the dangers associated with handling of explosives and use of cryogenic materials, the dangers of high-pressure blowout, the danger of hot water scald, and the effects of inhalation of dust with high respirable silica content.

Drilling operations for EGR processes are the same as primary gas well drilling. Such operations have the highest disabling injury rate of natural gas recovery and production activities, 48.93 disabling injuries per 1 million man-hours worked.[3.5] Occupational health hazards include health effects caused by noise from drilling and pumping; inhalation of airborne dust, gases and vapors; safety or construction operations; and potential dangers of pressure system releases. Fire and explosion dangers are also usually present.

Operation of the well drilling system requires carefully preparing drilling fluids or muds in accordance with the geological requirements. A variety of chemicals or other materials can be used in preparing such drilling fluids. Physical or chemical reactions are not always predictable. For example, under increased drilling temperature and higher geostatic pressure, or with changes in pH, some chlorinated bactericides, used with biodegradable starches and gums, can break down into extremely toxic gases. Such gases may be released at the surface upon return of the drilling fluid when the pressure is reduced to atmospheric pressure.[3.6] The quantity and duration of such unpredictable releases of toxic gases depends on the conditions at the bottom of the hole.

At facilities for recovering methane from geopressured resources, the potential for hot water scalds exist. The feasibility of wearing protective clothing in the areas of greatest risk should be determined.

In chemical explosive fracturing, the composition and fate of the residual explosives decomposition gases are not well understood, but the quantity of gases produced is not negligible when permissible occupational exposure limits are considered. Individual chemical neutralizers and safe disposal techniques need to be studied and developed. Neutralizing chemicals must be available on-site for use as required.

Table 3-6. LIST OF ECOLOGICAL ISSUES AND REQUIREMENTS RELEVANT TO ERDA'S ENHANCED GAS RECOVERY (EGR) PROGRAMS[a]

ECOLOGY AND LAND USE RESEARCH REQUIREMENTS	TASKS	EGR PROCESSES AND OPERATIONS	RELEVANT PROGRAMS	LOS[b,c]
4.1 Predict and mitigate the impacts of EGR site development on ecosystem productivity and population dynamics	4.1.1 On a site-specific basis, predict the potential impacts to species and ecosystems which would result from EGR process development. (D-7, E-6, I-1)	Production	Applicable to Methane from Coal and Geopressured Methane	6
	4.1.2 Determine whether endangered species would be impacted by site development. (E-6)			6
4.2 Determine the effects of key contaminants on functional aspects of ecosystems.	4.2.1 Compile data from literature concerning the tolerance of representative species to key contaminants from EGR processes. (D-1, D-3, D-4)			3/4
	4.2.2 Where data are insufficient, implement laboratory and field studies to measure tolerance of representative species to key contaminants. (D-1, D-3, D-4)			3/4
	4.2.3 Implement a program to identify and utilize indicator species for early observation and mitigation of environmental degradation. (D-2, D-9, E-6, E-9)			3/4
	4.2.4 Develop models to predict impacts of EGR related pollutants on representative ecosystems. (D-5, D-6, K-1, M-1)			5

[a] The generic list of issues and requirements appears in Appendix D.

[b] LOS = Level of Specificity.

[c] The interpretive key to the level of specificity appears in Table 3-3.

Foam/gas fracturing requires gas injection into water mixed with surfactants. If cryogenic nitrogen or carbon dioxide is used, the potential occurrence of frostbite is present.

The recorded noise levels for rigs, compressors, and pumps used during drilling and stimulation activities can exceed 90 dBA and are hazardous to the health of the workers. Proper care and standard engineering controls can effectively prevent excessive noise transmission and its effects on workers.

The majority of occupational health and safety impacts can be mitigated or eliminated by careful design, planning, and attention to details during all EGR operations. This may necessitate study and quantification of such impacts, along with periodic monitoring activities at representatives sites (see Table 3-7).

3.7 SOCIOECONOMIC ISSUES

Many of the geographic areas in which EGR technologies may be employed have been exploited previously for extraction of gas, oil, or coal. Commercial development of these rural areas for enhanced gas recovery may scarcely alter socioeconomic profiles already established by prior energy resource development and recovery. Initial site development and construction operations may be considered short-term impacts. Such impacts will depend on the magnitude of future site operations planned. Only if the resources recovered lead to the establishment of on-site end-use plants, such as power plants, ammonia plants, petrochemical and LNG plants, will there be significant impacts on the infrastructure and ancillary services of neighboring communities. On a long-term basis, this will involve replacing temporary construction workers with regular industrial workers and their families. The influx of workers needed to operate and maintain on-site end-use plants would vary depending on the magnitude of gas resources.

Table 3-8 lists the socioeconomic issues and requirements for EGR processes.

Table 3-7. LIST OF HEALTH AND SAFETY REQUIREMENTS RELEVANT TO ERDA'S ENHANCED GAS RECOVERY (EGR) PROGRAMS[a]

HEALTH AND SAFETY RESEARCH REQUIREMENTS	TASKS	EGR PROCESSES AND OPERATIONS	RELEVANT PROGRAMS	LOS[b,c]
5.1 Determine the effects of noise on workers and the public.	5.1.1 On a site-specific basis, predict noise levels for construction and drilling activities. (F-2)	AHF, CEF, DW, Site Preparation, Stimulation	Applicable to all EGR Programs	5
	5.1.2 Recommend abatement strategy.			4/5
5.2 Determine the risk to workers who handle explosives.	5.2.1 Review standard procedures for handling explosives.	CEF Stimulation Operations		5
5.3 Determine the effects of inhalation and surface contacts of emissions, effluents, and cryogenic gases.	5.3.1 Monitor emissions from drilling and stimulation operations and maintain accurate health records.			5
5.4 Determine the risk of geothermal heat scalds.	5.4.1 Make temperature and pressure measurements of geopressured reservoirs at selected sites. (F-3, F-5, F-9)	Production and End-Use Operations	Geopressured Methane	6
	5.4.2 Study the feasibility of having workers wear various types of protective clothing when working in areas of scald potential. (F-6)			5

[a] The generic list of issues and requirements appears in Appendix D.

[b] LOS = Level of Specificity.

[c] The interpretive key to the level of specificity appears in Table 3-3.

Table 3-8. LIST OF SOCIOECONOMIC ISSUES AND REQUIREMENTS RELEVANT TO ERDA'S ENHANCED GAS RECOVERY (EGR) PROGRAMS[a]

SOCIOECONOMICS RESEARCH REQUIREMENTS	TASKS	EGR PROCESSES AND OPERATIONS	RELEVANT PROGRAMS	LOS[b,c]
6.1 Evaluate nuisance and irritant factors from noise impacts.	6.1.1 Compile noise data on equipment used in EGR processes. (F-4, F-5, F-10, H-5)	AHF, CEF, CW, DW, Drilling, Stimulation and Production Operations	All EGR Programs	4
	6.1.2 On a site-specific basis, evaluate noise impacts and determine cost-effective noise abatement methods. (H-5, I-1, J-8)			5/6

[a] The generic list of issues and requirements appears in Appendix D.

[b] LOS = Level of Specificity.

[c] The interpretive key to the level of specificity appears in Table 3-3.

4. ENVIRONMENTAL ACTION PLAN

4.1 INTRODUCTION

This section deals with the criteria for setting priorities for research requirements and specific research projects, discusses ongoing and completed research, and identifies future research activities needed to assess EGR issues, requirements, and technologies. Environmental research projects are selected, funded, and scheduled each fiscal year. For this reason, an annual review of the EDP will be carried out to determine a need for revising planning activities. Section 4.2 describes the criteria for selecting the various research requirements and discusses the criteria for selecting specific projects. In part, these same criteria were used in selecting the suggested research projects which are outlined in Appendix C of this report. Section 4.3 describes ongoing and completed research. Knowing what research has been conducted makes it possible to avoid duplicating past research when recommending future projects. Section 4.4 is the environmental action plan which presents specific research projects that should be funded and develops the schedules and milestones for conducting such research.

4.2 CRITERIA FOR PRIORITIZATION AND SELECTION OF FUTURE RESEARCH REQUIREMENTS

Several interdependent factors need to be considered in selecting the environmental issues and determining the priorities for scheduling and funding environmental research for the EGR program. These factors include:

- Commercialization schedule
- Environmental goals
- Severity and duration of impacts
- Specificity of the impacts to the EGR technologies
- Current knowledge of impacts
- Public concern
- Cost effectiveness
- Budget limitations.

A primary consideration for determining research and assessment needs is the schedule of commercialization for various EGR processes. Management and budget information from environmental research and assessments should be available coinciding with, or preceding, scheduled technology development.

Environmental goals (see Section 3.1) established both by statute and by professional judgment are a critical factor in determining the type of research or assessment to be conducted first. A high priority will be given to pertinent research that is directed toward problems for which environmental goals have been established.

Public concern may make it necessary to investigate specific potential impact areas, to allay public apprehension, or to clarify a controversial issue. ERDA's responsiveness to such public concern will tend to reduce subsequent delays in implementing the EGR technologies.

4.3 ONGOING AND COMPLETED RESEARCH

A list of ongoing and completed research that may be applicable to EGR technology is presented in Appendix B and summarized in this subsection. The research listed ranges from general environmental studies to specific EGR environmental issues.

The sources of information for the projects listed in Appendix B include the following:

- ERDA Symposium on Enhanced Oil and Gas Recovery, Volume II, 1976
- American Petroleum Institute Publications and Materials Book, 1977
- ERDA Contracts and Grants for Cooperative Research on Enhancement of Recovery of Oil and Gas Progress Reviews #10, BERC, April 1977
- Science Applications, Inc., Eastern Gas Shales Project 6-Month Summary Report, Volumes I and II, December 1976
- ERDA Inventory of Federal Energy Related Environment and Safety Research for FY 1976, #77-50/1-4
- System Development Corporation's International Search Service.

The research list is categorized in two ways: first by the level of specificity, and second by environmental issues and requirements. There are six levels of specificity: 1) general environmental research, 2) energy-related general research, 3) specific energy source, non-specific technology groups, 4) specific technology, 5) specific sub-technology, and 6) site-specific projects. The environmental issues and requirements categories are those used generally to categorize research sponsored by ERDA.

Due to the vast quantity of research that may be relevant to EGR or in a category such as general environmental research, Appendix B is not comprehensive. Consequently, a comprehensive literature review will be conducted before the initiation of any new research projects.

4.3.1 Air Quality Impact Research (Issue A*)

The state of the art in air quality assessment and control has been advanced by many Federally and privately funded research programs. The results of many projects can be applied to the anticipated air quality impacts of EGR technology development and application. Research conducted by the U. S. Bureau of Mines (BOM) includes the development and testing of methane recorders and analyzers.

Air quality research specific to EGR processes or site specific were not identified and therefore are not included in Appendix B.

4.3.2 Water Resources Research and Assessments (Issue B)

The areas of water resources research include development and testing of instrumentation to characterize and monitor water pollutants, the study of trace element cycling, occurrence, and impact, thermal effluent effects, hydrocarbon releases in water, water circulation studies, and and water quality impacts on aquatic organisms and ecosystems.

There was no research dealing specifically with the water quality impacts of EGR technologies. To date, little water resources research has been conducted that describes the specific effects of EGR process effluents. ERDA has recently released an RFP requesting a study of environmental policy analyses of water quality and quantity issues relevant to ERDA programs. This should cover various EGR processes and is scheduled for completion within 2 years.

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* See generic list of issues and requirements in Appendix D.

4.3.3 Geology and Land Use Impacts (Issue E)

Geologic studies funded by the United States Bureau of Mines (BOM) and ERDA include: groundwater flow characterisitics under natural and induced pressure gradients (this may apply directly to hydraulic fracturing techniques and liquid waste disposal), mined land and oil and gas field subsidence, supporting research in instrumentation development, and the geohydraulic environmental effects of geothermal power production.

4.3.4 Ecological Impacts (Issue D)

Much of the research conducted in air and water resources and land and geology can be related to impacts on the ecosystem and its various components. General ecological research efforts by many government agencies have focused on the effects of thermal effluents and potential use of waste heat, water quality requirements for fish and wildlife, the effects of hydrocarbons and heavy metal concentrations on the food chain, air quality impacts on vegetation, and general regional environmental impact assessments.

Research specific to the environmental impact of oil and gas extraction has been conducted by several government and nongovernment entities. The USGS has studied the impact of the oil and gas industry on the Louisiana Coast, and the impact of geothermal resource investigations. API has prepared a survey of environmental protection laws and regulations related to exploration, drilling, production and gas processing plant operations. The Department of Interior (DOI) has conducted an assessment of oil and gas development on Federal wildlife refuges along the Gulf Coast.

Ecological research specific to EGR sites has not been conducted. An overall environmental assessment of a test well in West Virginia, that deals in part with ecological impacts of massive hydraulic fracturing, has been funded by ERDA and prepared by Science Applications, Inc. (SAI).

4.3.5 Health and Safety Impacts (Issues C and F)

Extensive general research has been conducted to characterize and monitor the health effects of exposure to various effluents and emissions from energy systems. The effects of inhalation, contact, and ingestion of particulates, gases, and fluids have been studied by many Federal government agencies, universities and private research organizations. The most active have been NIEHS, the National Cancer Institute (NCI), and EPA. The areas of research include: pulmonary and respiratory disorders; alteration of metabolic rates; embryopathology; identification of mutagens, teratogens and carcinogens;

brain disorders; and alterations in behavior patterns. Work has also been done in policy analysis of hazardous waste control and in establishing regulations for emissions from energy production processes.

The American Petroleum Institute has conducted research to establish safety practices in well drilling and the handling of flammable liquids. They also have established safety standards for wellhead equipment.

4.3.6 Socioeconomic Impacts

Very little information has been found in the sources listed at the beginning of Appendix B on socioeconomic research as it applies to energy.

4.4 FUTURE ENVIRONMENTAL RESEARCH ACTIVITIES

On the basis of the research requirements identified in Section 3, and the ongoing and completed research projects listed in Appendix B, an environmental research plan (consisting of projects which will be conducted concomitant with the EGR process development) has been formulated and is presented in Appendix C. The plan briefly describes the significance of the issues involved and presents the objectives and task descriptions of the proposed research.

This research program has been designed so that environmental data are available to ERDA at critical decision points in the development and testing of EGR processes. The ultimate objective is to ensure that the EGR processes will not cause any permanent, severe environmental damage. With this objective in mind, both generic and technology-specific projects have been devised. The generic areas of consideration, while not exclusive to EGR, must be included in order to guarantee environmental acceptability during the continuing development of the EGR program. Research is proposed in each of the seven impact areas described in Section 3.2.

Research is proposed in the following categories:

- Identification and compilation of current sources of data and identification of deficiencies in this data base
- Collection of additional data, where necessary, on a site-specific basis
- Identifying and characterizing impacts of EGR processes, where those impacts are not clearly understood

- Monitoring and analysis of such impacts to determine their severity and duration

- Evaluation of the environmental adequacy of control technology and construction and operation procedures

- Developing new control technology and operating procedures when existing systems are determined to be inadequate.

The information obtained through this research program will be utilized in two ways. It will be used to predict impacts on a site-specific basis and to design for environmental controls. It will also be utilized as essential input into the ERDA decisionmaking process. The schedule of the work plan (which is described in detail in Appendix C) is shown here in Table 4-1.

Table 4-1. PROPOSED ORGANIZATION AND SCHEDULING OF ENVIRONMENTAL ACTION PLAN

ACTIVITIES	MILESTONE SCHEDULES
	CY 1978 / CY 1979 / CY 1980 / CY 1981 / CY 1982 / CY 1983
	FY 1978 / FY 1979 / FY 1980 / FY 1981 / FY 1982 / FY 1983
1. AIR QUALITY RESEARCH	
1.1 Baseline Data Acquisition (A-1, A-3, J-1)	
1.2 Determination of Emissions from Construction and Operation Activities (A-1, A-3, A-4, J-1)	
1.3 Characterization and Quantification of Emissions Due to Stimulation and Production Operations (A-3, A-4, J-1)	INTERMITTANT (1 YEAR PER EACH NEW SITE)
2. WATER RESOURCES RESEARCH	
2.1 Identify the Potential Water Quality Impacts Due to Site Preparation and Drilling Operations as Part of the NEPA Process (B-3, B-4, B-6, D-10, E-5, E-7, E-11, J-4)	INTERMITTANT (6 MONTHS PER EACH NEW SITE)
2.2 Characterize, Identify, and Quantify the Chemical Constituents of Fracture Fluids (B-4, B-5, D-10, E-8, E-9, J-2, J-8)	
2.3 Determine Potential Impacts from Brine and Thermal Discharges (B-4, B-6, E-7, E-9, J-2, J-4, J-6, J-7, J-8)	B
3. GEOLOGY AND LAND IMPACTS	
3.1 Determine the Extent of Subsidence and Seismicity Caused by EGR Processes (E-4)	B A

Table 4-1. ORGANIZATION AND SCHEDULING OF ENVIRONMENTAL ACTION PLAN (Cont'd)

ACTIVITIES	MILESTONE SCHEDULES
	CY 1978 | CY 1979 | CY 1980 | CY 1981 | CY 1982 | CY 1983
	FY 1978 | FY 1979 | FY 1980 | FY 1981 | FY 1982 | FY 1983
4. ECOLOGIC RESEARCH	
4.1 Predict and Mitigate the Impacts of Site Development on Ecosystem Productivity and Population Dynamics (D-7, E-6, I-1)	INTERMITTANT (6 MONTHS TO 1 YEAR PER EACH SELECTED SITE)
5. HEALTH AND SAFETY RESEARCH	
5.1 Determine the Risk of Geothermal Heat Scalds (F-3, F-5, F-9)	
6. SOCIOECONOMIC RESEARCH	
6.1 Assess the Socioeconomic Cost of Gas Shortages	
6.2 Evaluate Nuisance and Irritant Factors From Noise Impacts	
7. PROGRAMMATIC EIS FOR EGR	
8. PROGRAMMATIC EIS FOR THE EASTERN GAS SHALES PROGRAM	
9. SITE SPECIFIC NEPA PROCEDURE FOR EACH SITE OPENING AND EXPANSION	Intermittent (6 months to 1 year per site for preparation)

Table 4-2. LEGEND OF MILESTONE SYMBOLS

SYMBOL	DECISION MILESTONE
△	Begin Milestone
▽	Completed Milestone
Ⓐ	Performance Review (PR)
Ⓑ	Decision to Proceed Based on Environmental Impact Statement or Environmental Assessment
Ⓒ	Decision on Project Expansion

5. MANAGEMENT STRATEGY

5.1 MANAGEMENT OF ERDA ENVIRONMENTAL RESPONSIBILITIES

Within ERDA, the Assistant Administrator for Fossil Energy (AFE) and the Assistant Administrator for Environment and Safety (AES) have major and complementary responsibilities for the environmental, health and safety aspects of fossil energy programs.

The Assistant Administrator for Fossil Energy manages and directs the fossil energy research, development, demonstration and commercial application program for the ERDA concerning coal liquefaction, coal gasification, gas and oil development, oil shale and coal utilization, including combined cycle and direct combustion, and magnetohydrodynamics; and advanced technology, including materials research, combustion systems, extraction technology (excluding coal), and offshore drilling technology, and their directly related environmental, safety, and socioeconomic matters. He provides policy guidance, programmatic direction, and coordination to the ERDA organizations engaged in carrying out the foregoing functions and activities. He acts as the principal spokesperson, advisor, and assistant to the Administrator on all aspects of the foregoing fossil energy programs. In concert with appropriate staff and field offices, he coordinates fossil energy activities with others such as Congress, Federal and state agencies, industry, universities, and foreign and international organizations having an interest in these activities. He also identifies major fossil energy research, development, demonstration, and commercialization problems in ERDA programs and takes action to resolve them, or recommends solutions. He establishes and implements procedures for periodic consultation with representatives of science, industry, environmental organizations, consumers, and other groups which have special expertise or interest in the areas of fossil energy research, development and technology. (ERDA Manual 0000-0100, Chapter 0135.)

The Assistant Administrator for Environment and Safety (AES) manages and directs the environment and safety program for the Energy Research and Development Administration and acts as the principal spokesman, advisor, and assistant to the Administrator on all aspects of biomedical, environmental, and safety research and development and the protection of health, safety, and environmental impacts associated with energy technologies. He develops transportation standards and technology for ERDA operations from the standpoint of environment and safety. He coordinates ERDA activities required or specified under the National Environmental Policy Act (NEPA), and, in concert with appropriate staff and field offices, coordinates environment and safety

activities with others such as Congress, Federal and state agencies, industry, universities, and foreign and international organizations having an interest in these activities. He administers health, safety, and environmental protection programs applicable to all ERDA activities, including performance of independent assessments of the health, safety and environmental research and development related to ERDA-wide problems of health, safety, and environment protection; and the overview and assessment of environmental and safety research and development, primarily control technology, performed under programs of other Assistant Administrators. He identifies major biomedical, environmental, and safety research, development, and demonstration problems in ERDA programs and takes action to resolve them or recommends solutions. In working with other assistant administrators, he assures that for each energy source and energy conversion system being developed or improved there is early identification and full consideration of such factors as environmental degradations, effluent hazards, uncontrolled land use, resource depletion, and waste generation, along with timely development of adequate plans and funding to resolve these and related problems. He adjudicates concurrence for all Environmental Impact Statements and Environmental Development Plans. In addition, the Assistant Administrator initiates and performs research, development and demonstration directed at achieving environmental protection and safety when such undertakings are not appropriate for assignment to a particular energy or energy conversion program. He establishes procedures for periodic consultation with representatives of science, industry, environmental organizations, consumers, and other groups which have special expertise or interest in the areas of biomedical, environmental and safety research, development, and technology. (ERDA Manual 0000-0100, Chapter 0145.)

The Assistant Administrator for Fossil Energy and Assistant Administrator for Environment and Safety shall include among program elements and activities research, development, and demonstration designed to assure that program activities under their direction are conducted with due regard for: safety, energy conservation, environmental and social consequences, the need for environmental assessments and the preparation of Environmental Impact Statements and control of technologies which utilize renewable or essentially inexhaustible energy sources with regard to their thermal efficiency and their net energy production. (ERDA Manual 0000-0100, Chapters 0135 and 0145.)

5.2 ENVIRONMENTAL OVERVIEW COMMITTEE (EOC)

To facilitate these activities, one Environmental Overview Committee will be established to advise AES and AFE management personnel on matters that relate to implementation of the Fossil Energy EDPs, adequacy of the research, and associated progress. The committee will consist of a maximum of eight members for AFE-AES Divisions. This committee will be co-chaired by AES/TO and AFE/ESP

committee members. Other representatives may be called upon to contribute to the EOC as necessary.

5.3 RESPONSIBILITIES FOR EDP UPDATING

The AES has the responsibility for ensuring the quality and timeliness of EDPs. Preparation is the joint responsibility of the AES and AFE. Other program and staff assistant administrators are to review EDPs relative to their current planning needs (ERDA IAD #0500-4).

5.4 INTERACTION WITH OTHER FEDERAL AGENCIES AND THE PRIVATE SECTOR

Other Federal agencies and the private sector are involved in various environmental and safety aspects of Enhanced Gas Recovery. ERDA will continue to cooperate with these organizations by providing information obtained through the work of AFE and AES, through interagency Memoranda of Understanding and Interagency Agreements, published reports, and cost sharing projects with the private sector. Included in such cooperation is work with the Water Resources Council (WRC) to assess water requirements of and availability for these projects, work with OSHA to set worker health and safety standards, and work with the private sector to develop a cost-effective technology.

5.5 PUBLIC INVOLVEMENT

This EDP and its annual updates will be made available for public review, and each year ERDA will consider public comments when prioritizing environmental issues and scheduling environmental research and assessment activities. Through the EDP process, the public will be kept aware of ERDA's activities in technology development and environmental research. This mechanism will allow the public to help ERDA evaluate its progress toward the goal of development of environmentally acceptable and commercially viable EGR technologies.

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APPENDICES

APPENDIX A

A.1 Federal Statutes and Orders and International Agreements

Legislation	Applicability to Enhanced Gas Recovery
• National Environmental Policy Act of 1969 (NEPA), PL 94-83 (as amended, August 9, 1975)	• Environmental Impact Statements (EISs) must be prepared for all major Federal actions significantly affecting the quality of the human environment.
• Federal Nonnuclear Energy Research and Development Act of 1974, PL 93-577, section 13(a)	• Water availability assessments are required for demonstration and commercial projects; responsibilities are shared with the Water Resources Council (WRC). Consultation with the Council on Environmental Quality shall be included as part of the assessment process.
• Water Resources Planning Act of 1965, PL 89-80	• Created the Water Resources Council which coordinates planning for water and related land resources.
	• Pursuant to the Act, Principles and Standards for Planning Water and Related Land Resources were published.
• Clean Air Act as amended June 1974 PL 93-319	• Ambient air quality standards have been set for SO_2, TSP, NO_2, CO, HC and O_x; more are being considered.
	• NSPS and regulations for the prevention of significant deterioration may affect plant siting in nonattainment areas; may require air emissions tradeoffs.
	• Best Available Control Technology (BACT) may be required of EGR facilities.

Legislation	Applicability to Enhanced Gas Recovery
• Federal Water Pollution Control Act Amendments of 1972 PL 92-500	• National Pollutant Discharge Elimination System (NPDES) permits are required to control wastewater discharges. • Since effluent guidelines have not been developed for most fossil energy technologies, permit requirements are determined on a case-by-case basis to meet State plans. • A "No Discharge" goal has been set for 1985.
• Resource Conservation and Recovery Act of 1976 PL 94-580	• Solid waste disposal must comply with most stringent air and water standards; monitoring is required. • New regulations will be developed in 1 to 2 years for a Federal hazardous waste handling permit system and State programs for non-hazardous solid waste.
• Toxic Substances Control Act (TOSCA) 1976 PL 94-469	• Disposal of specific materials (e.g., fracture fluid) used in EGR processes may be regulated.
• Safe Drinking Water Act 1974 PL 93-523	• Wastewater discharges may require additional treatment for heavy metals or organic waste if they impact drinking water supplies.
• Noise Control Act of 1972 as amended May 1976 PL 94 - 301	• To protect health and welfare, ambient noise levels are recommended; they may become standards for facilities regulated by State and local governments.
• Occupational Safety and Health Act (OSHA) 1970 - PL-91-596	• Health and Safety regulations must be met for workers at EGR sites.

Legislation	Applicability to Enhanced Gas Recovery
• Coastal Zone Management Act of 1972 as amended July 1976 PL 94-370	• State coastal zone management plans developed with Federal financial assistance may affect EGR geopressured gas siting.
• Marine Protection, Research and Sanctuaries Act of 1972 as amended June 1976 PL 94-326	• Permits are required for activities in wetland areas, which may restrict geopressured gas facility siting.
• Rivers and Harbors Act of 1899 33 U.S.C. 401-413	• Permits are required for dredge and fill activities in navigable waters, which may affect some EGR activities and sites. • Projects must be integrated with flood control, river, and dam projects.
• National Historic Preservation Act of 1966 80 U.S.C. 915 16 U.S.C. 470	• Federally financed, assisted, or permitted projects cannot impact important historic or cultural sites unless no alternatives exist.
• Endangered Species Act of 1973 as amended July 1976 PL 94-359	• Identification of endangered aquatic and terrestrial species at a potential construction site is required, which may affect EGR facility siting.
• Fish and Wildlife Coordination Act as amended in 1958 PL 85-624	• Any project requiring modification of bodies of water must be reviewed to prevent loss or damage to fish and wildlife. May apply to some EGR processes.
• Wild and Scenic Rivers Act as amended October 1976 PL 94-486	• Projects must not degrade the quality of wild and scenic rivers.

Legislation	Applicability to Enhanced Gas Recovery
• Executive Order 11752 - Prevention, Control and Abatement of Environmental Pollution at Federal Facilities 1973	• The Federal Government in the design, construction, operation and maintenance of its facilities, shall protect the quality of the environment through compliance with Federal, State and local standards and limitations.
• Executive Order 11990 Protection of Wetlands 1977	• In order to avoid the adverse impacts associated with the modification of wetlands, each Federal agency shall take action to minimize the destruction, loss or degradation of the wetlands and to avoid direct or indirect support of new construction in wetlands. This may apply to EGR processes.

A.2 Examples of Interstate or Regional Requirements

Legislation	Applicability to Enhanced Gas Recovery
• Colorado River Compact 1922; 22 U.S.C. 171 Colorado River Basin Compact 1948 - PL 80-37	• Apportioned the waters of the Colorado River between Upper and Lower Basin States. Applicable to WGSP.
• Delaware River Basin Compact 1961 - PL 87-328 Susquehanna River Basin Compact 1970 - PL 91-575	• Any project which will make significant use of basin waters shall be submitted to commission for review and approval. May apply to EGSP activities.
• Indian Water Rights 1908 207-US-546	• Court Case Winters vs United States where adequate water for a routine way of life is guaranteed to Indians on Reservations in the United States.

Legislation	Applicability to Enhanced Gas Recovery
• Colorado River Basin Project Act of 1968 PL 90-537	• Provides a program for the comprehensive development of the water resources for the Colorado River Basin. Applicable to WGSP.
• Mexican Water Treaty of 1944	• Obligates the United States to deliver to Mexico 1.5 million acre feet per year in the Colorado River.
• Agreement on the Salinity of the Colorado River 1974 PL 93-320	• The United States has agreed to decrease the salinity of the Colorado River water flowing into Mexico.
• Columbia River Treaty with Canada 1961	• Agreements concerning the Columbia River Basin including Libby Dam and upstream storage reservoirs in Canada.

APPENDIX B

ONGOING AND COMPLETED RESEARCH RELEVANT TO EGR TECHNOLOGY

This Appendix catalogues many of the ongoing and completed research projects which have implications for or direct application to EGR technology development and the problems associated with their deployment. This list is by no means complete, since some sources were only partially reviewed and still others have been found too late to include in this present index. The scope of EGR research, however, should be fairly evident from the examples included here. The information listed was obtained from the following sources:

- ERDA Symposium on Enhanced Oil and Gas Recovery, Volume I, 1976
- ERDA Contracts and Grants for Cooperative Research on Enhancement of Oil and Gas Progress Reviews, #10, BERC, April 1977
- ERDA Inventory of Federal Energy-Related Environment and Safety Research for FY 1976, #77-50/1-4
- System Development Corporation's International Search Service
- Fossil Energy Update, ERDA, FEU-77/7, July 1977
- American Petroleum Institute Publications and Materials Book, 1977
- RPIS Inventory, ERDA, 1977.

Projects listed include general studies applicable to all environmental problems as well as research more directly related to the EGR technologies. For each project there is listed a title; a Federal Inventory Number or RPIS number or Contract Number, as applicable; the monitoring agency; the performing agency; and a completion date, if known.

The Research here is covered in six categories:

- Category 1 — General Research
- Category 2 — Energy-Related Research
- Category 3 — Specific EGR Research, No Technology Specified
- Category 4 — EGR Specific Technology Research
- Category 5 — Sub-Technology Studies
- Category 6 — Site-Specific Research.

Within each category the projects listed have been subdivided according to the applicable environmental issues delineated earlier. Issue requirements are also indicated where applicable. Following the listing of project titles, brief summaries are presented for representative projects in Categories 1, 2, 3, and 4. Extended summaries are then presented for work in Categories 5 and 6. These last 2 categories have summaries for all projects with sufficient data available and which cover specific areas of concern to EGR.

CATEGORY 1 — GENERAL ENVIRONMENTAL RESEARCH

ISSUE A: Will operation of the energy system result in degradation of air quality in the region?

REQUIREMENT A-1: Assess current information on air quality

NUMBER	PROJECT	MONITORING AGENCY	PERFORMING AGENCY	YEAR COMPLETED
013017	Air Pollution Studies	ERDA	NOAA	
130019	ASTM Air Quality Evaluation Methods	TVA	TVA	
	Particulates: Air Quality Criteria Based on Health Effects	American Petroleum Institute	M. C. Battigelli	
	Ambient Air Quality Standards for Particulates Review and Evaluation	American Petroleum Institute	H. C. McLee	

REQUIREMENT A-2: Develop improved procedures and systems for continuous air monitoring

120003	Multiple Trace-Gas Monitoring System	NASA	NASA-Langley	

REQUIREMENT A-3: Accumulate baseline, operational, and post-operational air quality data around facilities and sites

033085	Size/Chemical Measurements of Atmospheric Particles	NIEHS	Rochester University	

REQUIREMENT A-6: Improve atmospheric transport and dispersion models

013010	Atmospheric Turbulence and Diffusion	NOAA	NOAA	
013018	Atmospheric Transport Models	ERDA	NOAA	
013019	Atmospheric Turbulence and Diffusion	ERDA	NOAA	
013020	Transport Deposition and Meteorological Experiments	ERDA	NOAA	
150190	Evaluation of Atmospheric Dispersion Data	ERDA	Batelle Pacific Northwest Labs	
	An Evaluation of Dispersion Formulas	N/A	American Petroleum Institute	1969

ISSUE B: Will operation of the energy system impact the water resources of the region?

REQUIREMENT B-1: Assess current information on surface and subsurface water resources and their allocation

013008	The Summarization and Interpretation of Historic, Physical, Oceanographic and Methodological Information for the Mid-Atlantic Region	BLM	NOAA	
054017	National Environmental Overview Program	USGS	USGS	1978
100018	Evaluation of National Commission on Water Quality Report and Recommendations on the Federal Water Pollution Control Act	FEA	Westinghouse Environmental Systems Department	1976

CATEGORY 1 — GENERAL ENVIRONMENTAL RESEARCH

ISSUE A: Will operation of the energy system result in degradation of air quality in the region?

REQUIREMENT A-1: Assess current information on air quality

NUMBER	PROJECT	MONITORING AGENCY	PERFORMING AGENCY	YEAR COMPLETED
013017	Air Pollution Studies	ERDA	NOAA	
130019	ASIM Air Quality Evaluation Methods	TVA	TVA	
	Particulates: Air Quality Criteria Based on Health Effects	American Petroleum Institute	M. C. Battigelli	
	Ambient Air Quality Standards for Particulates Review and Evaluation	American Petroleum Institute	H. C. McLee	

REQUIREMENT A-2: Develop improved procedures and systems for continuous air monitoring

120003	Multiple Trace-Gas Monitoring System	NASA	NASA-Langley	

REQUIREMENT A-3: Accumulate baseline, operational, and post-operational air quality data around facilities and sites

033085	Size/Chemical Measurements of Atmospheric Particles	NIEHS	Rochester University	

REQUIREMENT A-6: Improve atmospheric transport and dispersion models

013010	Atmospheric Turbulence and Diffusion	NOAA	NOAA	
013018	Atmospheric Transport Models	ERDA	NOAA	
013019	Atmospheric Turbulence and Diffusion	ERDA	NOAA	
013020	Transport Deposition and Meteorological Experiments	ERDA	NOAA	
150190	Evolution of Atmospheric Dispersion Data	ERDA	Batelle Pacific Northwest Labs	
	An Evaluation of Dispersion Formulas	N/A	American Petroleum Institute	1969

ISSUE B: Will operation of the energy system impact the water resources of the region?

REQUIREMENT B-1: Assess current information on surface and subsurface water resources and their allocation

013008	The Summarization and Interpretation of Historic, Physical, Oceanographic and Methodological Information for the Mid-Atlantic Region	BLM	NOAA	
054017	National Environmental Overview Program	USGS	USGS	1978
100018	Evaluation of National Commission on Water Quality Report and Recommendations on the Federal Water Pollution Control Act	FEA	Westinghouse Environmental Systems Department	1976

REQUIREMENT B-2: Develop improved procedures for continuous monitoring of water for pollutants

NUMBER	PROJECT	MONITORING AGENCY	PERFORMING AGENCY	YEAR COMPLETED
012003	Water Quality Assurance and Instrumentation	EPA	NBS	

REQUIREMENT B-4: Characterize, identify, and quantify the chemical constituents of the process streams, including gaseous, liquid, and solid wastes

111010	Chemistry, Fate, and Removal of Trace Contaminants from Low and Medium Salinity Geothermal Waters	National Science Foundation	UCLA	

REQUIREMENT B-6: Model the environmental transport and fate of liquids and solids released to surface and subsurface waters

	Computation of Solutions for the Flow of Fluids through Porous Material	Lawrence Livermore Labs	University of California	1974
	OGRE Code: A two-dimensional numerical model of Transient Flow of One or Two Compressible	Lawrence Radiation	University of California, Livermore	1970
	Elastic Wave Propagation Through an Infinite Stratum of Porous Material	ERDA	Sandia Labs	1976
	General Purpose Diffusivity Model for Fluid Flow and Heat Conduction in Porous Media	ERDA	USBM	1976

ISSUE C: What would be the effect on man of any deterioration of air and water quality?

REQUIREMENT C-1: Screen samples of emissions and effluents for biological effects

033019	Abnormal Trace Metals in Disease	NIEHS	Dartmouth	
033154	Detection of Air Pollutants and Low Levels of Mutagens/Carcinogens	NIEHS	NIEHS	
087009	Biomedical Effects of Explosives	ERDA	Lovelace Foundation	1976
	Recommended Practice for Biological Analysis Subsurface Injection Waters	N/A	American Petroleum Institute	1975

REQUIREMENT C-2: Conduct secondary biological screening in animals and plants

022168	The Study of Toxic Effects of Environmental Chemicals on Spermatogenesis	NIEHS	NIEHS	

REQUIREMENT C-3: Conduct acute and subacute effects studies with chemical or physical agents

033032	Can Vitamin E or Lipid Alter NO_2 or NO_3 Toxicity in the Lungs	NIEHS	Duke University, Department of Physiology and Pharmacology	
033038	Factors Affecting Irritant Potency of Gases and Aerosols	NIEHS	Harvard University	
033039	Metallothicnein in Physiology and Toxicology	NIEHS	Oklahoma University Health Sciences Center	
034019	Chemistry of N-Nitroso Compounds	NCI	NCI	
070020	Effects of Thermal Additives on the Dynamics of Fouling Communities at Beaufort, N. C.	EPA	Duke University	
070101	In-Vitro Screening of Selected Air Pollutants for Potential Carcinogenicity (Phase A)	EPA	Research Triangle Institute	

REQUIREMENT C-4: Conduct inhalation, ingestion and dermal exposure studies

NUMBER	PROJECT	MONITORING AGENCY	PERFORMING AGENCY	YEAR COMPLETED
033004	Study of Upper Respiratory Tract Clearance	NIEHS	Pittsburgh University	
033007	Response of Alveolar Macrophages to Inhaled Particles	NIEHS	Harvard University	
033022	Toxicity of Inert Particles to Alevolar Macrophages	NIEHS	Georgetown University	
033024	Behavioral Effects of Carbon Monoxide Exposure	NIEHS	University of Maryland Department of Psychology	
033051	Regional Deposition of Inhaled Particles in Man	NIEHS	New York University	
033207	Pulmonary Effects of Environmental Oxidant Pollutants	NIEHS	UC Davis	
070073	Compare Effects of Respirable Particles, Grass, and Mists Using Small Airway Resistance in Donkeys as the Model for Pulmonary Irritation	EPA	Institute for Environmental Medicine	
070075	Evaluate Effects of Chronic of Intermittant Exposure to Respirable Particles and Mists Using Mouse Pulmonary Infectivity Model	EPA	ITT Research Institute	
070079	Electroeccephalographic and Behavioral Studies of Rats During Long-Term Continuous Exposure to Sulfur Dioxide and Particulate Matter	EPA	ITT Research Institute	

REQUIREMENT C-5: Conduct reproductive, teratogenicity and mutagenicity studies.

033003	Benzene Toxicity and Metabolism	NIEHS	Thomas Jefferson University	
022014	Methylmercury Embriopathy	NIEHS	Washington Univ. School of Medicine	
033018	Teratogenic Effects of Heavy Metals	NIEHS	Dartmouth Medical School	
033177	Changes in Mammalian Pulmonary Function Produced by Inhaled Environmental Agents	NIEHS	NIEHS	
033197	Chemical and Environmental Mutogen Studies Utilizing the Tradescantion Test System	NIESH	Brookhaven National Lab	
034013	Genetic and Epigenetic Regulation of Mixed Function Mono-Oxygeneses	NCI	NCI	

REQUIREMENT C-7: Conduct metabolic and dose distribution studies

033074	Kinetics of Uptake and Excretion of Vapors in Man	NIEHS	Miami University, Florida	
034006	Metabolism of Chemical Carcinogens by Cultured Human Tissues	NCI	NCI	
034025	Studies of Microsomal Enzyme Systems Metabolizing Polycyclic Hydrocarbons in Environmental Animals and Humans	NCI	Texas University	

REQUIREMENT C-8: Conduct baseline characterization studies of tissues, cells and molecules most sensitive to energy-related pollutants

033104	Alterations of Cell Membranes and Metabolism by Ozone	NIEHS	U. S. Riverside Dept. of Biology	
033171	Study of Fractors Affecting Biotransformation of Xonobiotics in Extra Hepatic Tissues	NIEHS	NIEHS	

REQUIREMENT C-7: (Continued)

NUMBER	PROJECT	MONITORING AGENCY	PERFORMING AGENCY	YEAR COMPLETED
034033	Evaluation of the Significance of Experimental Chemical Carcinogenesis Data to Man	NCI	International Agency for Research on Cancer	

REQUIREMENT C-9: Define the potential for carcinogenic and synergistic interaction of oil and gas-related pollutants with other environmental stresses

033011	Effects of Heavy Metal Ions on a Chemical Synopsis	NIEHS	Cincinnati University	
033012	Biochemical Effects of Ozone and NO_2 in the Lung	NIEHS	New York University	
033031	Protection by Zinc Against Toxic Metals and Gases	NIEHS	Arizona State University Department of Surgery	
034011	Identification of the Ultimate Carcinogenic Form of Benzo (A) Pyrene	NCI	NCI	
034014	Benzo (a) Pyrene - 4,5 - Oxide Hydratose	NCI	NCI	
034026	Investigative Aspects of Enzyme Induction and Chemical Carcinogenesis	NCI	Weizmann Institute of Science	
034030	Production and Detection of Antibodies to Chemical Carcinogens and Other Small Molecules	NCI	Brandeis University	
034031	In Vitro Study of the Nature of the Interaction Between Chemical and Viral Carcinoggenesis	NCI	NCI	
034038	NCI - ERDA Carcinogenesis Program and Respiratory Carcinogenesis	NCI	Oak Ridge National Lab	

REQUIREMENT C-10: Improve bioassay systems, instruments, and methods for risk assessment.

033001	Analysis of Mechanisms of Experimental Emphysema	NIEHS	St. Luke's Hospital of the Methodist Church	
034007	Studies on the Mechanics of Induction of Aryl-Hydrocarbon Hydrozylase	NCI	NCI	
034010	Inducers and Inhibitors of Aryl-Hydrocarbon Hydroxylase Activity and Tumorigenesis	NCI	NCI	
034012	Development of An Assay for Glutathione (GSH) S-Transverse-Polycyclic Hydrocarbon Oxides	NCI	NCI	
034034	A Resource for Carcinogenic Bioassays and Related Research	NCI	Nebraska University	
070039	Perfection of Previously Developed Instrumentation for the Collection and Analysis of Carcinogenic Vapors in Ambient Atmospheres	EPA	Research Triangle Institute	

REQUIREMENT C-11: Validate the use of cell screening systems to predict carcinogenicity and mutagenicity in man.

033002	Quantitative Genetic Study of Environmental Mutagens	NIEHS	Louisiana State University	
034015	Studies on the Metabolism of Chemical Carcinogens	NCI	NCI	
034029	Development of In Vitro Methods for the Detection of Cell Mediated Immunologic Reactivity to Chemical Compounds	NCI	Texas University	

ISSUE D: What would be the effect on ecological systems of any deterioration of air and water quality?

REQUIREMENT D-1: Screen samples of emissions and effluents for acute toxicity to standard species

NUMBER	PROJECT	MONITORING AGENCY	PERFORMING AGENCY	YEAR COMPLETED
111015	Behavior of H_2S in the Atmosphere and Its Effects on Vegetation	Nat'l. Science Foundation	Univ. of Calif. at Riverside, Statewide Air Pollution Research Center	

REQUIREMENT D-2: Determine potential for materials to accumulate inbiota

033069	Photosynthesis Inhibition by Environmental Trace Metals	NIEHS	Missouri University Biology Division	

REQUIREMENT D-5: Determine the effects of key contaminants on functional aspects of model ecosystems

013048	Hydrocarbon Concentration in Food Chains	NOAA	Louisiana State University Sea Grant Program	

REQUIREMENT D-6: Evaluate changes in community structure and monitor for signs of toxicity in receiving waters associated with operating facilities

013027	Effects of Contaminants and Environmental Alterations in SE Coastal Plains Estuaries and Adjacent Coastal Waters	NMFS	NMFS	
	Stimulation and Inhibition of Phytoplankton Growth by Low Molecular Weight Hydrocarbons	NSF	Skidaway Institute of Oceanography	

REQUIREMENT D-7: Accumulate baseline, operational, and post-operational ecosystem data around facilities and sites

051008	Determine the Water Quality Needs of Fish and Wildlife in the Upper Colorado and Upper Missouri River Basins	FWS	FWS	

REQUIREMENT D-8: Evaluate ecosystems exposed to naturally occurring pollutants

013022	Structure and Function of Coastal and Estuarine Ecosystem of S.E. U.S.A.	NOAA	National Marine Fisheries Service	

REQUIREMENT D-9: Develop rapid identification of effects on ecosystems.

051019	Assessment of Low Altitude Remote Sensing Applications to Fish and Wildlife Resources on Disturbed Lands	Fish and Wildlife Service	College of Forestry in St. Paul	

ISSUE E: Can land be reclaimed, and can waste be managed in an environmentally acceptable way.

REQUIREMENT E-4: Determine the extent of subsidence or seimicity following extraction.

094034	Background Studies of Subsidence in the Gulf Coast Area	ERDA	USGS	1976

REQUIREMENT E-7: Evaluate procedures for management of liquid wastes

	Subsurface Saltwater Disposal	N/A	American Petroleum Institute	1960

ISSUE F: Are the risks to the occupational work force acceptable?

REQUIREMENT F-2: Develop individual dose monitoring systems

NUMBER	PROJECT	MONITORING AGENCY	PERFORMING AGENCY	YEAR COMPLETED

REQUIREMENT F-6: Develop protection and decontamination procedures and guidelines for accidental and routine exposure of workers.

013071	Management Support for Emergency Medical Technician/Diver and Physician Training	NOAA	Undersea Medical Society	

ISSUE I: Are proposed facilities in compliance with standards and regulations?

REQUIREMENT I-1: Prepare Environmental Impact Assessment or EIS documents.

013015	Environmental Assessment Studies	BLM	NOAA	
054018	Gulf of Mexico Outer Continental Shelf Environmental Studies	USGS	U. S. Geological Survey	
08198	Technical Support for Environmental Problem Definition and Pollution Studies	EPA	Radian Corporation	

REQUIREMENT I-2: Determine compliance with and obtain necessary air, water, land use and waste disposal permits.

100020	EPA State Implementation Plan for Ohio	FEA	Radian Corp.	

ISSUE J: Are there adequate environmental controls?

REQUIREMENT J-4: Develop systems and guidelines for management and control of gas, liquid, solid wastes, discharges, noise, odor, etc.

094031	Investigation of the Removal of Hydrogen Sulfide from Simulated Geothermal Brines by Reaction with Oxygen	ERDA	Dow Chemical	1976
130016	Particulate Technology	TVA	TVA	

REQUIREMENT J-6: Evaluate uses of wastes as alternatives for disposal.

007237	Potential Beneficial Use of Waste Heat for Greenhouse Production	EPA	Fort Valley State College	
130028	High Density Raceway Production of Catfish Utilizing Steam-Electric Generating Plant Heated Water Discharges	TVA	TVA	

REQUIREMENT J-7: Compare feasibility, cost, and impact of environmental control options.

070146	The Effects of High Temperature and Pressure on Particle Collection Mechanisms	EPA	Air Pollution Technology, Inc.	
094032	Removal of Hydrogen Sulfide from Geothermal Steam	ERDA	Battelle Pacific N.W. Lab.	
130031	Heat Dissipation Technology	TVA	TVA	
	Recommended Practice for Determining Permeability of Porous Media		American Petroleum Institute	1952

REQUIREMENT J-8: Evaluate methods for controlling or managing runoff and draining from affected areas.

070184	Evaluation of Selected Surface Treatment Agents for the Protection and Restoration of Shorelines and Salt Marsh Areas	EPA	American Petroleum Institute	

CATEGORY 2 — ENERGY RELATED RESEARCH

ISSUE A: Will operation of the energy system result in degradation of air quality in the region?

REQUIREMENT A-1: Develop improved procedures and systems for continuous air monitoring.

NUMBER	PROJECT	MONITORING AGENCY	PERFORMING AGENCY	YEAR COMPLETED
070024	Development of Standard Reference Material, Instrumentation and Methods Needed for Monitoring Air Quality Associated with Energy Development	EPA	NBS	
070024	Regional Ambient Air Monitoring of Energy Related Toxic Substances and Suspended Particles on the S. W. United States	EPA	EPA	
070026	Ambient Air Monitoring in Areas in Vicinity of Energy Related Sources/Western Energy Development	EPA	EPA	

REQUIREMENT A-4: Characterize, identify, and quantify chemical constituents of process steams, including gaseous, liquid and solid.

070048	Smog Chamber Studies of Atmospheric Chemistry of Organic and Nitrogen Containing Emissions from Emerging Energy Technology	EPA	Research Triangle Institute	
070078	Chemical Characterization and Toxicity of Metal Binding Components of Emissions from Mobile and Stationary Energy Sources	EPA	University of Cincinnati	

REQUIREMENT A-6: Improve atmospheric transport and dispersion models.

013014	Lidar Techniques for Measuring Particulate Pollutants from Energy Production and Their Transport and Dispersion	EPA	NOAA	
013016	Meteorological Interpretations and Predictions of Air Quality in the Western U. S. Related to Energy Activities	NOAA	Being set up	

ISSUE B: Will operation of the energy system impact the water resources of the region?

REQUIREMENT B-1: Assess current information on surface and subsurface water resources and their allocation.

051001	An RFP Forum on the Impact on Western Waters, Fish and Wildlife of Energy Development	FWS	Resources for the Future, Inc.	
051004	Critical Appraisal of Research Needs with Respect to Fish and Wildlife Implications of Western Water Allocation for Energy Development	FWS	University of Colorado Institute of Behavioral Sciences	

REQUIREMENT B-4: Characterize, identify, and quantify the chemical constituents of the process steam, including gaseous, liquid, and solid wastes.

070025	Energy Related Water Monitoring Data Interpretation	EPA	EPA	

ISSUE C: What would be the effect on man of any deterioration of air and water quality?

REQUIREMENT C-1: Screen samples of emissions and effluents for biological effects.

013051	Biological Effects of Waste Heat Effluents from Coastal Power Plants	NOAA	U. C., San Diego	

REQUIREMENT C-4: Conduct inhalation, ingestion and dermal exposure studies.

070080	Effects of Pollutants from Energy Consumption and Environmental Trace Metals on Lung Metabolism	EPA	UCLA	

REQUIREMENT C-4: (Continued)

NUMBER	PROJECT	MONITORING AGENCY	PERFORMING AGENCY	YEAR COMPLETED
070098	Determination of the Effects of Material from Alternate Energy Sources in Upper Respiratory Tract Clearance Mechanism	EPA	Ball State University	

REQUIREMENT C-5: Conduct reproductive, teratogenicity and mutagenicity studies.

033206	Effects of Energy Related Pollutants on Female Reproductive Tract Function	NIEHS	NIEHS	

REQUIREMENT C-6: Define the cellular and molecular mechanisms for biological damage and repair.

070097	Development of Cellular Model System to Determine Cytotoxicity from Alternate Energy Sources	EPA	Rockefeller University	

REQUIREMENT C-10: Improve bioassay systems, instruments, and methods for risk assessment.

012004	Energy Related Air Pollutant Analysis Instrumentation	EPA	NBS	
054038	Energy Supporting Research, Instrumentation Development	USGS	USGS	1978
070029	Remote Instrumental Techniques for Monitoring Energy Related Pollutants and Effects	EPA	EPA	
070096	Development of Methods for Determination of Carcinogenesis by Bacterial Mutogenesis Employing Crude Material from Alternate Energy Sources	EPA	Washington University St. Louis	
098100	Instrumentation and Methods for Characterizing Aqueous Effluents from Oil Shale, Oil Refining, and Geothermal Sources	ERDA	Oak Ridge National Laboratory	1978
100016	Technical and/or Policy Evaluation for Air and/or Water Environmental Impact from Energy Generation and Related Facilities and from Energy Intensive Industries	FEA	Environmental Research and Technology	
120002	Energy Related Remote and In-Situ Instrument Development	EPA	NASA	

ISSUE D: What would be the effect on ecological systems of any deterioration of air and water quality?

REQUIREMENT D-5: Determine the effects of key contaminants on functional aspects of model ecosystems?

070099	Effect of Material from Alternate Energy Sources on Whole Animal Defense Systems	EPA	Southeastern Foundation for Research and Education	

REQUIREMENT D-7: Accumulate baseline, operational, and post-operational ecosystem data around facilities and sites.

130032	Thermal Effects from Steam Electric Generating Fcailities	TVA	TVA	

Issue E: Can land be reclaimed, and can wastes be managed in an environmentally acceptable way?

REQUIREMENT E-8: Evaluate procedures for management of solid wastes.

070221	Policy Analysis for Hazardous Waste Control	EPA	Colorado School of Mines	

ISSUE F: Are the risks to the occupational work force acceptable?

REQUIREMENT F-9: Conduct site, safety. amd industrial hygiene surveys and assessments.

032017	Enumeration of Energy Occupational Health Problems	Public Health Services	NIOSH	

ISSUE H: Are the socioeconomic effects associated with the development acceptable?

NUMBER	PROJECT	MONITORING AGENCY	PERFORMING AGENCY	YEAR COMPLETED
080022	Social Costs of Energy Supply Systems	ERDA	Arizona National Lab	1978

ISSUE I: Are the socioeconomic effects associated with the development acceptable?

REQUIREMENT I-1: Prepare Environmental Impact Assessments or EIS documents

054034	Yampa River Basin Assessment - An Evaluation of Energy Development Alternative Factors	ERDA	USGS	1977
085122	Spatial Data System for Regional Ecological Impact Assessment Related to Energy Development	ERDA	Oak Ridge National Lab	1978

REQUIREMENT I-2: Determine compliance with and obtain necessary air, water, land use and waste disposal permits.

	Fuel Sulfur Regulations, Federal, State and Local	N/A	American Petroleum Institute	1978

ISSUE J: Are there adequate environmental controls?

REQUIREMENT J-6: Evaluate uses of wastes as alternatives for disposal.

130034	Use of Waste Heat in Sewage Sludge Digestion	TVA	TVA	
	Recommended Onshore Production Practices for Protection of the Environment	N/A	American Petroleum Institute	1974
	Energy and Cryoengineering	Los Alamos Science Lab	E. F. Hammel	
	Extraction of Energy Fields	OST	Federal Council for Science and Technology	1972
	Fossil Energy Research Program of ERDA, FY1977	ERDA	ERDA	1976
	Energy Development: The Environmental Trade-offs; Volumes 2 and 4	EPA	Stanford Research Institute	1975
	A Study to Develop Energy Estimates and Merit for Selected Fuel Technologies	DOI	Development Sciences, Inc.	1975

ISSUE M: Are the ecosystem disturbances associated with cooling systems acceptable or as low as practicable?

REQUIREMENT M-4: Develop alternate coolant intake structure design features to minimize ecological effects.

130030	Protection of Aquatic Life at Power Plant Cooling Water Intakes	TVA	TVA	

General Research Not Applicable to the Above Categories:

000002	Environmental Effects of Energy Mining	DOI	Cooperative State Research Service	
013006	Puget Sound Energy Related Research Project	NOAA	NOAA	
070032	Remote (Overhead) Research Monitoring of Energy Related Developments	EPA	EPA	
054001	United States Lineaments	USGS	USGS	

CATEGORY 3 — SPECIFIC ENERGY SOURCE, NON-SPECIFIC TECHNOLOGY

ISSUE A: Will operation of the energy system result in degradation of air quality in the region?

REQUIREMENT A-2: Develop improved procedures and systems for continuous air monitoring.

NUMBER	PROJECT	MONITORING AGENCY	PERFORMING AGENCY	YEAR COMPLETED
None	Methane Analyzer System to Record Continuously the Methane Content of Coal Mine Ventilation Air (USBM-RI-8009)	USBM	M. C. Irani P. W. Jeran D. W. Lawhead	1975
None	A Continuous Recording Methanometer for Exhaust Fan Monitoring *USBM-RI-7951)	USBM	M. C. Irani, A. Tall P. W. Jeran, B. M. Bench	1975

REQUIREMENT A-4: Characterize, identify, and quantify chemical constituents of process steams, including gaseous, liquid and solid.

None	Hydrocarbon Gases Produced in a Simulated Swamp Environment (USBM-RI-7690)	USBM	A. G. Kim L. Douglas	1972
None	Methane Emission from U. S. Coal Mines - A Survey (USBM-IC-8558)	USBM	M. G. Zebetakis, M. C. Irani E. D. Thimons, T. G. Bobick, M. Deul	1972
None	Methane Emission Rate Studies in a Central Pennsylvania Mine (USBM-RI-7591)	USBM	C. Findlory S. Krickovic	1971
None	Methane Emissions from Advancing Coal Mine Section in the Pittsburgh Coalbed (USBM-RI-8132)	USBM	P. W. Jeran D. H. Lawhead, M. C. Irani	1976
None	Methane Emission from U. S. Coal Mines in 1973, A Survey - A Supplement to IC-8558 (USBM-IC-8659)	USBM	M. S. Irani P. W. Leran M. Deul	1974
E40-15203	Geologic and Geochemical Studies of the New Albany Group in Illinois	ERDA	Illinois State Geological Survey	1977
EGSP-MERC No. 1	Surface Chemistry and Spectroscopic Techniques for Characterization of Organic Constituents of Devonian Shale	ERDA	Morgantown Energy Research Ctr.	1979
None	Gas Quality and Geochemical Studies in Gas Stimulation Experiments	Lawrence Livermore Lab	Univeristy of California, Livermore Lab	1972
070181	Air and Water Problems - Oil and Gas Production	EPA	Batelle Columbus Labs	
111012	Investigate Nature and Environmental Aspects of Heavy Metals Released During Geothermal Energy Development	National Science Foundation	Batelle Northwest Lab	1977
None	Radioactive Trace Elements in Upper Devonian Clastic Rocks, North Central Pennsylvania	N/A	Rensselaer Polytechnic Inst.	1972
None	Radioactive Trace Elements in Middle and Upper Devonian Clastic Rocks, Catskill Mountain Area, New York	N/A	Rensselaer Polytechnic Inst.	1972
None	U, K and Th Concentrations in Devonian Sedimentary Rocks of the Catskill Mountain area and their Interpretation	N/A	Rensselaer Polytechnic Inst.	1971

ISSUE B: Will operation of the energy system impact the water resources of the region?

REQUIREMENT B-2: Develop improved procedures for continuous monitoring of water for pollutants.

013036	Underway Water Sampling System	NOAA	NOAA
054009	Flow Meter Study for Offshore Oil, Gas, and Mud Flow Measurement Applications	USGS	Harry Diamond Labs

REQUIREMENT B-3: Accumulate and evaluate baseline, operational, and post-operational water quality or oceanographic data around facilities and sites.

NUMBER	PROJECT	MONITORING AGENCY	PERFORMING AGENCY	YEAR COMPLETED
013008	The Summarization and Interpretation of Historical, Physical, Oceanographic and Meteorological Information for the Mid-Atlantic Region	BLM	NOAA	

REQUIREMENT B-4: Characterize, identify, and quantify the chemical constituents of the process steams, including gaseous, liquid, and solid wastes.

None	Radioactive Trace Elements in Upper Devonian Clastic Rocks, North Central Pennsylvania	N/A	Rensselaer Polytechnic Inst.	1972
None	Radioactive Trace Elements in Middle and Upper Devonian Clastic Rocks, Catskill Mountain Area, New York	N/A	Rensselaer Polytechnic Inst	1972
None	U, K and Th Concentrations in Devonian Sedimentary Rocks of the Catskill Mountain Area and their Interpretation	N/A	Rensselaer Polytechnic Inst.	1971

REQUIREMENT B-6: Model the environmental transport and fate of chemical and thermal releases to surface and subsurface waters.

013009	An environmental assessment of Northern Puget Sound and the Straits of Juan De Fuca	EPA	NOAA	
None	Agueous Polymers for Treating Clays in Oil and Gas	AIMM	American Institute of Mining	1976

REQUIREMENT B-7: Quantify the consumptive water use by research or demonstration-sized operations, and measure the perturbation of groundwater.

See Project 800110 under B-3

ISSUE D: What would be the effect on ecological systems of any deterioration of air and water quality?

REQUIREMENT D-2: Determine potential for materials to accumulate in biota.

013031	Chronic Effects of Petroelum Hydrocarbons	NOAA	National Marine Fisheries Project

Also Applicable: Project 013033 under B-5

REQUIREMENT D-4: Determine the effects of sublethal exposures to representative class compounds on organismic and population characteristics.

RPIS-6967	The Effects of Sublethal Levels of Heat and Oil on the Behavior of Aquatic Animals	ERDA	Boston University

REQUIREMENT D-7: Accumulate and evaluate baseline, operational, and post-operational ecosystem data around facilities and sites.

070181	Air and Water Problems - Oil and Gas Prod.	EPA	Battelle Columbus Labs

ISSUE E: Can land be reclaimed, and can wastes be managed in an environmentally acceptable way?

REQUIREMENT E-4: Determine the extent of subsidence or seismicity following extraction

111002	The Analysis of Subsidence Associated with Geothermal Development	National Science Foundation	Systems Control, Inc.

REQUIREMENT E-5: Determine the effects of extraction on groundwater movement.

NUMBER	PROJECT	MONITORING AGENCY	PERFORMING AGENCY	YEAR COMPLETED
None	A Mathematical Model Simulating Flow of Methane and Water in Coal (NTIS PB-209-273)	N/A		1972

REQUIREMENT E-9: Evaluate the tendency for trace contaminants in waste materials to become biologically available, and characterize significant food chain transfers.

ISSUE F: Are the risks to the occupational work force or general public acceptable?

REQUIREMENT F-1: Evaluate current measuring and monitoring technologies and develop new ones, as required.

None	Methane Analyzer System to Record Continuously the Methane Content of Coal Mine Ventilation Air (USBM-RI-8009)	USBM	M. C. Irani P. W. Jeran D. H. Lawhead	1975
None	A Continuous Recording Methanometer for Exhaust Fan Monitoring (USBM-RI-7951)	USBM	M. C. Irani, A. Tall P. W. Jeran, B. M. Bench	1975

ISSUE H: Are the socioeconomic effects associated with the development acceptable?

REQUIREMENT H-1: Assess effects of energy facilities on local planning or surrounding communities.

013068	Study of State Nearshore and Onshore Data and Information Needs Related to Outer Continental Shelf Oil and Gas Development	DOC	NOAA	1976
054008	The Impacts of the Oil and Gas Industry on the Louisiana Coast	USGS	Nichols State University Department of Geography	

REQUIREMENT H-2: Determine impact on transportation supporting energy facilities

070178	Workshop for Planners, Onshore Support of OCS Oil and Gas	EPA	USGS	

REQUIREMENT H-3: Estimate the impact of the fuel cycle on present and future energy supplies and demand.

E(40-1)	Characterization and Evaluation of the Devonian Shales in West Virginia	ERDA	West Virginia Geological Survey	1977
E(40-1)	Analysis of Structural Geological Parameters that Influence Gas Production from the Devonian Shale of the Appalachian Basin	ERDA	West Virginia Geological Survey	1977
EY-76-C-05-5196	Evaluation of the Chattanooga Shale in the Tennessee Valley and Ridge for Natural Gas and Uranium	ERDA	Tennessee Dept. of Conservation Division of Geology	1977
E(49-13) 2287	Geological, Geochemical, and Geophysical Appraisal of Energy Resources of the Devonian Black Shale in the Appalachian Basin	ERDA	U. S. Geological Survey	1977
E(40-1) 5201	Energy Resources of the Devonian Shale in the Appalachian Basin	ERDA	University of Cincinnati	1977
None	Assessment of Enhanced Recovery Technology as a Means for Increasing Natural Gas Recovery in Texas	NSF	Texas Governor's Energy Advisory Council	1974

REQUIREMENT H-3: (Continued)

NUMBER	PROJECT	MONITORING AGENCY	PERFORMING AGENCY	YEAR COMPLETED
None	Planning Criteria Relative to a National RDT and E Program Directed to the Enhanced Recovery of Crude Oil and Natural Gas	N/A	Gulf Universities Research Consortium	1973
E40-15206	Characterization and Hydrocarbon Resource Appraisal of Middle and Upper Devonian Black Shales in N.Y. State	ERDA	University of New York, Regeants Research Fund Geological Survey	1977
None	Determining Cleat Orientation of Deeper Coalbeds from Overlying Coals (USBM-RI-8116)	USBM	C.M. McCullough, S.W. Lambert J.R. White	1976
None	Use of Surface Joint and Photolinear Data for Predicting Subsurface Coal Cleat Oreintation (USBM-RI-8120)	USBM	B. M. Bench W.P. Diamond, C.M. McCullough	1976
None	Cleat in Bituminous Coalbeds (USBM-RI-7910)	USBM	C.M. McCullough, M. Duel, P.W. Jeran	1974
None	Degasification of Virgin Pittsburgh Coalbeds through a Large Borehole (USBM-RI-7800)	USBM	H.H. Fields, S. Terikovic A. Sainato M.G. Zabetakis	1973
None	Commercial Quality Gas from a Multi-purpose Borehole Located in the Pittsburg Coalbed (USBM-RI-8025)	USBM	H.H. Fields J.H. Perry M. Deul	1975
None	Degasification and Production of Natural Gas from an Air Shaft in the Pittsburgh Coalbed (USBM-RI-8173)	USBM	H.H. Fields J. Cervik T.W. Goodman	1976
None	Methane in the Pittsburgh Coalbed, Washington County, Pa. (USBM-RI-7969)	USBM	A.G. Kim	1974
None	Methane in the Pittsburgh Coalbed, Green County, Pa. (USBM-RI-8026)	USBM	A.G. Kim	1975
None	Measuring the Methane Content of Bituminous Coalbeds (USBM-RI-8043)	USBM	C.M. McCullough, J.R. Levine F.N. Kissell, M. Deul	1975
None	Methane Gas Content of the Mary Lee Group of Coalbeds, Jefferson, Tuscaloosa, and Walkar Counties, Alabama (USBM-RI-8117)	USBM	F.N. Kissell C.H. Eldor C.M. McCullough	1973

REQUIREMENT H-7: Develop criteria and evaluate the national and regional requirement for capital and investment and social impact.

None	Planning Criteria Relative to a National RDT and E Program Directed to the Enhanced Recovery of Crude Oil and Natural Gas	GURC	Gulf Universities Research Consortium	1973

ISSUE I: Are proposed facilities in compliance with standards and regulations and NEPA?

REQUIREMENT I-1: Prepare Environmental Impact Assessments or EIS documents.

100009	Preparation of Site Specific Environmental Impact Analyses	FEA	Energy and Environmental Analysis, Inc.	

REQUIREMENT I-5: Assemble information and establish standards.

NUMBER	PROJECT	MONITORING AGENCY	PERFORMING AGENCY	YEAR COMPLETED
None	Recommend Practice for Core Analysis Procedures	API	American Petroleum Institute	1960
None	Recommend Land Drilling Operating Practices for Protection of the Environment	API	American Petroleum Institute	1975
None	Environmental Protection Laws and Regulations Related to Exploration, Drilling, Production and Gas Processing Plant Operations	API	American Petroleum Institute	1975

ISSUE J: Are there adequate environmental controls?

REQUIREMENT J-1: Assess the atmospheric emission and particle control needs

None	The Direct Method of Determining Methane Content of Coalbeds for Ventilation Design (USBM-RI-7767)	USBM	F. N. Kissell C. M. McCullough C. H. Eldor	1973
None	Methane Control in U. S. Coal Mines (1972) (USBM-IC-8600)	USBM	M. G. Zabetakism, M. Deul, M. L. Skow	1973

REQUIREMENT J-2: Evaluate the effectiveness of liquid and solid waste treatment, (contaminated water cleanup) management and disposal procedures.

None	Methane Control in United States Coal Mines - 1972 (USBM-IC-8600)	USBM	M. G. Zabetakis M. Duel	1973
070251	Pilot Scale Evaluation of Advanced Combustion Control Technology for Fossil and Waste Fuels	EPA	Acurex, Corp.	

REQUIREMENT J-4: Develop systems and guidelines for management and control of wastes or discharges and noise, radiation, odor, etc.

None	Methane Control in U. S. Coal Mines (1972) (USBM-IC-8600)	USBM	M. G. Zabetakis, M. Deul, M. L. Skow	1973
051021	Assessment of Oil and Gas Development on Federal Refuges Along the Gulf Coast	DOI	Research Planning Consultants	
None	Recommend Practice for Laboratory Testing of Surface Active Agents for Well Simulation	API	American Petroleum Institute	1977

REQUIREMENT J-5: Develop safety guidelines for extraction processing, storage and transport of fuels.

None	Methane Control in United States Coal Mines - 1972 (USBM-IC-8600)	USBM	M. G. Zebetakis, M. Deul, M. L. Skow	1973

CATEGORY 4 — SPECIFIC TECHNOLOGY

ISSUE A: Will operation of the energy system result in degradation of air quality in the region?

REQUIREMENT A-4: Characterize, identify and quantify chemical constituents of process streams, including gaseous, liquid and solid wastes.

070296	Geothermal Systems Environmental Assessment of Extraction, Conversion and Waste Disposal	EPA	EPA	1977
094033	Control of Hydrogen Sulfide Emission from Geothermal Power Plants	ERDA	EIC, Inc.	1977

REQUIREMENT B-5: Characterize the chemical and microbiological transformations of liquids and solids released to soil and water.

See Project 070296 under A-2.

ISSUE F: Are the risks to the occupational work force or general public acceptable?

REQUIREMENT F-1: Evaluate current measuring and monitoring systems and develop new systems, as required.

NUMBER	PROJECT	MONITORING AGENCY	PERFORMING AGENCY	YEAR COMPLETED
—	Safe Practices in Oil or Gas Drilling	—	American Petroleum Institute	1964
—	Safe Practices in Drilling Operations	—	American Petroleum Institute	1967

REQUIREMENT F-9: Conduct site, safety, quality assurance, and industrial hygiene surveys and assessments.

E (46-1) 8042	Systems Studies of Energy Conservation: Methane Produced from Coalbeds	Morgantown Energy Research Center	TRW Energy Systems Group	1977

ISSUE G: Are the hazards associated with processing, transfer, storage, or end-use of energy sources acceptable?

REQUIREMENT G-3: Assess the potential health and environmental hazards associated with storage, utilization and transfer of energy sources or processes.

See Project E (46-1) 8042 under F-9.

ISSUE J: Are there adequate environmental controls?

REQUIREMENT J-1: Assess the atmospheric emission and particle control needs.

See Projects 070296 and 094033 under A-2.

REQUIREMENT J-2: Evaluate the effectiveness of liquid and solid waste treatment, (Contaminated water cleanup) management and disposal procedures. See Project 070296 under A-2.

CATEGORY 5 — SPECIFIC SUB-TECHNOLOGIES

No applicable projects under Issues A through M.

CATEGORY 6 — SITE SPECIFIC PROJECTS

ISSUE A: Will operation of the energy system result in degradation of air quality in the region?

REQUIREMENT A-1: Assess current information on air quality.

EY-77-C-21-8078	Environmental Impact Assessment for the Proposed MERC-1 Gas Well to be Drilled at the Morgantown Energy Research Center, Morgantown, West Virginia	ERDA-	SAI	1977

APPENDIX C

LOGISTICS OF THE ENVIRONMENTAL ACTION PLAN

The organization of the Environmental Action Plan was discussed in Section 4.4. In the Appendix at hand, specific tasks are coded by complexes of three digits. The first digit refers to the sub-program encompassing the task, the second digit indicates the project incorporating the task, and the third digit states the rank of the task within its project. Separate discussion is given for each project (two-digit entries of milestone Table 4-1). The discussion includes: Project Objective, Background and Significance, Technical Approach, and Schedule. The Project Objective cites the overall goals of the project, which may be stated as a paraphrase of the title of the project, in a more elaborate fashion. The Background and Significance provides the rationale which led to the conception of the project as a vital environmental compliance activity. It also states the interrelations of the project with other vital ERDA activities and indicates the significance of the project for the environmental acceptance of the technical EGR program. The Technical Approach presents the tools of analysis, scientific methodologies, systematic bodies of knowledge, etc., which will be utilized for the achievement of the project objectives. These means of technical performance are grouped into specific project tasks (three-digit entries). The Schedule of the project elaborates on the information presented in the milestone Table 4-1, usually by specifying the duration of each specific task of the project.

The proposed tasks in this Appendix are potential projects. Decisions such as if and when they are to be initiated will be made as the need arises.

1. AIR QUALITY RESEARCH

PROJECT 1.1 BASELINE DATA ACQUISITION

OBJECTIVE: *To develop a comprehensive ambient air quality data base for EGR development.*

BACKGROUND AND SIGNIFICANCE:

A comprehensive air quality data base is necessary: 1) to determine air quality prior to EGR operations; 2) to assess compliance with air quality legislation; 3) to determine air quality control equipment requirements. Baseline data are needed to correlate EGR-related emissions and air quality impacts. Baseline data are currently being collected by EPA, by divisions within ERDA which are studying coal and oil shale, by state and local agencies, and by some universities. Baseline data collection may be necessary to fill gaps in the existing data base.

TECHNICAL APPROACH:

1.1.1 Compile and review existing air quality data. Assess the need for additional data. Determine the status of air quality at EGR sites prior to EGR operations. Assess the maximum allowable emission of pollutants for EGR operations. (A-1, A-3)

1.1.2 Initiate studies to acquire data missing from existing data base. Where baseline data are unavailable, determine concentrations at EGR sites prior to operations. (A-3, J-1)

SCHEDULE:

Intermittent; 6 months per each new site.

PROJECT 1.2 DETERMINATION OF EMISSIONS FROM CONSTRUCTION AND OPERATION ACTIVITIES

OBJECTIVE: *To characterize and quantify emissions from EGR construction, drilling and maintenance equipment and activities; and to develop controls for these emissions prior to extensive EGR development to minimize environmental impacts.*

BACKGROUND AND SIGNIFICANCE:

In order to determine the air quality impacts caused by construction, drilling and maintenance activities, data on air emissions due to activities such as solid waste combustion, operation of diesel-powered equipment, etc., are needed. Potential adverse impacts include noncompliance with air quality regulations, damage to EGR work force, and changes in the ecosystems dynamics.

TECHNICAL APPROACH:

1.2.1 Determine allowable emission rates for construction and operational equipment (A-1, A-3, A-4, J-1)

1.2.2 Compile data concerning emissions from site clearing, drilling, and access road construction activities. Evaluate the need for procedural changes. If necessary, recommend mitigation measures.

SCHEDULE:

Initiate and complete in FY 1979.

PROJECT 1.3 CHARACTERIZATION AND QUANTIFICATION OF EMISSIONS DUE TO STIMULATION AND PRODUCTION OPERATIONS

OBJECTIVE: *To quantify emissions produced during stimulation and production activities; to characterize gases released by the chemical explosive fracturing process; and to predict, on a site-specific basis, impacts due to gas emissions from production operations.*

BACKGROUND AND SIGNIFICANCE:

Emissions from stimulation and production activities will depend upon the characteristics of the gas which is being extracted. Emissions from the CEF process have not been characterized. This information must be obtained before site-specific air quality impacts can be predicted as part of EIA or EIS preparation.

TECHNICAL APPROACH:

1.3.1 At selected sites, perform tests to quantify emissions during production operations. Extrapolate data for use at other sites. (A-3, A-4, J-1)

1.3.2 At selected sites, characterize and quantify emissions during CEF stimulation operations. (A-3, A-4, J-1)

SCHEDULE:

Intermittent; 1 year per each new site. Initiate project in FY 1979 and continue as necessary.

2. WATER RESOURCES RESEARCH

PROJECT 2.1 IDENTIFY THE POTENTIAL WATER QUALITY IMPACTS DUE TO SITE PREPARATION AND DRILLING OPERATIONS AS PART OF THE NEPA PROCESS

OBJECTIVE: *Identification of potential water quality impacts associated with site preparation and drilling operations for input into documents required by NEPA.*

BACKGROUND AND SIGNIFICANCE:

NEPA, PL 94-83, requires that environmental impact assessments be performed on major projects associated with Federal funds. As part of this assessment for EGR operations, the potential water quality impacts need to be determined.

TECHNICAL APPROACH:

2.1.1 Develop a means of estimating site-specific water quality impacts caused by soil erosion and siltation due to site preparation activities. (B-4, D-10, E-11, J-4)

2.1.2 Review current procedures for handling and disposing of liquid and solid waste. If necessary, develop and initiate improved waste handling and disposal procedures to minimize adverse water quality impacts. (B-3, B-4)

SCHEDULE:

Task	Initiate	Complete
2.1.1	FY 1979	Perform as necessary
2.1.2	FY 1979	FY 1980

PROJECT 2.2 CHARACTERIZE, IDENTIFY AND QUANTIFY THE CHEMICAL CONSTITUENTS OF FRACTURE FLUIDS

OBJECTIVE: *Identification of environmental impacts that may be caused by the use of fracture fluids.*

BACKGROUND AND SIGNIFICANCE:

Upon completion of the fracturing process, the well will be producing and a portion or all of the fracturing fluids will flow back. This effluent will contain the spent fracture fluids, formation water (which can be saline and can contain heavy metals or other trace elements), and hydrocarbons. The composition of fracture fluids will be site specific. Improper disposal of this effluent can pollute surface and subsurface water bodies.

TECHNICAL APPROACH:

2.2.1 Conduct testing of fracture fluids at selected sites to identify any trace elements, gases, or heavy metals that may be present after contact with geologic formations, and determine the potential water quality degradation if accidental spills or leaks occur. (B-4, D-10)

2.2.2 Under controlled conditions, determine rates of degradation of fracture fluid components. (B-5, E-9, E-10, J-2, J-8)

SCHEDULE:

Both tasks should be initiated in FY 1979 and completed in FY 1980.

PROJECT 2.3 DETERMINE POTENTIAL IMPACTS FROM BRINE AND THERMAL DISCHARGES

OBJECTIVE: *To assess possible impacts due to thermal and brine discharges involved in EGR processes utilized in geopressured reservoirs.*

BACKGROUND AND SIGNIFICANCE:

In the case of methane recovery from geopressured reservoirs, the composition of the geopressured fluids varies from relatively fresh to highly saline waters and may vary in temperature from about 175° to 325°F. Even after the extraction of thermal energy and methane, the water is still at sufficiently high temperatures to

cause thermal pollution if discharged into surface bodies of water. This needs to be cooled before surface discharge or underground disposal through injection wells. The effects of such discharges on surface or subsurface waters are relatively unknown and the applicability of available disposal methods to EGR processes has not been quantified.

TECHNICAL APPROACH:

2.3.1 Conduct studies to determine the salinity of brine from geopressured wells and assess the water quality impacts of releasing this brine in surface water or injecting it into subsurface geologic formations. (B-4, B-6, E-7, E-9, J-2, J-4, J-7, J-8)

2.3.2 Characterize the potential thermal effluents from geopressured production processes and assess the water quality impacts. (B-6, J-2, J-7, J-8)

2.3.3 Collect existing research data dealing with techniques of disposal for hot saline water and initiate research as needed. (E-7, J-2, J-4, J-6, J-7, J-8)

SCHEDULE:

In FY 1980, decide whether to initiate project based on environmental assessments. If project is initiated in FY 1980, complete in FY 1981.

3. GEOLOGIC AND LAND USE RESEARCH

PROJECT 3.1 DETERMINE THE EXTENT OF SUBSIDENCE AND SEISMICITY CAUSED BY GEOPRESSURED METHANE PRODUCTION

OBJECTIVE: *To determine the potential for subsidence and seismic activities induced by stimulation and extraction operations, and to implement a system for detecting and measuring these geologic events, during geopressured methane production.*

BACKGROUND AND SIGNIFICANCE:

Fluid production may redistribute the stresses in the reservoir rock. A stress redistribution could result in movement of rock along zones of weakness. This movement may be minor adjustment confined to the sursurface or it may involve surface movement. Depending on the amount, surface movement could result in surface structure damage and pose safety hazards. Gas extraction and other subsurface fluid removal may result in subsidence. If subsidence reaches the surface, localized hazards similar to seismic events can result.

TECHNICAL APPROACH:

3.1.1 Conduct ground elevation surveys before and after production of gas at geopressured methane development sites. Correlate results with geologic conditions (structure, stratigraphy, etc.), engineering design (depth of hole, size of charge, etc.), and gas production rates.

3.1.2 Conduct seismic studies at geopressured methane EGR sties with a history of seismic events.

SCHEDULE:

The Division of Geothermal Energy will be performing subsidence research.

4. ECOLOGICAL RESEARCH

PROJECT 4.1 PREDICT AND MITIGATE THE IMPACTS OF SITE DEVELOPMENT ON ECOSYSTEM PRODUCTIVITY AND POPULATION DYNAMICS

OBJECTIVE: *To predict, prevent, and/or mitigate, on a site-specific basis, impacts to species and ecosystems which would result from the EGR development process.*

BACKGROUND AND SIGNIFICANCE:

Impacts to species and ecosystems are highly variable and are usually dependent upon primary impacts such as air, water and noise pollution and alteration in habitat. For EGR development, these parameters will be dependent upon project size, EGR technology, phase of the energy cycle and locations of activity. Baseline data need to be collected, primary impacts must be predicted and the effect of these impacts on ecosystem dynamics must be analyzed.

TECHNICAL APPROACH:

4.1.1 As part of the EIA or EIS process, evaluate potential impacts to species and ecosystems using predictions of water, air and noise impacts; and by evaluating the extent of site clearing and effectiveness of restoration proposals. Predict emigration; alteration in reproductive behavior (e.g., nesting and spawning); and alteration in growth patterns or alterations in species distribution or diversity (e.g., population changes to the disposal of thermal or saline effluents). (D-7, E-6, I-1)

4.1.2 As part of the EIA or EIS process, predict impacts to rare or endangered species. Contact local authorities, consult *Federal Register* make site surveys if necessary. (E-6)

SCHEDULE:

Perform both tasks intermittently; allow 6 months to 1 year per each selected site.

5. HEALTH AND SAFETY RESEARCH

PROJECT 5.1 DETERMINE THE RISK OF GEOTHERMAL HEAT SCALDS AND INJURY FROM BLOWOUTS

OBJECTIVE: *To determine the risk of sustaining steam burns while working with EGR resources having high steam content and of blowouts during drilling of geopressured gas wells.*

BACKGROUND AND SIGNIFICANCE:

Geopressured methane reservoirs offer a major chance of exposure to high pressure, high temperature steam with possible resulting burns. Conditions where such exposure might occur need to be determined and procedures devised for handling any resulting emergency. For high risk areas, appropriate control technology will need to be evaluated and implemented. The reservoirs should be mapped and measured for areas of existing high pressure and areas where pressure buildup and/or blowouts could occur.

TECHNICAL APPROACH:

5.1.1 Make temperature and pressure measurements of geopressured reservoirs at selected sites. (F-3, F-5, F-9)

5.1.2 Study the need and feasibility of having workers wear protective clothing when working in areas of scald and blowout potential. (F-6)

SCHEDULE:

Initiate and complete both tasks in FY 1980.

6. SOCIOECONOMIC RESEARCH

PROJECT 6.1 ASSESS THE SOCIOECONOMIC COST OF GAS SHORTAGES

OBJECTIVE: *To determine the importance of the gas produced by EGR and to aid in the management of EGR operations during gas shortages.*

BAKCGROUND AND SIGNIFICANCE:

The quantity of gas supplies has become an issue of increasing importance. The unavailability of gas may have a variety of social and economic impacts which may include increased unemployment, increased cost of goods and services that require gas, personal hardship to persons using gas for space heating. An assessment of the socioeconomic impacts of a gas shortage is a very valuable planning tool.

TECHNICAL APPROACH:

Assess current information on gas supplies, fossil fuel supplies, and the total energy availability. Review the past, present and the expected future utilization of gas. Conduct a study to determine the effect of gas shortages on social and economic systems. Using the results of the study, recommend procedures for responding to gas shortages in a way that the effect, if any, on EGR operations will be minimal.

PROJECT 6.2 EVALUATE NUISANCE AND IRRITANT FACTORS FROM NOISE IMPACTS

OBJECTIVE: *To determine which EGR operations may precipitate adverse community reaction due to noise and evaluate mitigation measures.*

BACKGROUND AND SIGNIFICANCE:

EGR operations will produce noise at levels that are site specific. The impact of the noise on socioeconomic conditions will depend heavily on such factors as the characteristics of the noise produced, the surface geography, the location and type of facilities that may be affected, background noise levels, etc. Adverse changes in noise characteristics could cause adverse community reactions potentially causing project delays, changes in equipment, and other undesireable effects.

TECHNICAL APPROACH:

Collect noise data from selected EGR sites. Develop criteria for project operations based on EGR operations and noise impacts. Investigate the need for improvement in noise control procedures and methods. Assess noise impacts on nearby communities and review community reactions to adverse changes in noise characteristics.

SCHEDULE:

Initiate in FY 1980. Conduct project review at end of first year. Continue study as needed.

APPENDIX D

GENERIC LIST OF ENVIRONMENTAL ISSUES AND REQUIREMENTS RELATED TO ENERGY DEVELOPMENT

This Appendix contains a generic list of issues and requirements related to energy technology. This list was used in part to prepare the tables in Section 3 dealing with the issues, requirements and tasks relevant to ERDA's Enhanced Gas Recovery (EGR) program. Those requirements and tasks listed in Section 3 are cross-referenced to the generic list by the alphanumeric code used in this Appendix. Only those tasks that were considered applicable to EGR technology were used.

Issue A: *Will operation of the energy system result in degradation of air quality in the region?*

- A-1 Assess current information on air quality
- A-2 Develop improved procedures and systems for continuous air monitoring
- • A-3 Accumulate and evaluate baseline, operational, and post-operational air quality data around facilities and sites
- • A-4 Characterize, identify, and quantify *chemical* constituents of process streams, including gaseous, liquid and solid wastes
- • A-5 Characterize chemical transformation of atmospheric releases and atmospheric cleansing processes
- A-6 Improve atmospheric transport and dispersion *models* to predict dose to man and ecosystems
- A-7 Provide a capability for response to major accidental releases

• Site- or process-specific work

Issue B: *Will operation of the energy system impact the water resources of the region?*

- B-1 Characterize and assess current information on surface and subsurface water resources and adequacy of the water supply
- B-2 Develop improved procedures for continuous monitoring of water for pollutants
- • B-3 Accumulate and evaluate baseline, operational, and post-operational water quality or oceanographic data around facilities and sites
- • B-4 Characterize, identify, and quantify the chemical constituents of the process streams, including gaseous, liquid, and solid wastes
- • B-5 Characterize the chemical and microbiological transformations of liquids and solids released to soil or water
- • B-6 Model the environmental transport and fate of chemical and thermal releases to surface and subsurface waters to predict dose to man and ecosystems
- • B-7 Quantify the consumptive water use by research or demonstration-sized operations, and measure the perturbation of ground water

• Site- or process-specific work

Issue C: *What would be the effect on man of any deterioration of air and water quality?*

- **C-1** Screen samples of emissions and effluents for biological effects
- **C-2** Conduct secondary biological screening in animals and plants
- **C-3** Conduct acute and subacute effects studies with chemical or physical agents
- **C-4** Conduct inhalation, ingestion and dermal exposure studies
- **C-5** Conduct reproductive, carcinogenicity, teratogenicity and mutagenicity studies
- **C-6** Define the cellular and molecular mechanisms for biological damage
- **C-7** Conduct metabolic and dose distribution studies
- **C-8** Conduct base-line characterization studies of tissues, cells and molecules most sensitive to energy-related pollutants
- **C-9** Define the potential for carcinogenic and synergistic interaction of pollutants with other environmental stresses
- **C-10** Improve bioassay systems, instruments, and methods for risk assessment
- **C-11** Validate the use of cell screening systems to predict carcinogenicity and mutagenicity in man and develop predictive models

- Site- or process-specific work

Issue D: *What would be the effect on ecological systems of any deterioration of air and water quality?*

- **D-1** Screen samples of emissions and effluents for acute toxicity to standard species
- **D-2** Determine potential for materials to accumulate in biota
- **D-3** Screen pre- and post-treatment effluents and fractions for acute toxicity to species indigenous to development sites
- **D-4** Determine the effects of sublethal exposures to representative class compounds on organismic and population characteristics
- **D-5** Determine the effects of key contaminants on functional aspects of model ecosystems
- **D-6** Evaluate changes in community structure and monitor for signs of toxicity in receiving waters associated with operating facilities
- **D-7** Accumulate and evaluate baseline, operational, and post-operational ecosystem data around facilities and sites
- **D-8** Evaluate ecosystems exposed to naturally occurring pollutants
- **D-9** Develop rapid identification of effects on ecosystems
- **D-10** Evaluate ecological impact of runoff and drainage from affected areas

- Site- or process-specific work

Issue E: *Can land be reclaimed, and can wastes by managed in an environmentally acceptable way?*

- **E-1** Provide a collection of plant materials and technologies for use in reclamation of landscapes
- **E-2** Develop techniques for reestablishment of disturbed sites
- **E-3** Determine the recovery time for reclaimed landscapes
- **E-4** Determine the extent of subsidence or seismicity following extraction
- **E-5** Determine the effects of extraction on ground water movement
- **E-6** Accumulate baseline, operational, and post-operational ecological data
- **E-7** Evaluate procedures for management of liquid wastes
- **E-8** Evaluate procedures for management of solid wastes
- **E-9** Evaluate the tendency for trace contaminants in waste materials to become biologically available and characterize significant food chain transfers
- **E-10** Characterize chemical and microbiological transformations of organic residuals which enter the environment
- **E-11** Determine and evaluate the effects of landscape alterations on the structure of the watershed, including waterflow and quality, and on other affected areas.

Issue F: *Are the risks to the occupational work force or general public acceptable?*

- **F-1** Evaluate current measuring and monitoring systems and develop new systems, as required
- **F-2** Evaluate current individual dose monitoring systems and develop new systems, as required
- ● **F-3** Design and implement a program to evaluate health and safety risks
- ● **F-4** Evaluate physiological effects of pollutants
- ● **F-5** Develop risk estimates for exposure
- **F-6** Develop protection and decontamination procedures and guidelines for accidental and routine exposure
- ● **F-7** Assess data from biological screening and toxicity studies for application to industrial hygiene and public health
- ● **F-8** Conduct epidemiology studies
- ● **F-9** Conduct site, safety, quality assurance, and industrial hygiene surveys and assessments
- **F-10** Evaluate physiological stress of workers and need for improved occupational guidelines

● Site- or process-specific work

Issue G: *Are the hazards associated with processing, transfer, storage, or end-use of energy sources acceptable?*

- **G-1** Characterize, identify, and quantify the chemical constituents in the volatile fractions and the combustion products
- **G-2** Evaluate the toxic properties of products
- **G-3** Assess the potential health and environmental hazards associated with storage, utilization and transfer of energy sources or processes
- **G-4** Assess the need for and, if necessary, develop treatment for accidental and routine exposures

- Site- and process-specific work

Issue H: *Are the socioeconomic effects associated with the development acceptable?*

- **H-1** Assess effects of energy facilities on local planning or surrounding communities
- **H-2** Determine impact on transportation supporting energy facilities
- **H-3** Estimate the impact of the fuel cycle on present future energy supplies and demand
- **H-4** Develop methods for measurement and comparison of aesthetic values
- **H-5** Evaluate nusiance and irritant factors such as noise and odor
- **H-6** Assess manpower and training needs
- **H-7** Develop criteria and evaluate the national and regional requirement for capital and investment and social impact
- **H-8** Develop criteria and evaluate local requirements for resources, capital requirements, labor and community support facilities

- Site- and process-specific work

Issue I: *Are proposed facilities in compliance with standards and regulations?*

- **I-1** Prepare Environmental Impact Assessments or EIS documents
- **I-2** Determine compliance with and obtain necessary air, water, land use and waste disposal permits
- **I-3** Evaluate land management regulations and practices and determine effect on development
- **I-4** Assess the need for new standards
- **I-5** Assemble information and establish standards
- **I-6** Assure quality and reliability of design, construction, operation, and maintenance activities; plan and conduct tests to verify compliance

- Site- and process-specific work

Issue J: *Are there adequate environmental controls?*

- **J-1** Assess the atmospheric emission and particle control needs
- **J-2** Evaluate the effectiveness of liquid and solid waste treatment (contaminated water cleanup) management and disposal procedures
- **J-3** Determine end-use environmental control technology requirements
- **J-4** Develop systems and guidelines for management and control of wastes or discharges and noise, radiation, odor, etc.
- **J-5** Develop safety guidelines for extraction processing, storage and transport of fuels
- **J-6** Evaluate uses of wastes as alternatives for disposal
- **J-7** Compare feasibility, cost, and impact of environmental control options
- **J-8** Evaluate methods for controlling or managing wastes or discharges and noise, radiation, odor, etc.

- Site- and process-specific work

Issue K: *What is the significance and what are the applications of the environmental health and safety related work?*

- ● **K-1** Integrate information, model impacts, identify gaps or perform sensitivity analyses
- **K-2** Prepare plans and research schedules for EDPs, integrated assessments, etc.
- **K-3** Perform plans and surveys for site selection and decommissioning
- **K-4** Systemize data and information
- **K-5** Evaluate natural resource impacts and tradeoffs
- **K-6** Perform cost/benefit analyses
- **K-7** Conduct integrated assessments of issues and potential constraints
- **K-8** Compare energy scenarios for their overall environmental impact
- **K-9** Assess findings for application, or transfer to technologists
- **K-10** Develop and recommend energy policy options

● Site- and process-specific work

Issue L: *Will adverse ecological and climatological effects result from increases in the atmospheric concentrations of CO_2?*

- **L-1** Quantify the relative contribution of fossil fuel combustion to the global CO_2 budget
- **L-2** Development of atmospheric models to assess effects on climate from increased CO_2 levels
- **L-3** Development of models of CO_2 cycling
- **L-4** Development of models to relate atmospheric concentrations of CO_2 to changes in primary productivity and other ecological effects
- **L-5** Perform observations and experiments to validate models
- **L-6** Develop strategies or technological fixes for reducing impacts
- **L-7** Define socioeconomic impacts which result from global CO_2 effects

Issue M: *Are the ecosystem disturbances associated with cooling systems acceptable or as low as practicable?*
M-1 Develop validated models of impacts on populations of organisms
M-2 Characterize the chemical releases and their effects
M-3 Evaluate the effects of alternative biocides and anti-corrosion agents
M-4 Develop alternate coolant intake structure design features to minimize ecological and health effects
M-5 Determine Effects of physical impacts and chemical releases on weather and climate
M-6 Plan and conduct tests to verify compliance with design criteria

APPENDIX E

LIST OF ACRONYMS

AES	Assistant Administrator for Environment and Safety
AES/TO	Assistant Administrator for Environment and Safety/ Technology Overview
AFE	Assistant Administrator for Fossil Energy
AFE/ESP	Assistant Administrator for Fossil Energy/Environment and Socioeconomic Programs
AHF	Advanced Hydraulic Fracturing
AIMM	American Institute of Mining and Metallurgy
API	American Petroleum Institute
BACT	Best Available Control Technology
BCF/D	Billion cubic feet per day
BERC	Bartlesville Energy Research Center
BLM	Bureau of Land Management
CE	Chemical Explosives
CEF	Chemical Explosive Fracturing
CDW	Conventionally Drilled Wells
CW	Conventional Wells
DEIS	Draft Environmental Impact Statement
DDW	Directionally Drilled Wells
DOI	Department of the Interior
DW	Deviated Wells
EDP	Environmental Development Plan
EGR	Enhanced Gas Recovery
EGSP	Eastern Gas Shales Program
EIA	Environmental Impact Assessment

EIS	Environmental Impact Statement
EOC	Environmental Overview Committee
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ERDA	Energy Research and Development Administration
FEA	Federal Energy Administration
FF	Foam Fracturing
FWS	Fish and Wildlife Service
GPA	Geopressured Aquifer
Geo. Meth.	Geopressured Methane Program
GURC	Gulf Universities Research Consortium
HARB	Horizontal Adit with Radiating Boreholes
IAD	Immediate Action Directive
KCl	Potassium chloride
KF	Keil Fracturing
LNG	Liquefied Natural Gas
MERC	Morgantown Energy Research Center
MHF	Massive Hydraulic Fracturing
NBS	National Bureau of Standards
NCI	National Cancer Institute
ND	Negative declaration
NEPA	National Environmental Policy Act
NHF	Normal Hydraulic Fracturing
NIEHS	National Institute of Environmental Health and Safety

NIOSH	National Institute of Occupational Safety and Health
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NSPS	New Sources Performance Standards
OGST	Division of Oil and Gas Shale Technology
OSHA	Occupational Safety and Health Administration
PNG	Petroleum and Natural Gas Program
R&D	Research and Development
RDT&E	Research, Development, Test and Evaluation
SAI	Science Applications, Inc.
TCF	Trillion Cubic Feet
TVA	Tennessee Valley Authority
USBM	U. S. Bureau of Mines
USGS	U. S. Geological Survey
VSHB	Vertical Shaft with Horizontal Boreholes
WGSP	Western Gas Sands Program
WRC	Water Regulatory Commission

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