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CORING AND LOGGING PLAN
EASTERN GAS SHALES PROJECT

MARCH 1977

Prepared by

TRW
ENERGY SYSTEMS PLANNING DIVISION
McLEAN, VIRGINIA 22101

PREPARED FOR THE UNITED STATES
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Patrick S. Kujawa - Management Planning

Sarwar Mahmud - Technical Report and Analysis

In addition, the efforts and data provided by the following ERDA professionals are also gratefully appreciated:

William K. Overbey, Jr. - Project Manager

Arlen D. Hunt - Assistant Project Manager

G. Rennick

C. Byrer

J. Kovack

G. Schott

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1.0 INTRODUCTION

The Coring and Logging Plan (CLP) is a device to implement parts of the field operations, physical characterization and geochemical characterization work packages of the Eastern Gas Shales Project. The Eastern Gas Shales Project (EGSP) is a multi-year project initiated by the U.S. Energy Research and Development Administration (ERDA) to stimulate natural gas production in the Eastern Petroliferous Basins. The specific orientation of the project is toward determining the gas reserves within the Devonian shale, thoroughly characterizing the shale, and advancing the technology of gas exploration and production.

In order to implement this project, it is necessary to carry out an extensive program to characterize the shale and determine the specific parameters that affect gas accumulation and migration. The strategy of analysis is to systematically take cores throughout the three areas of interest; that is, the Appalachian, Michigan and Illinois Basins. These cores will be taken first in conjunction with wells which various gas companies will be drilling in the basins under a cooperative funding arrangement. Later on in the project, a number of wholly ERDA-funded cores will be taken, especially in areas of exploratory interest or where government-owned land is involved. Throughout the project life, it is proposed that about 65-70 cores will be taken which will penetrate the complete stratigraphic sequence of the shale and amount to approximately 25,000 feet of core. The core will be sampled and analyzed according to the charts and procedures delineated in this document.

Subsequent to the coring of a well, a complete suite of logs will be run. For a number of such events, a special research suite will be used, whereas the remainder of the wells will be logged with the standard production suite. The log analysis will be compared with the core analysis and the correlation will be used to calibrate and interpret future well logs. This will allow a very detailed basin analysis with a comparatively small number of statistically significant cores required.

The core sites are being chosen by determining new areas of productive interest as established by gas company, state geological survey and federal government geologists knowledgeable in the respective basins, and integrating these with areas in which cores have been taken and are still available for analysis. In the near future, production base maps in each state, by county, will be available from an extensive computer file. These will be overlain with lineament maps which are being prepared from remote sensing data. Areas of high fracture probability, as indicated by lineament correlation, which have not been produced, will then be cored, logged and stimulated for production. This technique, and others like it, will be used to determine where cores should be taken to obtain maximum project information. As the program progresses, results from exploration R&D, physical and geochemical characterization, geophysical well log analysis and geological evaluations will provide many such correlations to narrow down the choice of core sites.

When a core is taken, it will be oriented, described, and sampled in the field. The Morgantown Energy Research Center (MERC) will have a representative in the field for each operation who will supervise packaging and transmittal of the various samples of core based upon a pre-planned format. Guidelines for determining the variables in the generalized format will be determined as a result of the finalization of the EGSP-Project Implementation Plan (PIP).

These, and other logistics procedures, are in a process of evolution due to the number of contractors involved in both the core retrieval and core testing aspects of the plan. Various techniques, such as stratigraphic and characterization workshops and contractors meetings, are being used to enable continued planning efforts and, at the same time, implement the project and implement technology transfer. This document, then, is an evolving plan whose purpose is to clearly define the scope of work involved in acquiring and analyzing core samples and logs of the Devonian Shale. This plan is expected to be assimilated into the PIP and assigned to various work packages. It will be updated as part of the review cycle of those work packages.

This coring and logging plan contains a work breakdown structure (WBS) which generically details the logical reduction of the various operations involved. It also contains event sequence diagrams which can be used by the respective work package managers to define and schedule the specific tasks which will implement the planned objectives. Appended to the plan are the coring and logging logistics plans and procedures for sampling, for the core physical laboratory and for the petrographic and geochemical analysis laboratory. The laboratory and sampling procedures were prepared by MERC.

2.0 WORK BREAKDOWN

This section contains the description of the elements, the subelements, and the tasks of the work breakdown structure (WBS), attached herewith (Figure 1). The initial breakdown of the coring and logging plan (CLP) is into four elements, which are: planning operations, field operations, laboratory operations, and data processing operations. Each operation consists of several subelements and each subelement comprises several tasks. A brief description of the subelements and tasks follows.

2.1 PLANNING OPERATIONS

Development and execution of the CLP requires that a comprehensive plan be formulated as the very first step. Eastern gas shales have normally been overlooked as a major gas producing horizon; hence, most oil and gas exploring operations merely have drilled through the shales and bored down to the more economically commercial oil or gas producing horizons. Hence, very little is known about these shales or their potential for gas production. The major shale basins have been mapped by individual state surveys, but minimal correlation has been made on a regional basis. Hence, planning operations form the first essential element of the CLP.

Planning operations consist of six subelements, each comprising several tasks. The subelements are coring and logging review, costing, environmental assessment, site selection, contracts, and logistics. The tasks within these subelements are described below.

2.1.1 Coring and Logging Review

This subelement consists of the four tasks defined below.

1. Data Analysis and Evaluation - In order to initiate a formal work plan, the existing data must first be analyzed and evaluated. This would include an extensive and comprehensive literature search, accompanied by a collection of existing well logs and previous drilling data. From such data, preliminary stratigraphic and structural cross-sections and correlations will be developed. Such regional correlation maps will help to define areas where only insufficient data are available and also will highlight areas needing higher R&D efforts. At the same time, correlation of structural patterns already mapped, with the lineaments revealed by analysis of remote-sensing imagery and their relationship to gas producing regions, will identify the regions to be addressed by the ERDA plans. Only after development of the regional data mentioned above can ERDA prepare its future drilling and coring plans. This task is most important and could be quite time-consuming.

Pending completion of this effort, ERDA can initiate coring and logging plans only on a cooperative basis with industry's drilling plans. Hence, it is important to acquire such plans well in advance of their implementation.

2. New Data Requirements - Evaluation of existing data and comparison with its proposed objectives will enable ERDA to establish criteria for the data it wishes to obtain. Basically, this subtask will identify such data and also establish the criteria for selection of future drilling sites. As the final objective is to determine quantity and extent of the resources, the new data requirements will be tailored towards obtaining such information.

3. Coring, Logging, and Testing Specifications - Having determined the data requirements, it becomes necessary to develop specifications for coring, logging and testing the shales. These specifications should be almost equally applicable to both the cooperative as well as the fully-funded ERDA programs. The specifications in some cases may be modified in accordance with varying site conditions.

In the case of cooperative programs, where ERDA funds only the coring, logging and testing elements, specific guidelines will be developed to enable the drilling program to proceed in a manner compatible with both ERDA requirements and operator's objectives. On the other hand, drilling specifications also must be established for the fully-funded ERDA wells. The best possible coordination must be achieved in order to optimize the end results.

Coring specifications will detail the type, lengths and depths of coring during each run for each hole, and may vary with the hole location. However, the samples and tests to be executed on core samples can be more specifically defined. The testing program will cover all elements of geological, physical, and chemical analysis necessary to comprehensively characterize the shale and determine the available and recoverable resources. Both commercial and research type well logging techniques will be specified and should be conducted.

4. Preliminary Site Selection - On the basis of analysis and evaluation of the existing data, and in conjunction with the proposed industry drilling plans, tentative sites should be selected and defined. Preliminary selections then may be modified in accordance with the environmental impact factors and cost elements or any other important considerations. Suitable alternatives should be identified and properly evaluated.

2.1.2 Costing

This subelement also consists of four tasks identified as follows.

1. Funding - In planning the plan's costing elements, the primary objective will be to determine the sources and modes of funding and to quantify funds anticipated from the various sources. This would involve funds sanctioned by Congress and released by ERDA, as well as funds from state, autonomous agencies and private industry. A constant and reiterative budgeting system will be evolved to ensure adequate plan funding throughout the entire period of its execution.

2. Scheduling - Time schedules of expenditures and proper allocation of funds must be planned and executed. At the same time, details on modes of allocation and expenditure will have to be determined within the limitations of general accounting procedures already established by the various funding organizations and the operational agency.

3. Evaluations - As an essential part of the costing element throughout the CLP, it will be important to evaluate target achievements as compared with cost schedules. This will help determine any shortfalls or overruns and also help direct future implementation of the plans.

4. Revisions and Modifications - The analysis and evaluation conducted in the previous task will enable ERDA to formulate necessary changes or modifications in the time and cost schedules.

2.1.3 Environmental Assessment

This subelement is of great importance and can help eliminate unforeseen hurdles that might delay the entire plan. The following three tasks should be performed.

1. Baseline Data Evaluation - Baseline data will be collected to evaluate existing air, water and land use conditions at each selected site, and necessary analysis of the existing ecosystems also will be made.

2. Environmental Impacts Evaluation - A detailed analysis of possible environmental impacts of the entire CLP will be prepared and properly documented. Possible impacts on air, water and land use factors, as well as problems associated with waste and pollution, will be analyzed and documented.

3. Mitigation of Impacts - As a necessary function of the environmental impact studies, very careful documentation will be made of all steps being planned to mitigate any possible adverse environmental impact, to ensure smooth operation of the plan.

2.1.4 Site Selection

This subelement consists of two tasks of prime importance which are outlined below.

1. Site Selection Criteria - Site selection criteria will be dependent on the following factors: historical background, geological potential, industry development plans, industry support, and market potential. Each of these individual criteria is of great importance and must be thoroughly analyzed in order to make the final site selection.

2. Project Strategy - Another major factor influencing final site selection is the project strategy which must be defined at an early stage. This includes studies on the plan's socioeconomic aspects, the impact of public interest, the cost benefit analysis, possible legal constraints and several other considerations. These analyses will help the decision-making process in final selection of potential sites.

2.1.5 Logistics

This subelement consists of four tasks and is of major importance in achieving successful completion of the CLP.

1. Personnel and Teaming - Of necessity, the CLP will involve personnel from different organizations with varying expertise and representing various disciplines. Various individuals will be working on different aspects of the plan, and the need for coordinating both people and activities will be essential. Field, services, laboratory and supervisory personnel will have to be assigned specific duties and responsibilities. Individuals or groups of individuals will have to be trained to coordinate all activities. The personnel will include individuals from ERDA, federal agencies, state geological surveys, laboratories, universities, and industry. Necessary training and advance planning will assure smooth operations.

2. Scheduling - This task essentially will function by confirming activities scheduled for either cooperative or ERDA-funded programs and by assuring that the logistics are correctly defined and understood by all concerned. Possible site constraints must be identified and corrective action initiated to eliminate possible delays.

3. Specifications and Procedures - A final check of all specifications and procedures, and any necessary modifications, will ensure that all activities are properly defined and understood. Detailed specifications must be clearly established along with all associated formats, reporting techniques, data processing methods, records and maintenance.

4. Other Vital Logistics - Planning the logistics for transportation of personnel, equipment, supplies, samples and records must be completed in advance of actual operations. Accommodation, storage, and handling of core samples must be determined, and safety and emergency procedures, site utilities and effluent disposal methods must be instituted.

2.1.6 Contract Procedures

This subelement has been divided into four tasks.

1. Leasing Agreements - Appropriate leasing arrangements for equipment, facilities, expertise and land must be made. Legal aspects of all such arrangements must be clearly defined and applicable regulations complied with so as to avoid possible future complications and resultant delays. Procedures and specifications for such leasing agreements must be established.

2. Cooperative Agreements - Special attention must be given to cooperative agreements with governmental agencies, universities, state agencies or private industry, in order to clearly identify the major duties and responsibilities of each group. Coordination among the various groups and ERDA must be organized in such a manner as to ensure efficient operation of the project. Equipment purchases under cooperative agreements

require proper documentation and subsequent allocation. ERDA interests and those of the cooperating organization must be matched for mutual benefit to accrue. Legal formalities must be complied with in all cases.

3. Contract Agreements - Detailed procedures and specifications for each contract must be defined with precision. They should be formulated clearly, in a manner to enable maximum possible support for ERDA personnel. Pre-award contract discussions are essential so as to eliminate any misunderstandings or disagreements. Specific details may be necessary for special contracts, and these must be carefully indicated in the final documents. All legal implications should be clearly defined and evaluated.

4. Contract Awards - Finally, all contracts will be awarded as expeditiously as possible. Clear provisions for extending or limiting the scope and content of the work should be included, so that evaluation of test results may be used in shaping future stages of the plan.

2.2 FIELD OPERATIONS

On completion of the main planning operations and contract awards, field operations will be initiated. The field operations have been subdivided into six subelements, each of which consists of several tasks. These subelements are field and site planning, field and site preparation, drilling activities, coring and sampling, borehole logging, and borehole testing. The tasks within these subelements are described below.

2.2.1 Field and Site Planning

This subelement consists of three tasks described below.

1. Field Personnel - Both supervisory and field operations personnel will be involved in actual execution of the project; hence, it is necessary to plan how individuals or groups of people will interrelate with each other. Moreover, conditions will vary with each contract and often with each well site location. Supervisory personnel must be fully aware of the contract specifications for all drilling, coring, logging and testing activities. They will ensure compliance with such procedures, and should be trained to make prompt and expeditious decisions at the site, in case any variations are necessitated by special or unusual site conditions. They must be aware of the nature and method for conducting each aspect of the field operations. A major task for the field staff will consist of accurate recording and monitoring of all activities, as well as coordination of the activities of the drilling, coring, sampling, logging and testing crews. Only proper teaming and coordination will help ensure harmonious operations.

2. Field and Site Logistics - Actual site conditions will dictate the preplanned field and site logistics for accommodation, storage, transportation and scheduling of personnel, equipment and supplies. Each of these items has its own relative importance to proper execution of the work and must be clearly defined. Safety procedures and emergency planning are also essential activities which must form an integral part of the field logistics.

3. Field and Site Plans - Procedures for checking and monitoring of all field activities must be clearly defined and implemented. These include drilling, coring, logging, testing, and sampling plans. At different stages, work authorizations will be issued as necessary, and proper coordination will be maintained throughout the project task.

2.2.2 Field and Site Preparation

This subelement is a necessary adjunct to actual field operations, and generally comprises most field activities. The functions of both ERDA and the contractors have been defined and are indicated below.

1. MERC/ERDA Functions - ERDA personnel will be responsible for furnishing detailed site plans and drilling locations, along with all available oil and gas well data. Environmental assessments and impact statements and coordination of services also will be provided by ERDA when necessary. Finally, ERDA will bear final responsibility for ensuring that the sites are restored by the contractors to normal conditions.

2. Contractor Functions - Contractor personnel must ensure that they are aware of and capable of complying with all contract specifications and procedures. They will be responsible for surveying and levelling at each well site, and will arrange for expeditious and timely transportation of equipment, personnel and supplies to and from each site. They also will be responsible for any and all site preparations which will help expedite the work, and must restore each site to almost original condition. Their responsibilities also will include provision of detailed and accurate records, control of effluent damages, site accommodation and storage as well as provision of adequate inspection and monitoring facilities. It will be the contractor's responsibility to ensure that adequate utilities such as water, electricity, sewage, etc., are available at each site.

2.2.3 Drilling Activities

This subelement is also defined by the ERDA and contractor functions.

1. MERC/ERDA Functions - ERDA responsibilities will include issuance of specific task authorizations, scheduling of drilling operations, monitoring and supervision of the work, and verification of all data and records. In special cases, site decisions will be made if site conditions warrant any modifications of the established specifications. Coordination of drilling activities with other planned work also must be accomplished by ERDA field personnel.

2. Contractor Functions - Contractors will conduct the drilling according to the specifications and procedures specified by ERDA. They also will be prepared for performance of specialized drilling techniques that may be required in the R&D effort pertaining to such drilling activities. They must cooperate with the ERDA or other supervisory field personnel and coordinate the work of crews provided by the logging and sampling services. Cores will be obtained in the sizes and at the depths specified during the course of the drilling, but the contractor will be

prepared to incorporate any modifications dictated by unusual or special site conditions. The contractor also will ensure completion of the borehole, removal of his equipment and restoration of the site upon completion of the drilling. All requisite records and data will be furnished to ERDA.

2.2.4 Coring and Sampling Activities

Coring the shale horizon will be accomplished during the course of the drilling activity. This task defines the work required after recovery of cores from the borehole, and consists of three tasks, for which detailed specifications and procedures will have been developed.

1. Core Recovery and Reassembly - After extracting the cores from the borehole in either 30- or 60-foot lengths, the entire core is to be recovered from the core-barrel and accurate records and measurements are to be obtained. The entire core lengths are to be accurately reassembled, and records of actual core recovery are to be maintained. This requires specialized methods and training to be able to identify the regions where cores have been lost, damaged or otherwise rendered irretrievable. Percentage recoveries will indicate only quantities so lost or damaged.

2. Core Sampling and Recording - This task is one that could be performed either at the site or in the core-testing laboratories. In order to avoid dual and triple handling and transportation, accompanied by possible damage and deterioration of the cores, it would be highly desirable to perform this task in the field. It has already been determined that Battelle Columbus Laboratories will conduct the outgassing analyses for core samples canned in the field. Similarly, Mound Laboratories will be performing the hydrocarbon analyses. Representatives from Battelle Laboratory will take core samples in the field, can and pack such samples, and ship them back to the respective laboratories. Hence, it would be feasible to obtain other samples of the core needed for conducting the geological, physical and chemical laboratory tests, directly in the field and ship them directly to the laboratories responsible for testing. The balance of the core then could be shipped to the final destination and archived.

Samples will be taken at intervals specified in the contract documents. To achieve this, preliminary records of the entire core lengths will be completed first. This would include orientation and marking of the core, a brief lithological description, recording of macrofractures and core photography. Such action would be facilitated by the use of some form of mobile field office or laboratory, as the task may be quite time-consuming, particularly with long core lengths. Copies of the field records will be dispatched to the Data Processing Center.

3. Core Handling and Transportation - As noted earlier, the cores are retrieved in about 60-foot lengths and must be handled with great care and adequate speed. They must be accurately recorded, cleaned, sampled and then packaged and boxed for onward transmission. Normally, the cores are shipped in 3-foot long sections. However, if sampling is performed in the field, necessary precautions must be taken to define the gaps left by missing samples. The outgassing and hydrocarbon analysis

samples taken by Battelle personnel must be sealed in airtight cans before transport. In all cases, however, the cores will be transported by private means to ensure minimal disturbance and safe handling.

2.2.5 Borehole Logging

Immediately after completion of drilling and coring operations, the borehole logging subelement will be undertaken. This subelement is divided into three tasks, all of which may or may not be applicable to the individual boreholes.

1. Dryhole Well Logging - In a number of areas it is possible to drill the holes and obtain cores without the use of liquids or drilling muds. In such areas both commercial and research suites of dryhole well logs will be run. These should include gamma-ray, formation density, temperature and differential temperature, caliper, sibilation, dry resistivity, and in situ stress logs, along with any other specialized logs that may be required. If possible, fluid-filled borehole logs will be run.

2. Fluid-Filled Well Logging - On completion of the dryhole well logging, and in holes where drilling fluids have or can be utilized, complete commercial and research suites of logs will be run. Actual site conditions and shale character will determine the applicability of such log runs in the dryhole wells. However, the fluid-filled well logging should include gamma-ray logs, compensated formation density, caliper, compensated neutron, induction, dual laterolog resistivity, dual induction laterology-8, sonic velocity-compensated, self potential, 3D velocity, and seisviewer logs. Any other special well logs may be taken at different sites.

3. Interpretation of Well Logs - After obtaining the well-logging records, the logs will have to be interpreted by either computerized or non-computerized methods. Such interpretations need careful scrutiny, and the records then must be fed into the main data processing element.

2.2.6 Borehole Testing

Quite frequently it will be necessary to execute borehole tests to determine permeabilities of the shale, pressure build-up, competence of the shale and possibly some other specialized borehole tests. Such tests normally will be executed after completion of the well-logging operations previously described. The results of such tests must be furnished to the data processing centers as well as to the laboratory where the final report will be written.

2.3 LABORATORY OPERATIONS

The laboratory operations will follow sequential completion of the field operations. They have been subdivided into three subelements, each consisting of several tasks. The subelements are laboratory planning, core sampling and processing, and technology transfer. The tasks under these subelements are detailed on the following pages.

2.3.1 Laboratory Planning

This subelement consists of the following two tasks.

1. Laboratory Selection - Parts of this subtask may have been performed earlier in the initial planning operations conducted before the award of firm contracts. However, some of the many factors influencing the selection of laboratories performing core sample tests are reviewed briefly below.

The selection criteria will include the expertise and capability of the personnel involved, the equipment owned or available, the proximity of the site, the types of tests required, the capability for transferring technology and other socioeconomic factors. In many cases, the laboratories will be prepared to conduct the tests on a cost-sharing basis and may have some funds available for procurement of specialized equipment and personnel. Partial funding by ERDA for equipment purchases may be necessary in other cases, and procedures will have to be clearly defined in regard to future ownership of such equipment. Procedures also will be established to determine the flow of data from each of the laboratories concerned. In some cases, the final reports will be the responsibility of the laboratory performing the core sample tests; in other cases, different laboratories will be performing different types of tests on portions of the same core; and in yet other cases, the final report will be the responsibility of some organization other than the laboratories performing the tests. All these factors must be taken into consideration and specific procedures must be clearly defined in order to achieve optimum coordination and rapid results.

2. Laboratory Techniques and Specifications - Normally, most laboratory techniques and specifications will have been developed in the earlier stages of planning. However, not all laboratories are equipped to conduct all the necessary tests. Hence, it will be desirable to require that techniques and specifications for the laboratory tests be specified for each particular laboratory. The laboratory tests may be classified as either routine or special tests. On one hand, they will include study of the geological and physical parameters of the shales, on the other, the chemical properties of the shale and gas. New research techniques also will be specified upon occasion. Finally, an analysis of the statistical significance of the test results will be necessary to evaluate the resources.

The continuing process of new data acquisition will help in identifying the potential of various areas and in mapping the results, which in turn will help demarcate promising new locations.

2.3.2 Core Sampling and Processing

Obtaining core samples in the field may have been accomplished as described in coring and sampling activities, Task 2. But it is also possible that this task may not have been feasible in the field. Hence, the entire core may have to be shipped to the first testing laboratory along with the raw field data and records, and the sampling will be conducted at this laboratory.

This subelement consists of three tasks described below.

1. Core Handling at Receiving Laboratory - In case the entire core has been shipped to a specific laboratory, it will be necessary to receive and record the shipment and arrange for temporary storage of the core boxes. Properly labelled shelves will suffice. As a next step, the core must be reassembled and the preliminary orientation noted in the field will have to be accurately verified and recorded. Routine geological and physical parameters of the core will be identified and recorded. At the same time, microfractures in the core will be marked and recorded. On completion of the routine geological and physical tests on the core, samples will be selected and extracted from specified intervals for conducting the geochemical and special geological and physical tests which may involve destruction of some of the core sections. However, the use of suitably sized and similarly oriented wooden roller-type blocks to replace the gaps left by sample removal will help maintain as complete a core length as possible. The cut core samples then may be transferred to the testing laboratory by private vehicles, and should never be entrusted to any form of public transport. The bulk of the remaining core can be boxed and archived. However, if the first receiving laboratory is capable of running the specialized geological and physical test, such shipment of core samples will be unnecessary; instead, a schedule for sample testing will have to be established.

2. Sample Testing and Analysis of Results - This task consists of performing all the geological, physical and chemical tests previously established in the specifications. It will include determination of the various parameters of the shale, by both routine as well as by specialized tests. The results of all such tests will be accurately evaluated and recorded. From these records, the statistical significance analysis will be derived. All results and records will be published in the form of reports, and records will be transferred to the Data Processing System.

3. Core Storage and Archiving - Decisions will be made regarding the mode and period of core sample storage, because this will require considerable space and accurate inventory. In most instances, the state geological surveys would be the most obvious repositories; but in some instances, it may be more convenient for federal agencies or universities to furnish both space and time for archiving the cores. Irrespective of who will eventually store the core material, it is essential that accurate records of the materials stored be maintained and updated regularly with the addition or removal of more core material. The cores must be preserved in such a manner that little or no deterioration occurs, and ready access to the material is available for future reference and consultation.

2.3.3 Technology Transfer

This subelement involves the transfer of new and advanced technologies to the public and industrial sectors, and consists of two tasks.

1. Technologies - Selection of the new technologies which need to be transferred will be made by ERDA. Some of these are: sonic velocity testing, petrographic analyses, rock mechanics study techniques, maturation study methods, outgassing analysis techniques, sampling techniques and statistical evaluation methods. Other technologies may be developed during the course of the current R&D effort, and these also will be transferred.

2. Transfer Techniques - Various technology transfer techniques are available and can be readily utilized. These include workshops, seminars, oral briefings, technical conferences, videotapes, handbooks, manuals, reports and other publications. Telephone stop orders are an essential requisite to the plan, as it often may be necessary to eliminate certain technology usage during the course of the work.

2.4 DATA PROCESSING OPERATION

The last major element of the CLP, also of major importance, is the data processing operation. This operation consists of two main subelements with several tasks in each category. The subelements are data planning and data management.

2.4.1 Data Planning

This subelement consists of three tasks.

1. Data Requirements - Large volumes of data will be generated during the course of executing the CLP. Part of this mass will be developed during the field operations and the remaining portion will be derived from the laboratory operations.

Much of the field data will consist of location maps, regional stratigraphic and structural maps, isopac and isolith maps of the Devonian Shale, and oil and gas fields maps. Locations and elevations of existing and new well sites will be indicated on most of these maps. In addition, drilling, coring and well-logging records and interpretations will also form part of the field data base. Finally, the lithological descriptions, photographic records, core sample records, laser borescope records, fracture pattern and fluid records also will be required.

The laboratory records will consist of the complete suite of data derived from execution of the various geological, physical and chemical tests conducted on the core samples. The records also will include evaluations of the results and statistical significance analyses.

2. Data Collection Systems - Procedures and specifications for data collection systems will be established as soon as possible. This will include forms and types for use in recording the data, with clear indication of personnel responsible for data collection. Each job or task requiring a permanent record setup will have a special form, in which maximum information will be recorded. As many tasks may be closely interrelated, it may be possible to use the same form to record the results from more than one task. Formatting the data in numerical and logical sequence will ensure accurate data collection. With the accumulation of large volumes of data, use of some type or form of mathematical or computer modeling will be most beneficial. Handbooks or manuals could be used to give detailed information on the use of various forms. Finally, the personnel or organizations responsible for data collection will be identified.

3. Data Storage and Retrieval Systems - The form and mode of data storage and retrieval will have to be precisely defined in order to be of any use. The data will be computerized. This will involve a most detailed and somewhat involved effort, but will prove of immense value when placed in operation.

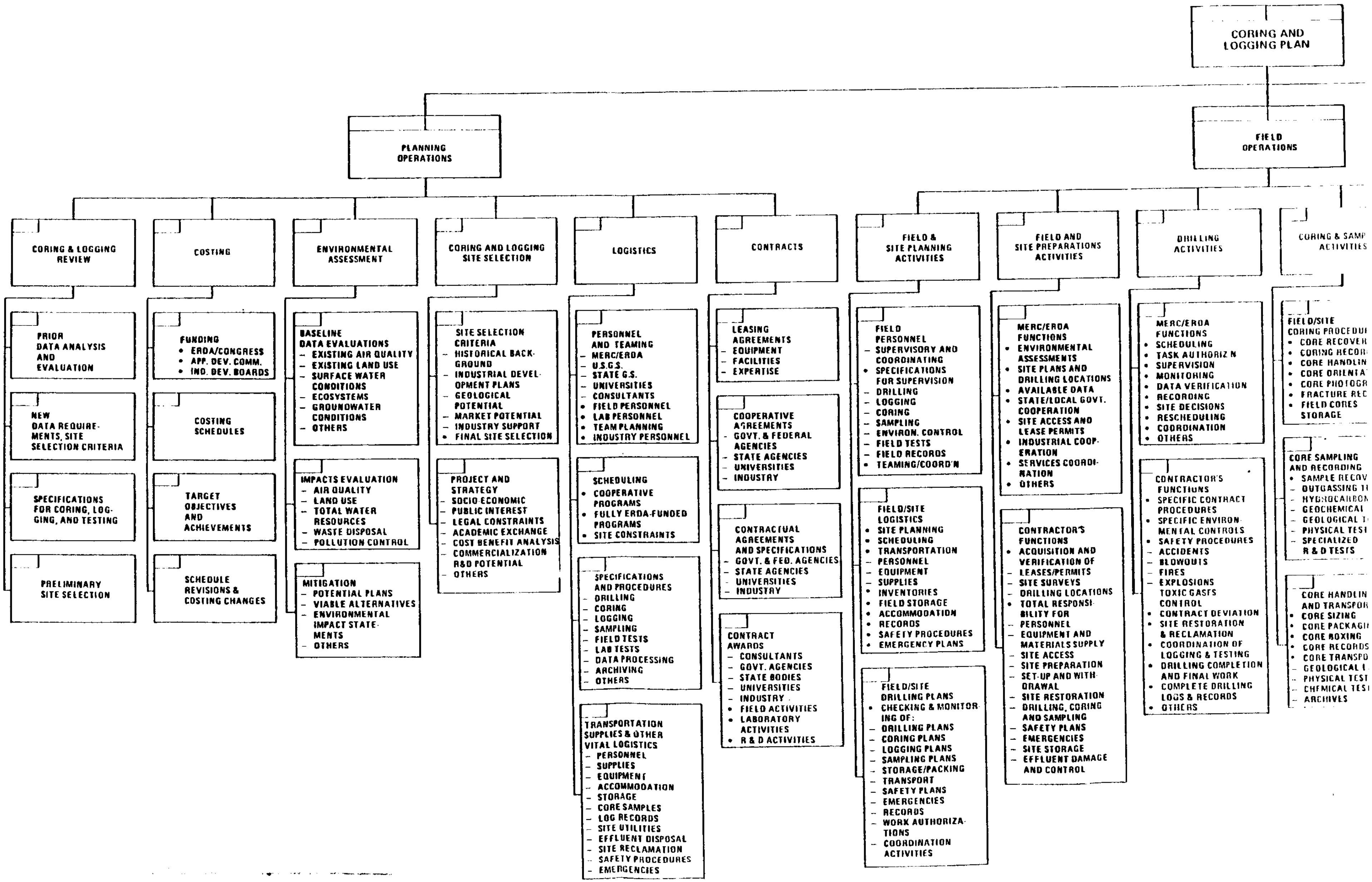
2.4.2 Data Management

Having established the specifications and procedures for data collection, storage and retrieval in the previous subelement, the actual data management activity can be implemented in the present subelement. There are two tasks under this heading.

1. Data Handling - On receipt of raw data and test results from the field and from the laboratory, the data is to be formatted to suit the computer data bank system, and to facilitate storage and retrieval work. At the same time, it will be determined as to when, where and how the data will be stored and utilized.

2. Data Dissemination and Education - Having compiled and stored the new data, it will be necessary to establish means for first publicizing its availability and later of developing suitable techniques for its dissemination. Detailed methods and procedures will be established so that there will be little or no hindrance in disseminating the data for educational purposes and other fruitful applications.

Although the data processing task has been described here as part of the CLP, it should be remembered that this forms an integral part of the overall Project Implementation Plan. Hence, it is obvious that the output of the data processing task will form an input into the EGSP Information Management System.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CORING AND LOGGING SITE SELECTION
SITE SELECTION CRITERIA – HISTORICAL BACKGROUND – INDUSTRIAL DEVELOPMENT PLANS – GEOLOGICAL POTENTIAL – MARKET POTENTIAL – INDUSTRY SUPPORT • FINAL SITE SELECTION
PROJECT AND STRATEGY – SOCIO-ECONOMIC – PUBLIC INTEREST – LEGAL CONSTRAINTS – ACADEMIC EXCHANGE – COST BENEFIT ANALYSIS – COMMERCIALIZATION R&D POTENTIAL – OTHERS
LOGISTICS
PERSONNEL AND TEAMING – MERC/ERDA – U.S.G.S. – STATE G.S. – UNIVERSITIES – CONSULTANTS • FIELD PERSONNEL • LAB PERSONNEL • TEAM PLANNING • INDUSTRY PERSONNEL
SCHEDULING • COOPERATIVE PROGRAMS • FULLY ERDA-FUNDED PROGRAMS • SITE CONSTRAINTS
SPECIFICATIONS AND PROCEDURES – DRILLING – CORING – LOGGING – SAMPLING – FIELD TESTS – LAB TESTS – DATA PROCESSING – ARCHIVING – OTHERS
TRANSPORTATION SUPPLIES & OTHER VITAL LOGISTICS – PERSONNEL – SUPPLIES – EQUIPMENT – ACCOMMODATION – STORAGE – CORE SAMPLES – LOG RECORDS – SITE UTILITIES – EFFLUENT DISPOSAL – SITE RECLAMATION – SAFETY PROCEDURES – EMERGENCIES
CONTRACTS
LEASING AGREEMENTS – EQUIPMENT – FACILITIES – EXPERTISE
COOPERATIVE AGREEMENTS – GOVT. & FEDERAL AGENCIES – STATE AGENCIES – UNIVERSITIES – INDUSTRY
CONTRACTUAL AGREEMENTS AND SPECIFICATIONS – GOVT. & FED. AGENCIES – STATE AGENCIES – UNIVERSITIES – INDUSTRY
CONTRACT AWARDS – CONSULTANTS – GOVT. AGENCIES – STATE BODIES – UNIVERSITIES – INDUSTRY • FIELD ACTIVITIES • LABORATORY ACTIVITIES • R & D ACTIVITIES
FIELD & SITE PLANNING ACTIVITIES
FIELD PERSONNEL – SUPERVISORY AND COORDINATING • SPECIFICATIONS FOR SUPERVISION – DRILLING – LOGGING – CORING – SAMPLING – ENVIRON. CONTROL – FIELD TESTS – FIELD RECORDS • TEAMING/COORD'N
FIELD/SITE LOGISTICS • SITE PLANNING • SCHEDULING • TRANSPORTATION – PERSONNEL – EQUIPMENT – SUPPLIES • INVENTORIES • FIELD STORAGE • ACCOMMODATION • RECORDS • SAFETY PROCEDURES • EMERGENCY PLANS
FIELD/SITE DRILLING PLANS • CHECKING & MONITORING OF: – DRILLING PLANS – CORING PLANS – LOGGING PLANS – SAMPLING PLANS – STORAGE/PACKING – TRANSPORT – SAFETY PLANS – EMERGENCIES – RECORDS – WORK AUTHORIZATIONS – COORDINATION ACTIVITIES
FIELD AND SITE PREPARATIONS ACTIVITIES
MERC/ERDA FUNCTIONS • ENVIRONMENTAL ASSESSMENTS • SITE PLANS AND DRILLING LOCATIONS • AVAILABLE DATA • STATE/LOCAL GOVT. COOPERATION • SITE ACCESS AND LEASE PERMITS • INDUSTRIAL COOPERATION • SERVICES COORDINATION • OTHERS
CONTRACTOR'S FUNCTIONS • ACQUISITION AND VERIFICATION OF – LEASES/PERMITS – SITE SURVEYS – DRILLING LOCATIONS • TOTAL RESPONSIBILITY FOR – PERSONNEL – EQUIPMENT AND MATERIALS SUPPLY – SITE ACCESS – SITE PREPARATION – SET-UP AND WITHDRAWAL – SITE RESTORATION – DRILLING, CORING AND SAMPLING – SAFETY PLANS – EMERGENCIES – SITE STORAGE – EFFLUENT DAMAGE AND CONTROL
DRILLING ACTIVITIES
MERC/ERDA FUNCTIONS • SCHEDULING • TASK AUTHORIZ N • SUPERVISION • MONITORING • DATA VERIFICATION • RECORDING • SITE DECISIONS • RESCHEDULING • COORDINATION • OTHERS
CONTRACTOR'S FUNCTIONS • SPECIFIC CONTRACT PROCEDURES • SPECIFIC ENVIRONMENTAL CONTROLS • SAFETY PROCEDURES – ACCIDENTS – BLOWOUTS – FIRES – EXPLOSIONS TOXIC GASES CONTROL • CONTRACT DEVIATION • SITE RESTORATION & RECLAMATION • COORDINATION OF LOGGING & TESTING • DRILLING COMPLETION AND FINAL WORK • COMPLETE DRILLING LOGS & RECORDS • OTHERS
CORING & SAMP ACTIVITIES
FIELD/SITE CORING PROCEDU • CORE RECOVER • CORING RECOR • CORE HANDLIN • CORE ORIENTA • CORE PHOTOGR • FRACTURE REC • FIELD CORES STORAGE
CORE SAMPLING AND RECORDING • SAMPLE RECOV – OUTGASSING – HYDROCARBON – GEOCHEMICAL – GEOLOGICAL – PHYSICAL TEST – SPECIALIZED R & D TESTS
CORE HANDLIN AND TRANSPOR • CORE SIZING • CORE PACKAGI • CORE BOXING • CORE RECORDS • CORE TRANSPO – GEOLOGICAL – PHYSICAL TEST – CHEMICAL TEST – ARCHIVES

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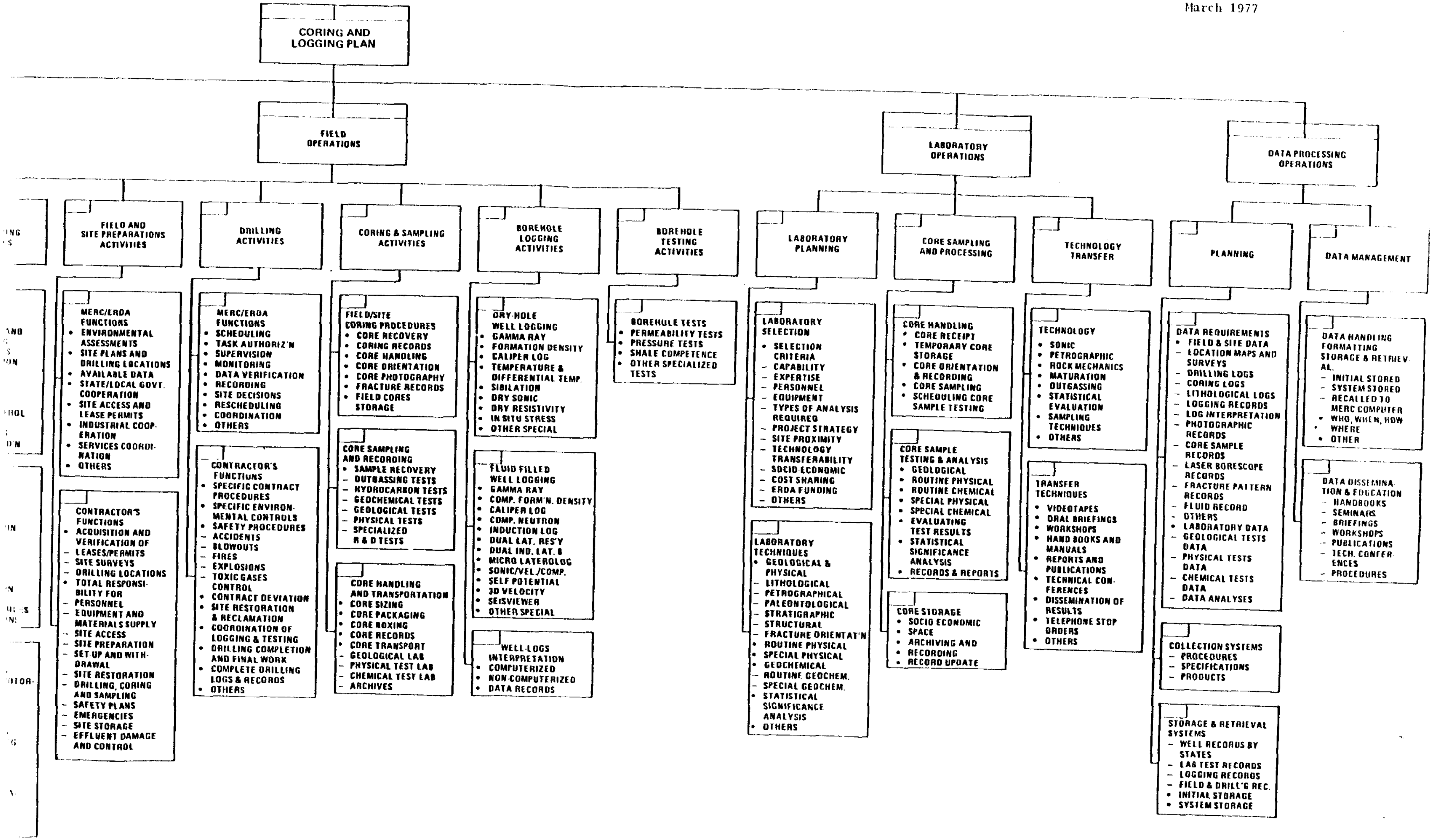

FIGURE 1.
WORK BREAKDOWN STRUCTURE

3.0 IMPLEMENTATION

Implementation of the Coring and Logging Plan is effected by integrating the scope of work, as illustrated in the WBS, to an organization of people and by providing those people with the necessary devices to bring the plan into action. These two aspects are set forth below.

3.1 ORGANIZATION

The CLP, being a subset of the EGSP, will be subject to the overall direction of the Project Manager, W. K. Overbey, Jr. At the Assistant Project Management level, A. E. Hunt is responsible for the Resource Division. There is a present vacancy in the APM slot for the Technology Division, with that responsibility reverting to the PM. W. K. Overbey, Jr. and A. E. Hunt presently comprise the EGSP Project Office along with secretarial assistance of R. D. Newlon. This office is within the Advanced and Special Project Division of MERC under J. Pasini III, Assistant Director.

ERDA representatives as Technical Project Officers (TPO's) will monitor all EGSP contracts. These TPO's are experts in particular technologies and are chosen from the technical staffs of ERDA/HQ, MERC/ERDA and the USGS. There is one TPO on each contract.

Many of the activities will be done by contractors; however, some in-house analyses will be performed at MERC. Contracts have been made with universities, state geological surveys, industry and federal agencies. A listing of the contractors involved and the overall CLP organization are represented in Figure 2.

3.2 EVENT SEQUENCE

From the WPM level on down, very detailed steps have to be planned and executed. Devices presented in this plan to assist in that implementation task are the Event Sequence Diagrams, Figures 3 through 6, which indicate the sequence of activities between subelements of the WBS. They will be used by the staff to determine the schedules for execution of the work and the costing allocations. They also provide the necessary foundation to construct a PERT-type activities network which could be used for project time and cost control.

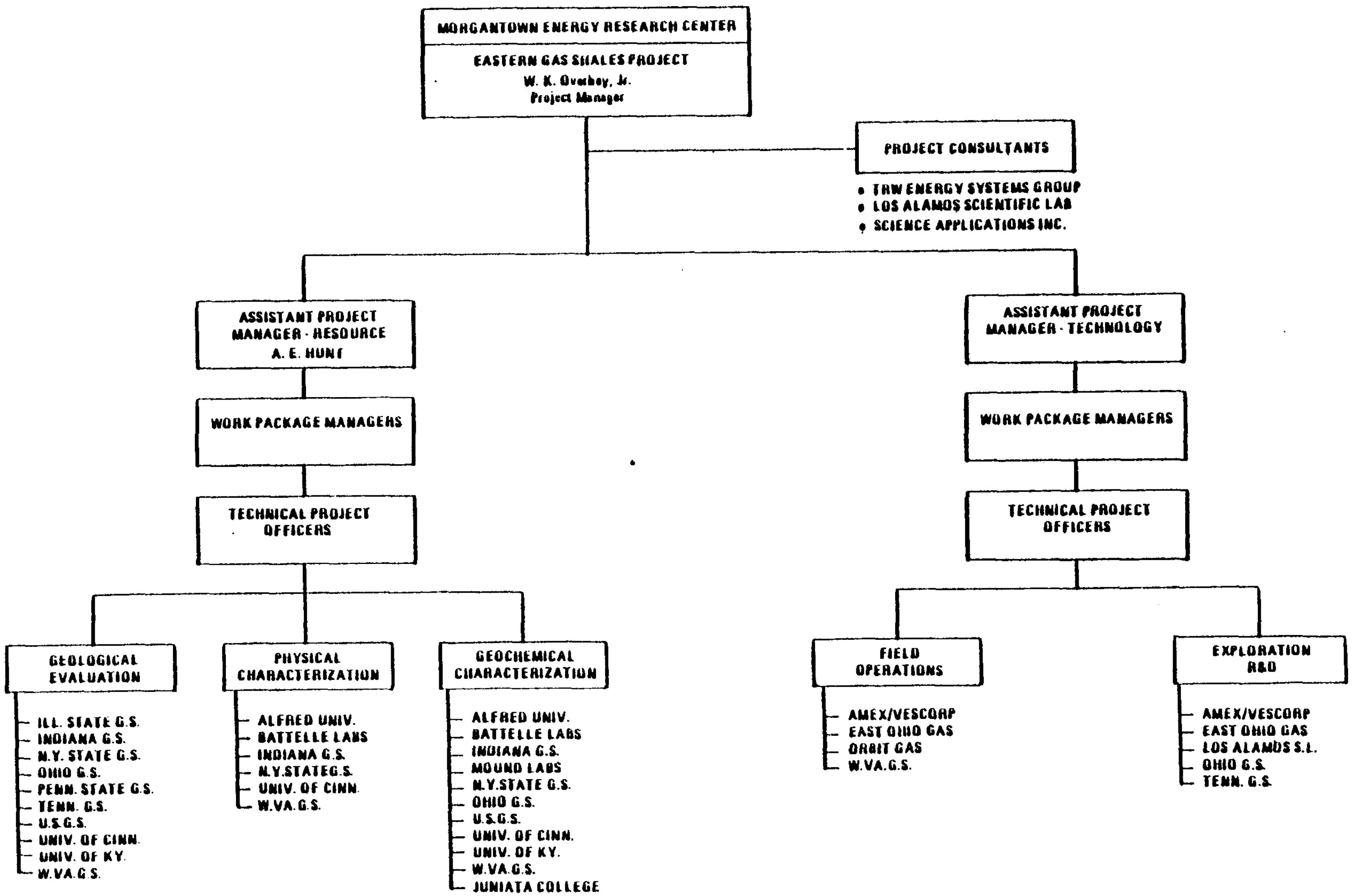

FIGURE 2. CORING AND LOGGING ORGANIZATION

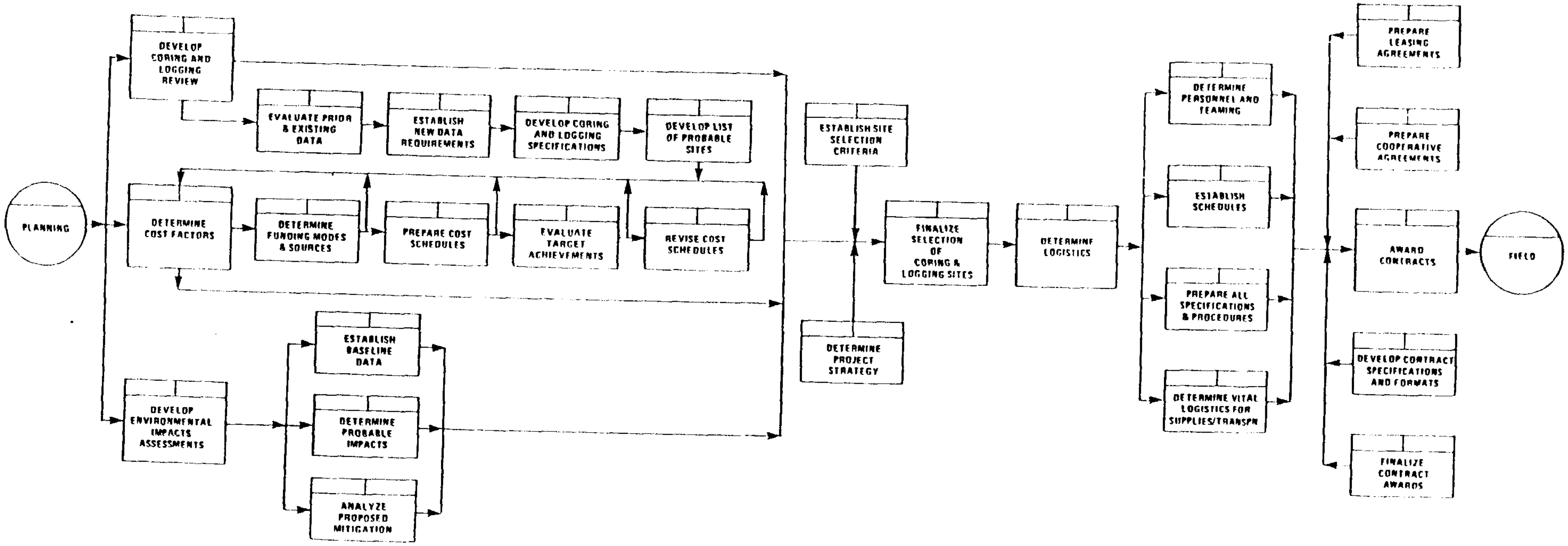

FIGURE 3.
EVENT SEQUENCE OF PLANNING OPERATIONS

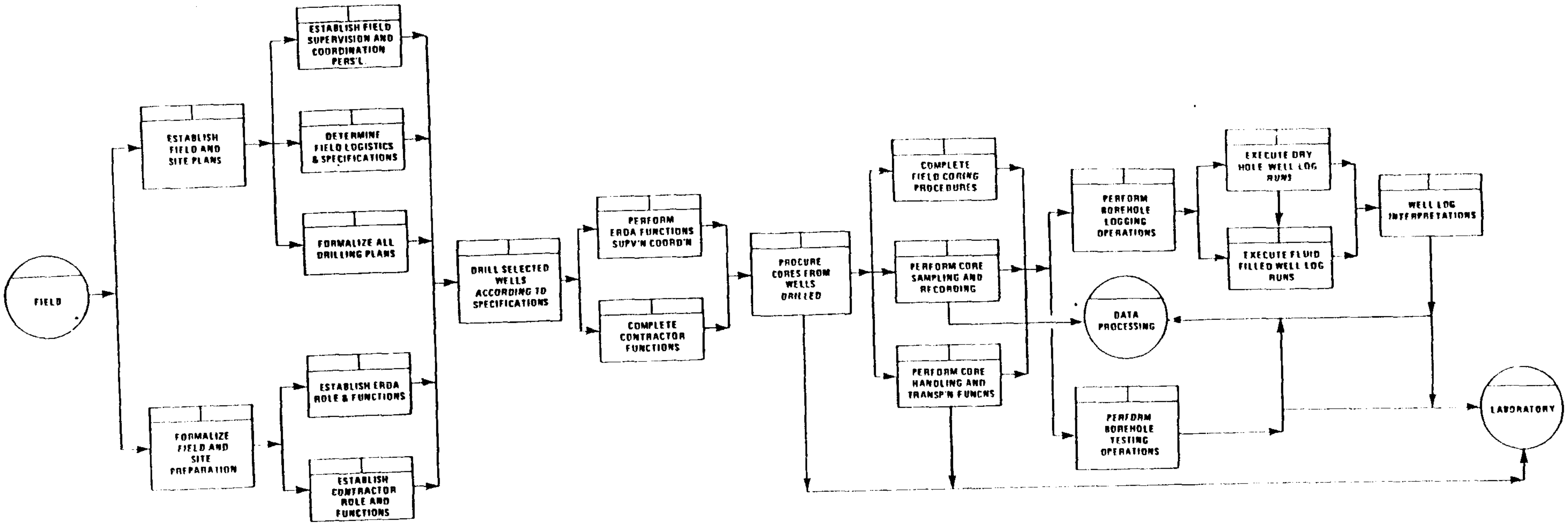

FIGURE 4.
EVENT SEQUENCE OF FIELD OPERATIONS

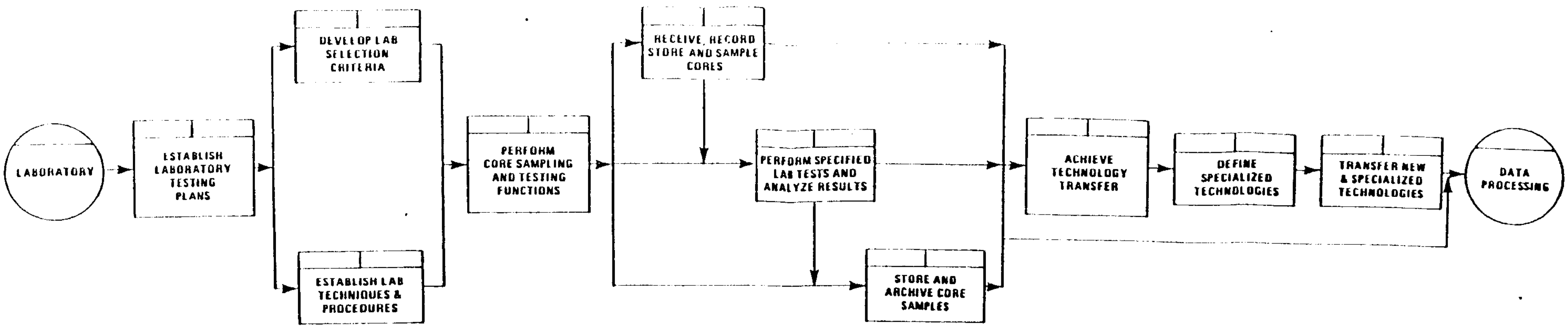

FIGURE 5.
EVENT SEQUENCE OF LABORATORY OPERATIONS

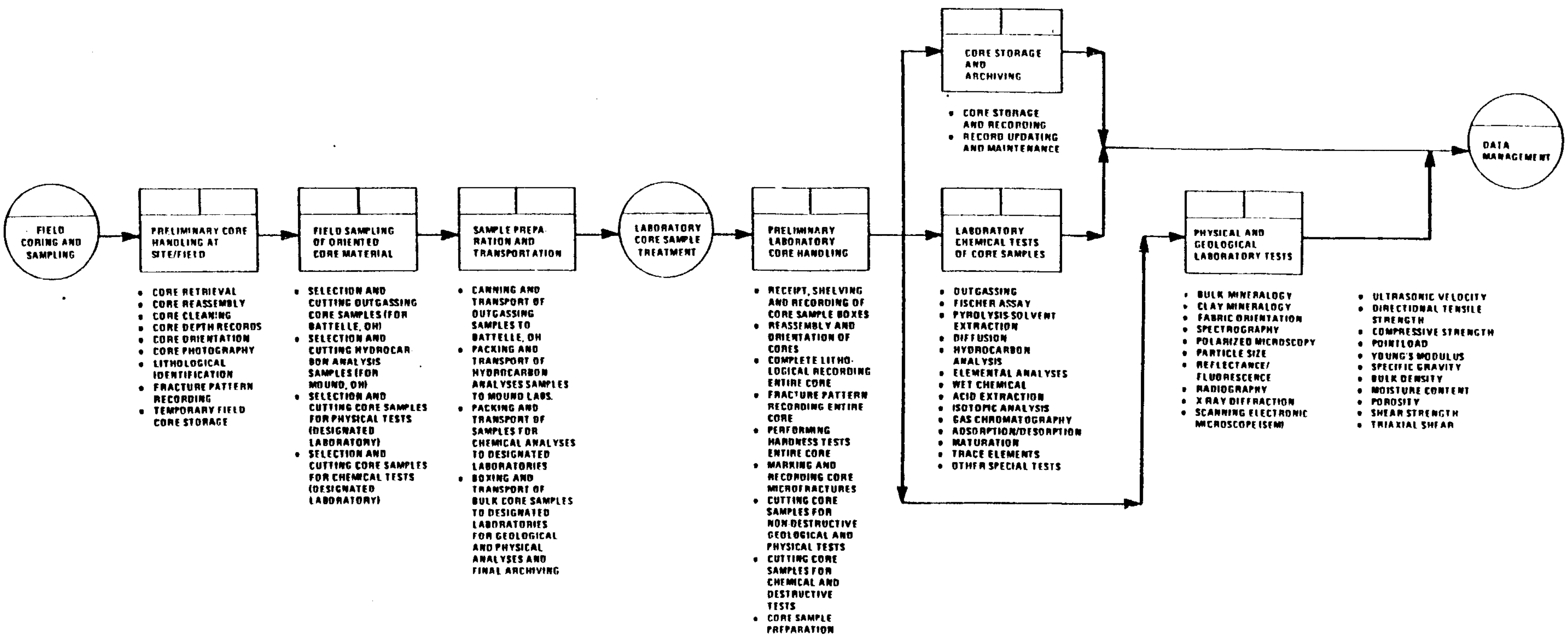

FIGURE 1. FLOWCHART OF LOGISTICS PLAN FOR TREATMENT OF EGSP ORIENTED CORES

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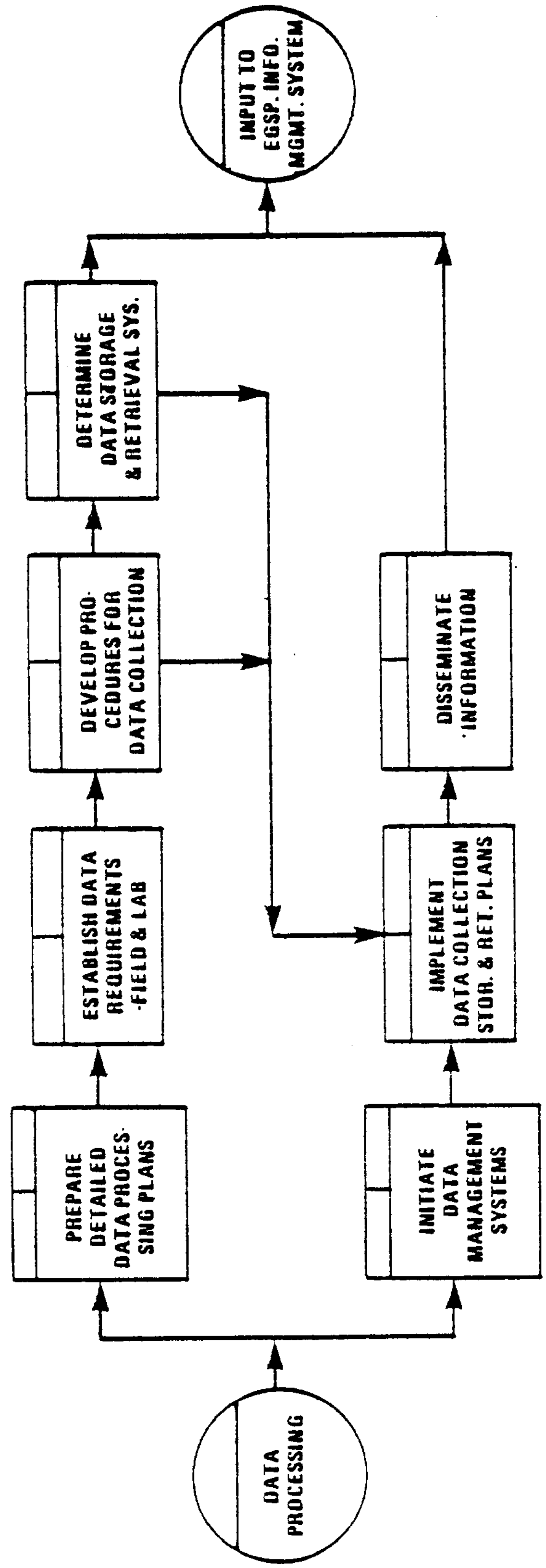

FIGURE 6. EVENT SEQUENCE OF DATA PROCESSING OPERATIONS

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APPENDIX A

CORING LOGISTICS PLAN

CORING LOGISTICS PLAN

In order to derive a comprehensive logistics plan which would be applicable to all coring samples, the following data are essential requisites: (1) drilling and coring programs and schedules; (2) regional location of drilling and coring sites; and (3) laboratory testing elements. It appears that item 1 will not be available for a year or more and is dependent on completion of a comprehensive stratigraphic analysis by the USGS.

Meanwhile, however, MERC/ERDA is establishing its EGSP program on the basis of unsolicited proposals and responses by oil and gas drilling companies. Contracts are being negotiated for the specialized coring and sampling requirements with such firms. Separate contracts have been negotiated with various universities and state surveys for conducting the different laboratory tests needed to complete the project. As many of these contracts are not yet finalized only a tentative sample testing program can be devised at present.

Testing of core samples fall into two major categories. These are: (1) geological and physical testing, and (2) geochemical testing. Specialized geochemical tests such as "outgassing" and "Fischer Assays", together with their respective associated chemical tests, are scheduled to be conducted by Battelle Columbus, Ohio, and Mound Laboratory, Ohio, respectively, for all cores from all regions.

In accordance with these requirements, a matrix showing the core-sample testing elements and their regional distribution has been prepared and is attached as Table 1. This table has been derived by an analysis of the proposals and task specifications submitted by the various contractors. On the basis of this matrix, the following generalized Logistics Plan has been formulated and is shown as Figure 1, which is self-explanatory. Seven main tasks have been outlined by boxes, and the interrelationship with the CLP has been indicated by the circled elements. The tasks are sequentially numbered 1 through 7.

Task 1 - Preliminary Core Handling at the Site

The various subtasks to be performed in the field include retrieval, reassembly, orientation, cleaning, marking, depth-recording, and photography of the cores. Lithological description and record of visible fracture patterns also will be made. ERDA representatives will be present at the site during the drilling and coring operations. Representatives from Battelle and other laboratories as well as State Geological Surveys should be at the site on completion of the drilling and coring.

Task 2 - Sampling Oriented Cores in the Field

2.1. Selection, cutting and removal of samples for outgassing and hydrocarbon analyses (Battelle and Mound Laboratories, respectively) must be conducted immediately after core recovery. The outgassing samples must be sealed in cans and plastic-wrapped for delivery to Battelle Laboratories. To attain maximum accuracy, it is suggested several 12-inch lengths of

4-inch diameter, wooden roller-type blocks, with orientation grooves cut along the length of the blocks, and transverse divisions marked in tenths of a foot, be available at the site at all times. Suitable lengths of such wooden roller-type blocks should be used to fill in the gaps left by removal of core samples for laboratory testing. Such replacement blocks would be oriented in accordance with the sample removed. It is of great importance to identify existing fracture patterns in the core before removal of any samples.

2.2. Samples for hydrocarbon and other analyses will be cut and removed in a similar manner. Wooden roller-type blocks again will replace the section removed.

2.3. The same procedure will be followed for the laboratory designated to conduct the chemical analyses of the core samples. Once again, replacement with the wooden roller-type block will be effected.

2.4. Finally, the remaining bulk core material will be plastic-wrapped, boxed, labelled and transported by private carriers to the laboratory performing the geological and physical tests. With proper planning and coordination, it should be possible to transfer the bulk core material to the agency or laboratory designated as the final storage and archiving agency, or one that is fairly close to such agency.

Task 3 - Sample Preparation and Transportation

3.1. All outgassing core samples which have been appropriately canned, labelled and boxed by the Battelle representative should be transported by car, truck or other private carrier mode. Under no circumstances should they be consigned to mail or public carrier. Necessary transmittal, dispatch and receipt documents always should be used.

3.2. Fischer-Assay samples should be handled similarly and transported by private carriers.

3.3. The same pattern should be adopted by representatives of the laboratories responsible for the geochemical test samples.

3.4. Finally, the bulk core samples will be transported by private carriers to the designated laboratory or agency responsible for physical and geological tests, along with all logs, documents and records.

NOTE: It may be necessary to establish temporary field offices in mobile trailers in order to attain the objectives outlined in Tasks 2 and 3. This would be particularly essential in cases where the shale thicknesses are anticipated to be fairly large. However, the economics of mobile trailer field offices would have to be compared with the economics of multiple transfer of bulk core materials.

Task 4 - Preliminary Laboratory Core Handling

4.1. All cores received must be carefully documented, recorded and shelved in an appropriate sequential pattern.

4.2. The cores are removed from their boxes, reassembled, and accurately oriented.

4.3. Hardness tests are run on the cores, and all data are carefully and accurately documented.

4.4. Original core-fractures are to be marked and recorded. These must be accurately logged.

4.5. Lithological characteristics of the cores are carefully and accurately described and recorded.

4.6. Appropriate lengths of core will be photographed to display the core characteristics, depth and orientation markings.

4.7. Test samples are cut from the core assembly. In case such samples are not replaced in the core assembly, similar lengths of wooden roller blocks will be set in these positions vacated by the samples which have been cut and removed.

4.8. These core test-samples now must be prepared for the different tests to which they will be subjected.

4.9. Before subjecting the cut core samples to the different tests, all microfractures observed in the specimens will be marked and accurately recorded for dimensions and direction.

Tasks 5 and 6 - Laboratory Testing

All geological and physical testing elements, as specified in each contract, will now be conducted on the various core samples. This process may vary with sites and by individual contract specifications. However, it is advisable to prepare detailed specifications for each contract, and to spell out the various tests.

Similar testing will be conducted by the chemical testing laboratories. Necessary specifications will have to be detailed in each case.

Task 7 - Core Storage and Archiving

7.1. As all core samples to be tested either by physical or chemical means have been removed and appropriately replaced by equal lengths of wooden roller blocks, the bulk of the core material must be repacked, boxed and put into permanent storage for a specified period of time. Careful records of the cores will be made as they are stored and shelved, for future reference.

7.2. Whenever new core material arrives at the same storage point, the records will be continuously updated.

Task 8 - Data Management

All data from the different laboratories will be compiled at one central location in order to form the basis of the final resources evaluation and shale characterization report.

Analysis of the data also will be conducted at the same central location and the results will be incorporated in the final report.

The entire data will be processed through the established Data Management System.

A generalized format for use with the oriented core logistics plan is also attached.

TABLE 1. MATRIX SHOWING CORE-SAMPLE TESTING ELEMENTS BY REGIONAL DISTRIBUTION

PROGRAM ELEMENTS	GEOLOGICAL AND PHYSICAL				GEOCHEMICAL AND ANALYTICAL						OTHER PROJECT ELEMENTS			REMARKS
LABORATORY TESTING ELEMENTS → / LOCATION BASINS AND STATES	STRATIGRAPHIC AND STRUCTURAL	MINERALOGIC AND PETROGRAPHIC	DIRECTIONAL PROPERTIES DETERMINATION	RESOURCES APPRAISAL AND DATA STORAGE AND RETRIEVAL	CORE OUTGASSING AND SUPPORT	SHALE ELEMENTS ANALYSIS	ORGANIC MATTER ANALYSIS	HYDROCARBON AND GAS ANALYSIS (FISCHER ASSAY)	GAS ADSORPTION AND DESORPTION ANALYSES	OTHERS	EST. NO. OF HOLES DRILLED	EST. TOTAL FOOTAGE DRILLED	PROPOSED FUNDING J=JOINT, E=ERDA	
	LABORATORIES PERFORMING VARIOUS TESTS													
1. APPALACHIAN														
NEW YORK	N.Y.G.S. ALF.U. N.Y.G.S.	N.Y.G.S. ALF.U. N.Y.G.S.	ALF.U.	N.Y.G.S. ALF.U. PA.G.S.	BATTELLE	U.S.G.S.	U.S.G.S.	MOUND	U.S.G.S.					
PENNSYLVANIA	ALF.U.	ALF.U.	ALF.U.	ALF.U.	BATTELLE	WV.G.S.	W.V.G.S.	MOUND	W.V.G.S.					
OHIO	U.CINC. OH.G.S.	U.CINC. OH.G.S.	MERC	OH.G.S.	BATTELLE	OH.G.S.	OH.G.S.	MOUND	OH.G.S.					
W. VIRGINIA	W.V.U. W.V.G.S.	W.V.U. W.V.G.S.	MERC	W.V.U. W.V.G.S.	BATTELLE	W.V.G.S.	W.V.G.S.	MOUND	W.V.G.S.					
VIRGINIA	U.S.G.S.	U.S.G.S.	MERC	U.S.G.S.	BATTELLE	U.S.G.S.	U.S.G.S.	MOUND	U.S.G.S.					
E. KENTUCKY	U.KY.	U.KY.	MERC	U.KY.	BATTELLE	U.KY.	U.KY.	MOUND	U.KY.					
TENNESSEE	TN.G.S.	TN.G.S.	MERC	TN.G.S.	BATTELLE	W.V.G.S. IL.G.S.	W.V.G.S. IL.G.S.	MOUND	W.V.G.S. IL.G.S.					
2. ILLINOIS BASIN														
INDIANA	IND.G.S.	IN.G.S.	IND.G.S.	IN.G.S.	BATTELLE	IN.G.S.	IN.G.S.	MOUND	IN.G.S.					
ILLINOIS	IL.G.S.	IL.G.S.	IL.G.S.	IL.G.S.	BATTELLE	IL.G.S.	IL.G.S.	MOUND	IL.G.S.					
W. KENTUCKY	U.KY.	U.KY.	IL.G.S.	IL.G.S.	BATTELLE	IL.G.S.	IL.G.S.	MOUND	IL.G.S.					
3. MICHIGAN BASIN														
MICHIGAN	MERRA DOW	MERRA DOW	MERC	MERRA DOW	BATTELLE	MERRA DOW	MERRA DOW	MOUND	MERRA DOW					

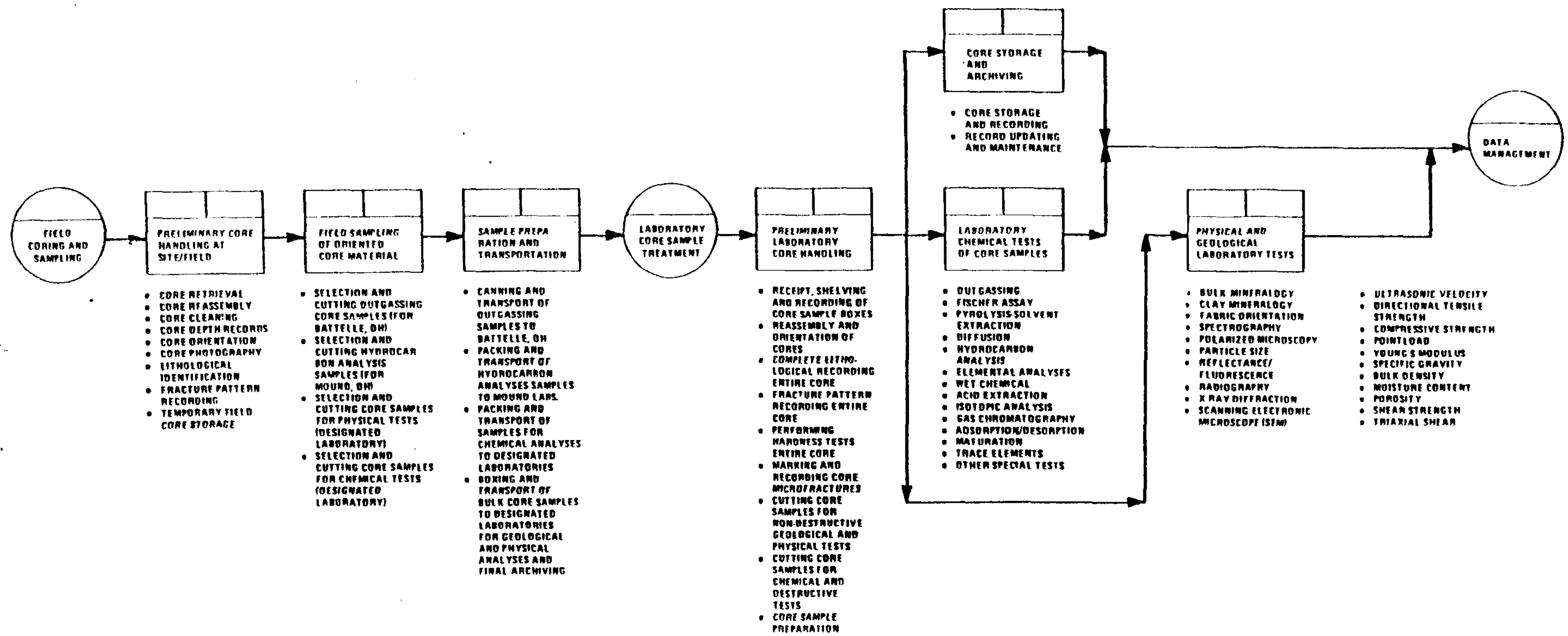


FIGURE 1. FLOWCHART OF LOGISTICS PLAN FOR TREATMENT OF EGSP ORIENTED CORES

GENERALIZED FORMAT FOR USE WITH ORIENTED CORES LOGISTICS PLAN

1. GENERAL INFORMATION

BASIN: ______ WELL NO: ______ CORING DEPTH: ______ CORE START: ______ CONTRACT NO.: ______

STATE: ______ LOCATION: ______ CORE LENGTH: ______ CORE STOP: ______ DATE: ______

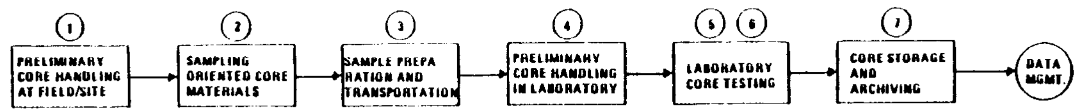
COUNTY: ______ GRID CO-ORD'S: ______

ELEVATION: ______

2. SPECIFIC TASK DISTRIBUTION

DRILLING CONTRACTOR(S)	______	OUTGASSING CORE SAMPLES	BATTELLE, OH.	SAMPLES DISPATCH DATE	______
CORING CONTRACTOR(S)	______	FISCHER ASSAY SAMPLES	MOUND, OH.	SAMPLES ANALYSES DATE	______
WELL-LOGGING CONTRACTOR(S)	______	GEOLOGICAL/PHYSICAL TESTS SAMPLES	______	TEST RESULTS REPORT DATE	______
ERDA SUPERVISOR(S)	______	CHEMICAL TESTS SAMPLES	______	CORE STORAGE/ARCHIVE LOCATION	______
OTHER REPRESENTATIVES	______	OTHER TEST SAMPLES	______	CORE RECORDS	______

3. LOGISTICS PLAN ELEMENTS



ERDA ______	ERDA ______	GEOL. ______	ERDA ______	STATE ______
STATE ______	STATE ______	PHYS. ______	STATE ______	UNIV. ______
______	BAT. ______	CHEM. ______	UNIV. ______	LAB ______
______	MOUND ______	OTHERS ______	OTHER ______	OTHER ______
______	UNIV. ______	______	______	______

SPECIAL REMARKS/COMMENTS

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APPENDIX B

LOGGING LOGISTICS PLAN

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LOGGING LOGISTICS PLAN

1.1 INTRODUCTION

Almost all well logging plans are extremely site-specific and totally dependent on subsurface conditions encountered at different locations. Hence a generalized plan defining well logging operations at all wells drilled for the EGSP would not be feasible. However, it is possible to enumerate the various well logging elements and the factors influencing their selection and use. On the basis of such criteria, a generalized format has been developed for well logging operations at most locations.

1.2 IMPORTANT CRITERIA INFLUENCING WELL-LOGGING OPERATIONS

a) Drilling & Coring Operation - Subsurface geological conditions in the Eastern Gas Project vary considerably in different regions. Some holes can be drilled by "dry" methods utilizing only compressed air for removal of cuttings and for non-oriented coring operations. In such cases "dry-hole" well logs are first run, and then, if necessary and possible, "fluid-filled" well logs are run for more sophisticated tests. Such tests would depend on the degree of detail required at any specific site, and may or may not be conducted.

b) Costs and Economic Factors - The more detailed and sophisticated well logging techniques are usually expensive and could be time consuming, particularly in deep holes. But for shallow wells between 4000 to 6000 feet in depth, different suites of well logs can be completed in a day or a few days. Cost is the main factor influencing the number, types and depths of the well logs. Normally production companies are more likely to conduct those well-logging tests which would give them the requisite results within the minimum time and expense. However, when such operations are wholly or partially funded by others, the appropriate investigating agency would determine the suite of well logs to be completed.

1.3 LOGISTICS PLAN - WELL LOGGING

The logistics plan has been based on the procedures outlined in a note by Mr. Royal Watts, of MERC. The plan elements are arranged sequentially through four stages as shown in Table I.

Task 1: Dry-hole Well Logging - On completion of the drilling in dry holes a suite of logs will be run in accordance with the list. Gamma-ray, formation density and caliper logs are obtained in one run; and temperature/differential temperature, sibilation, dry sonic, dry resistivity, in-situ stress and any other special tests are logged in subsequent runs. The entire operations can be completed within a day or two, whereas the exact type of logs to be run will be decided by ERDA, preferably on completion of the drilling operations.

Task 2: Fluid-filled Well Logging - In cases where additional details are required, and depending on the hole conditions, the holes will be filled with suitable fluid mix and the fluid-filled well logging suite will be run.

However, if subsurface conditions are such that dry drilling is impossible then obviously only the fluid-filled well logging suite will be run. Here again, gamma-ray, compensated formation density, caliper and compensated neutron logs will be otained in one run, whereas the other logs will be obtained in subsequent runs. These would consist of induction or dual induction laterolog-8, dual resistivity laterologs, micro-resistivity or microlaterologs, sonic-velocity compensated, self potential, 3-D velocity, seis-viewer or televiewer and any other special logs.

Task 3: Log Interpretation - Log interpretation can be processed by either computerized or non-computerized methods. However, efforts should be made to obtain computerized interpretation capable of determining the following elements: in situ elastic properties, porosity, fractures, kerogen content, fluid saturation and lithologic characteristics. This element of the well logging program is of utmost importance. Correlation between field tests and laboratory tests on the shale cores is very difficult and considerable experience is needed to define the trends and patterns, rather than develop exact correlations.

Task 4: Data Processing & Publication - The final element of the well logging plan consists of compiling all the coring and well logging results and preparing the final report. All available data must be set in a suitable storage and retrieval system, and the final report published and distributed.

The attached generalized format should help identify the well logging elements in addition to the logistic plan responsibilities.

TABLE I. FLOW CHART OF LOGISTICS PLAN FOR WELL LOGGING PROGRAM

① DRY-HOLE LOGGING →	② FLUID FILLED LOGGING →	③ INTERPRETATION OF LOGS →	④ DATA PROCESS & PUBLICATION
• GAMMA RAY	• GAMMA RAY	• COMPUTERIZED/NON-COMPUTERIZED	• DATA COLLECTION
• FORMATION DENSITY	• COMPENSATED FORMATION DENSITY	• IN SITU ELASTIC PROPERTIES (*)	• STORAGE/RETRIEVAL
• CALIPER	• CALIPER	• POROSITY	• PUBLICATION
• TEMP. & DIFF'L. TEMP.	• COMPENSATED NEUTRON	• FRACTURES	• DISTRIBUTION
• SIBILATION/NOISE	• INDUCTION	• KEROGEN CONTENT	
• DRY SONIC	• DUAL LATEROLOG RESISTIVITY	• FLUID SATURATION	
• DRY RESISTIVITY	• DUAL INDUCTION LATEROLOG 8	• LITHOLOGY	
• IN SITU STRESS	• MICROLATEROLOG.		
• OTHER SPECIAL	• SONIC/VELOCITY COMPENSATED		
	• SELF POTENTIAL		
	• 3-D VELOCITY		
	• SEIS-VIEWER/TELEVIEWER		
	• OTHER SPECIAL		

NOTES:

1. ACTUAL LOG SUITES ARE SITE SPECIFIC
2. SOME PROGRAM PREPLANNING ADVANTAGEOUS

(*) Shear Velocity
Pressure Velocity
Shear Modulus
Bulk Modulus
Young's Modulus
Density
Poisson's Ratio

GENERALIZED FORMAT FOR USE WITH WELL LOGGING LOGISTICS PLAN

1. General Information

BASIN ______	WELL No. ______	WELL DEPTH ______	LOGGING START ______	CONTRACT # ______
STATE ______	LOCATION ______	LOGGING DEPT ______	LOGGING COMPLETED ______	DATE ______

2. Specific Program Responsibilities

DRILLING CONTRACTOR(s) ______	DRY-HOLE LOGGING ______
STUDY CONTRACTOR(s) ______	FLUID FILL LOGGING ______
LOGGING CONTRACTORS ______	LOG INTERPRETATION ______
MERC/ERDA REP ______	DATA PROCESSING ______
STATE/STUDY REP ______	FINAL REPORT ______

3. Logistics Plan Elements

① DRY HOLE LOGGING	② FLUID FILL LOGGING	③ INTERPRETATION OF LOGS	④ DATA PROCESSING & PUBLICATION
• LOGGING REP ______	• LOGGING REP ______	• COMPUTERIZED ______	• DATA PROCESS ______
• LOGS RUNS ______	• LOGS RUNS ______	• NON COMPUTER ______	• DATA STORAGE ______
______	______	• REPRESENTATIVE ______	• PUBLICATION ______
______	______	______	• DISTRIBUTION ______
• ERDA REP ______	• ERDA REP ______	______	
• OTHERS ______	• OTHERS ______		

Special Remarks/Comments

APPENDIX C

SAMPLING PROCEDURES

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MINERALOGY AND GEOCHEMISTRY LAB

CORE SAMPLING PROCEDURE

APPALACHIAN BASIN, EGSP

Spacing: 5 ft.

Assigned Span: $\overline{(5n - 6)}$ ft to $\overline{(5n - 5)}$ ft.

Subsection Length: 8"

A. Petrographic Studies

Sample Type: NE ¼ Subsection, oriented, slabbed

Quantity: 1 ea. Length: 8"

Condition: ______________________

For Dispatch to: ______________________

B. Mineralogic/Geochem Analysis

Sample Types: Pulverized W½ Subsection

1. Fischer assay subsample: 8 mesh

   Quantity: 115± 5 gm

   For Dispatch to: Mound Lab

2. Geochemical analysis subsample: 60 mesh

   Quantity: __________ gm

   For Dispatch to: ______________________

3. Trace Elements/Uranium subsample; 60 mesh

   Quantity: __________ gm

   For Dispatch to: ISGS or USGS

4. Mineralogy Subsample: 60 mesh

   Quantity: __________ gm

   For Dispatch to: ______________________

   Special Analyses Subsample: 60 mesh

   Quantity: __________ gm

   For Dispatch to: ______________________

5. Ash Mineralogy subsample: 325 mesh

   Quantity: __________ gm

   For Dispatch to: ______________________

OUTGASSING LABORATORY
CORE SAMPLING PROCEDURE
APPALACHIAN BASIN, EGSP

SPACING: 10 ft.

Assigned Span: $\overline{(10n - 10)}$ ft to $\overline{(10n - 9)}$ ft

Sample Type: (Canned whole subsection)

Quantity: 1 ea. Length: 5 in.

Destinations: Odd Sequence - Battelle Labs
Even Sequence - Mound Labs

PHYSICAL GEOLOGY LABORATORY
CORE SAMPLING PROCEDURE
APPALACHIAN BASIN, EGSP

SPACING: 10 ft.

Assigned Span: $\overline{(10n - 5)}$ ft. to $\overline{(10n - 3)}$ ft.

A. Ultrasonic/elastic properties

Sample Type: Oriented, cut subsection

Quantity: 1 ea. Length: 8"

Condition: 6" right cyl., sides free of chips & breaks

B. Line-load Tensile Strength

Sample Type: Oriented, subcored cut subsections

Quantity: 6 ea. Length: 1 in. Diameter 2 in.

Condition: parallel cut ends, Max chip ¼ in. into side or face.

C. Point load Fracture Strength

Sample Type:(same as B)

Quantity: 7 ea. Length: 1 in. Diameter 2 in.

Condition: (same as B)

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SAMPLE LIST

Core: ______________________________
(Well #, Twp, Co. & State, Driller & Date)

Geologist: ______ Organization: ____________________
(name) (State Geological Survey)

Sample Type: ____________________ Nom. Quantity: ____________
(subsection or mesh) (length or wt)

For: ______________ At: ______________
(test or analysis) (contractor)

Copies of this list to accompany core and set or each subset of samples, and to be retained by sampling laboratory.

Sample No.	Date Taken	Depth From - To	Lithol. Interval	Remarks, Anomaly
1				
2				
3				
4				
5				
6				
7				
etc.				

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APPENDIX D

CORE LABORATORY PROCEDURES

ORIENTED CORE LABORATORY

The task description and procedural summary of the oriented core laboratory at MERC is divided into four phases. The initial phase includes the planning of cored wells and the preparation of personnel for field work. The second phase of the core handling involves the field procedures at the core well site. Once the core is in the oriented core laboratory, the third phase entails actual laboratory tasks and tests. The final phase includes compiling the data and archiving the core specimens.

Task No.	Task Description	Task Procedure
		I. Planning and Preparation
1	Scheduling of Coring Operations	Core will be acquired from various core wells throughout the Appalachian region. Coring operations at MERC should be scheduled 30 days prior to the actual coring operation. There also should be at least a week between coring operation field trips to allow for continuity and efficiency in handling, shipping, and proper storage of core, along with proper utilization of manpower.
2	Preparation of Field Personnel	A four-man team is required to handle core in the field. Initially, the core well location should be determined. Next, the distance to the well location should be determined and the vehicle types chosen for the trip. The amount of core to be taken also should be determined, with the equipment needed. Briefing of all personnel involved should take place as soon as necessary. Contacting of other interested agencies and labs should be done as soon as the tentative coring date is scheduled.
		II. Field Work
3	Retrieval of Core	Field work at the well site is divided into several phases. The first phase includes actual retrieval of the core which requires its removal from the 60' core barrel. Actual coring time per core barrel averages 8-10 hours depending upon the amount of silt in the zones being cored. The time required to bring the barrel to

Task No.	Task Description	Task Procedure
		the surface is 1-2 hours. The core is placed and transported from the barrel on the rig floor in wooden 3' boxes and reassembled on casing or troughs of angle iron near the drilling rig. Care should be taken in handling the shale. The core should be initially reassembled as accurately as time allows while the core is being retrieved.
4	Reassembling Core	Placing the 3' sections of core on a trough should be done carefully. The core should be lined up by the three orientation grooves on the core. Shear fractures, vertical fractures, and broken pieces of the shale core will occur throughout the entire section.
5	Removing Drilling Mud	The next phase involves cleaning the drilling mud from the core section. This is necessary to mark the depth and describe the core lithologically.
6	Marking Depth of Core	This phase includes marking the core every foot. Care should be taken not to duplicate or omit any depth. A record of depth should be closely correlated with the driller's log/geolograph.
7	Lithologic Description	If time and weather permit, a general lithologic description of the core should be recorded on a strip chart along with visible fractures. The scale could be 1" - 1'.
8	Photographing Core	Those sections of the core of immediate significance to research personnel should be photographed. Necessary photographic accessories should be available for night operations. Close-up photographs with a 35 mm camera would suffice for the quality of photographs needed.
9	Sample Selection	The samples used for geochemical analysis, outgassing, and other tests are extracted and recorded.

Task No.	Task Description	Task Procedure
10	Placement of Core in Boxes	The core specimens are now ready to be placed in boxes. The boxes (3' x 4½" x 4½") should be assembled and marked before each core barrel is emptied. The name of the cooperating company, well number, and box number may be marked on top of the box as it is assembled. The core is placed in clear plastic which has been draped in each core box, then the core is wrapped tightly with the plastic and taped. The depth of the core (interval) is added to the other information on the box top. The core is stacked and covered properly for future transport back to the laboratory. Each foot of shale core weighs approximately 10 pounds.
11	Time Allotment of Field Work	The above sequence from retrieving core from the barrel to boxing the core takes between 3-4 hours with four personnel. The crew should anticipate the next barrel will be ready five hours after boxing the last sections of the previous core when coring on an air-soap mixture. This time may be shortened if the next core jams in the barrel. The time between core retrieval should be spent wisely in resting, sleeping, and eating to be prepared for the core retrieval and assembling operation. Coring rates when drilling with mud (aquagel, water, barite mixtures) will be considerably longer.

III. Core Laboratory Procedures

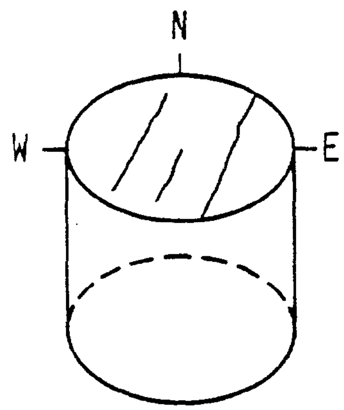
12	Labeling Core Boxes for Storage (200'/day)	After the core has been transported back to the laboratory, the first step is to properly label one end of the box for storage on shelves. The company name, well number, box number, and depth interval must be transferred clearly and legibly to the end of the core box.
13	Placing of Core in Shelving (200'/day)	The boxes are then placed in the storage shelves in descending sequential order beginning with the first box of the first run and ending with the last box of the last run.

Task No.	Task Description	Task Procedure
14	Hardness Test (100'/day)	The core is now ready to be processed and examined by various tests in the laboratory. A four-man crew is necessary to process the core samples efficiently. The first test performed is the hardness test. This test gives a quick analysis of the relative hardness of the core sections. The test is performed with a scleroscope which uses the Brinnel scale of hardness as the standard. Tests are made taking 10 readings per foot on either the side of the core or the flat surface of a bedding plane. Whichever surface is used must be used consistently throughout. These 10 readings are added together, divided by 10, and an average hardness reading is obtained for each foot. Two personnel operate two scleroscopes and read the values from the instruments, while two personnel record the figures, take averages, and place them on a composite sheet in descending well order. A four-man team can test an average of 100'/day. These data are used in conjunction with the well logs for fracturing zones of the core well.
15	Reassembling Core	Two boxes of core are placed on a core holder (wooden tray) and reassembled. The core is rinsed or wiped clean if drilling mud is evident on outer surfaces. Downcore arrows and depth marks are then retraced if necessary. This stage may be time consuming if the core samples are highly fractured.
16	Orientation of Core	The next step is to orient the core by coordinating the grooves on the oriented core with the compass on the goniometer (F8424 Christensen Diamond Products Co.). The grooves on the core have been previously set according to the core orienting log. The orientation log shows the orientation of the core every two feet. This allows the core to be labeled in its natural orientation. After orienting the core every two feet, all of the core can be marked by use of a straight edge, and the four major compass points can then be marked on the core.

Task No.	Task Description	Task Procedure
17	Recording of Core Fractures	The next phase of the core analysis is to record the natural and induced fractures in the core. Fractures are recorded in each one-foot interval. The length of each fracture, its strike and dip, and the frequency of similar fractures are recorded. The fractures are classified into two categories: vertical and inclined. The vertical natural fracture is given particular attention when these data are recorded because it could represent highly fractured zones.
18	Lithologic Description of Core	The following three procedures should be followed when doing the lithologic description: 1. The lithologic description of the core should follow a certain sequence to keep everything uniform. The description of the core should take place in a well-lighted area with a table or bench large enough for maneuvering and inspecting the core sections. 2. The equipment used in describing the core includes: (1) a binocular microscope with μ scale, (2) an examining probe, (3) an aluminum engineering 6' rule (marked in tenths of a foot), (4) hydrochloric acid (10%), (5) a geological color chart, and (6) various laboratory trays, beakers, tweezers, and brushes. 3. After each 6' core section is reassembled, it is described lithologically. The grain size, texture (silt or shale), color (USGS Color Chart), percentage of the different colors, and additional minerals found in the core are noted. Hydrochloric acid is added as a test for the presence of calcite, dolomite, or other effervescing minerals. Additional features such as spores, spore casts, worm burrows, pyrite, cross-bedding, iron-stains, slickensides, and mineralized fractures are also noted. Organic zones (dark grey-black) and kerogentype odors are recorded. It should be noted whether the core is whole, highly fractured, or impossible to orient or reassemble.

Task No.	Task Description	Task Procedure
19	Photographic Log	As the core is being oriented and described, those zones or areas which best characterize the core may be noted on a separate log. Any outstanding or unusual characteristic should also be listed according to box number and depth. Later, these sections will be photographed by professional photographers for black and white prints, color prints, and color slides. This phase usually takes one day and involves preparing the specimens and assisting the photographers.
20	Cutting and Marking Core for Test Samples	A. The next phase of core processing involves the selection of core samples to be used in various tests. Initially, selected core sections from every tenth of a foot along the North reference line should be re-marked.
		B. The selection of Ultrasonic Velocity Test Samples is next. A 4-8" specimen is selected every 5' and cut into a perfect cylinder. These specimens may be difficult to locate in some core sections because of the high frequency of fractures.
		C. The next phase is to select and cut 2" specimens to be used for Line Load Directional Tensile Strength Test and Point Load Test. Six 2" specimens per 10' core section are required for the Tensile Strength Test and ten 2" specimens per 10' core section are required for the Point Load Test.
21	Marking of Microfractures	The next phase is to mark all microfractures on the cut surfaces. Each fracture is recorded in red pencil on the surface of the core. The length of the microfractures (in millimeters) and the

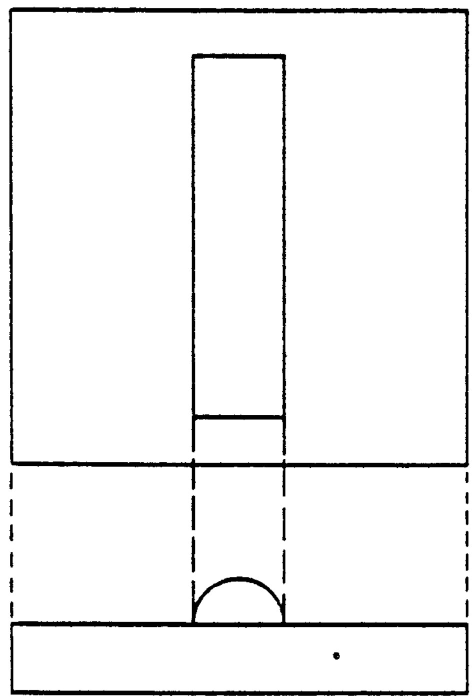
Task No.	Task Description	Task Procedure
		quadrant (either northeast or northwest) in which they occur are recorded. All microfractures in each degree range (every 5°) of each quadrant are recorded on a composite sheet.



Marking and measuring of microfractures.

Task No.	Task Description	Task Procedure
22	Selection of Other Samples	The selection of samples for other tests conducted by other laboratories is the next phase. The selection of samples may be supervised by the core lab personnel or arranged otherwise. All samples removed by others must be recorded as to size and depth interval. Samples for various tests include Fischer Assay, Modulus Tests, X-ray Analysis, Permeability-Porosity Tests, and others.
23	Directional Tensile Strength Test	At intervals of 10', 6 samples (2" x 4") are selected for Line Load Tensile Strength Tests. The load stress is measured 90° from the breaking direction. The instrument used is the Tenious Olsen Press.

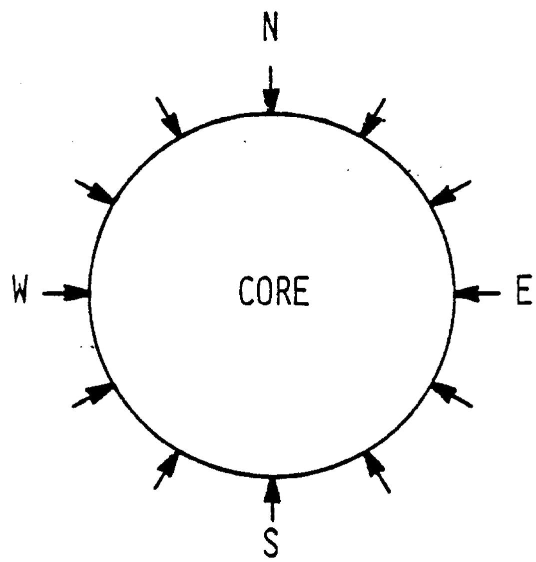
Task No.	Task Description	Task Procedure
		The sample is placed horizontally between the two platens in the instrument and compressed.



A top view of the platen used on both sides in the Line Load Directional Tensile Strength Test.

1. Each sample is broken in one of six directions, 30° apart. For example, one sample is broken at N 60° W, one at N 30° W and one at N°. The sample is also broken

Task No.	Task Description	Task Procedure
		at N 30° E, N 60° E, and N 90° E. The sample is compressed from both directions, i.e., N 60° W, and S 30° E.



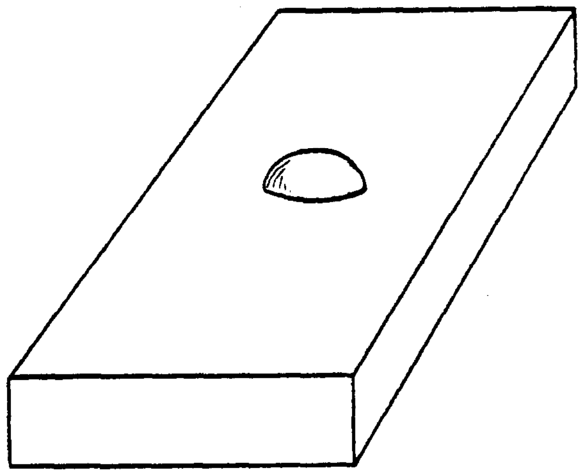
Possible directions which may be broken for Tensile Strength and Point Load tests.

2. The tensile strength of each sample is recorded in pounds per square inch (0-60,000 lbs.) on a large circular scale. The breaking point is then recorded on a composite sheet. This test usually requires two personnel: one breaking samples and the other recording the breaking point (in psi) on a composite sheet.

3. In the last phase of this test, the induced fractures on the sample are numbered according to the sample number and then the fractures are traced on paper. This gives an accurate visual record of all samples. This step also requires two personnel.

Task No.	Task Description	Task Procedure
24	Point Load Test	The next test requires samples which do not require grouping as in the previous test. The remaining samples are to be used in the Point Load Test.

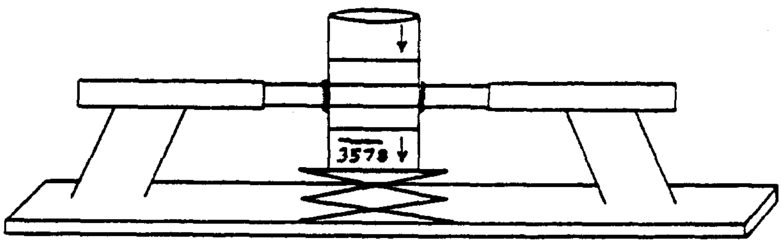
Task No.	Task Description	Task Procedure
		1. These samples are compressed in a vertical direction by loading them directly in the center on both the top and bottom sides. Hemispherical platens are used in this test for both the top and bottom, as seen in the illustrations.



A top view of the hemispherical platen used in the Point Load Test.

		2. The breaking point stress is then read on the Tinius Olsen Scale and recorded on a composite sheet in pounds per square inch.
		3. In the last phase of the Point Load Test, the induced fractures on the sample are numbered according to the sample number and then the fractures are traced on paper.
25	Ultrasonic Velocity Test	Once the 6-8" samples for the Ultrasonic Velocity Test have been selected, the orientation in 30° increments is recorded on one end of the sample, using a circular template. The orientations of the core to be tested are N 0°, N 30° E, N 60° E, N 90° E, N 60° W, and N 30° W. The diameter of the core is measured in each of the above directions using a vernier micrometer. The sample is then wrapped with black plastic tape so that the tape just touches itself but does not overlap, and no exposed core is found. The area taped is directly in the middle of the sample and three

Task No.	Task Description	Task Procedure
		widths of the tape are used, yielding a taped area with a width of approximately two inches. The taped areas of the sample is then coated with a di-electric silicon lubricant and then placed in the sonic velocity apparatus. The ultrasonic velocity is then measured in the six directions mentioned above, and an average of ten values for each direction is used as the final measurement. One technician is required to operate and record the average of the sonic impulse.



4" x 6" core sample being tested in the ultrasonic velosity apparatus.

IV. Summarizing Data and Archiving Core

Task No.	Task Description	Task Procedure
26	Compiling all Data in Oriented Core Lab	Several xeroxed copies should be made of all data recorded. These copies can be distributed to all personnel. All data from every test are compiled in order from the first to the last test. The data will be used for various phases of the shale characterization. The lithologic description will be used as background information for the various tests on the shale core. The description also will be used as coorelative data in locating zones of high hydrocarbon content on a regional scale. Fracture data will be used for the planning of directionally deviated wells and hydraulically induced fractures. The hardness, directional tensile strength, point load, and ultrasonic velocity tests will be utilized to characterize the rock

Task No.	Task Description	Task Procedure
		mechanics of each core section. All the data collected in the oriented core laboratory will be used as support data in related shale characterization studies.
27	Summarizing Core Well Data	All data obtained in the oriented core laboratory should be compiled for possible publication. Lithologic data will initially be published as background information for additional tests and characterization studies on the shale core. Each well cored will have pertinent geographic and geologic information related to its particular locality. A location map is constructed showing the exact location of the cored well. A general geologic column is also drafted showing the specific lithologies in the cored well locality. Additional illustrations showing the well logs, hardness test, and any of the rock mechanics results displaying significant correlations should be included in the final report. A final draft should be submitted for approval and editing before the report is sent to the publishers.
28	Archiving Core	The final phase of the core handling procedure is proper storage of the remaining core specimens. The core should be stored in a building where it will be easily accessible if samples are required later. Excessive dampness, heat, and cold should be avoided in the core storage area. A record of the storage location of each cored well should be kept and updated in the oriented core laboratory files.

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APPENDIX E

ANALYSIS LABORATORY PROCEDURES

ANALYSIS LABORATORY PROCEDURES

The oriented shale cores are first photographed, then examined for macrofractures and lithologically described. Using well-log data, segments* 8 inches in length are then selected for physical property measurements and standard core analysis. The physical properties to be measured include degassing tests (to measure gas output under normal drain rate and induced drain rate through thermal treatment for total gas output), fracture orientation and density, directional velocity and resistivity, pore size distribution and surface area measurement, thermal conductivity, and tensile strength. The standard core analysis includes porosity, permeability and fluid saturation measurements. After the physical properties have been measured, the selected segments are characterized in detail along with the remaining core segments to obtain chemical and mineralogical properties.

The core segments are next cut into subsections at regularly spaced intervals, for example, every 10 feet. The subsections are then vertically halved along the N-S direction, and the freshly cut faces are photographed and lithologically described. The eastern halved-subsection thus produced is next vertically halved again. The north-eastern quarter-subsample is used for petrographic analysis, UV/VIS reflectance measurements, and surface micromineralogical analyses using infrared spectroscopy, x-ray diffraction analysis and scanning electron microscopy. The southeastern quarter-subsample is archived after surface microsampling.

The western halved-subsection is pulverized to -8 mesh, and using standard laboratory techniques a representative 100 gram sample is removed for the standard Fischer Assay to determine oil yields. The remaining -8 mesh material is then pulverized to pass -60 mesh, and subjected to a variety of compositional studies.

A portion of the -60 mesh material is analyzed for moisture, specific gravity, and the ash percentage, using standard laboratory methods. Chemical analyses, including organic and mineral carbon, nitrogen, hydrogen, and sulfur forms, are obtained on a further portion of the -60 mesh material. Using wet chemical analyses, elemental concentrations in the ash are obtained for silicon, aluminum, iron, calcium, magnesium, sodium, potassium, phosphorous, titanium, and sulfur. Trace elemental analyses are obtained on the -60 mesh material initially using survey techniques, such as spark-source mass spectrometry, optical emission spectrometry or other techniques. Quantitative trace elemental analyses for the elements boron, manganese, copper, nickel, barium, chromium, and strontium are obtained by more detailed SSMS studies or other techniques with better precision and accuracy.

A further portion of the -60 mesh core material is further ground to pass -325 mesh, and then electronically low temperature ashed at 145°C under vacuum. This procedure removes the organic material and leaves mineral structures relatively unaltered. Bulk mineralogical analyses are then obtained by combined infrared and x-ray diffraction analysis, and micromineralogical analysis by scanning electron microscopy.

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*See attached list of core sample terminology and definitions.

In addition to the Fischer Assay method for determining oil yields, total hydrocarbon content is also determined from the weight loss obtained by low temperature ashing the -325 mesh core material. Organic material is isolated from the shale by solvent extraction and characterized by a variety of analytical techniques, e.g., combined TGA and gas chromatography. Thermal chromatography is applied on small samples to obtain further data on oil and gas yields.

Radioactive measurements and quantitative analyses of uranium and thorium contents are obtained on a portion of the -60 mesh material.

Unused sample amounts will be archived for future reference or tests. Archived samples include: (1) the intact south-eastern-quarter-subsections, (2) the intact north-eastern-quarter-subsections after petrographic studies, (3) the remaining -60 mesh pulverized material from the western-halved-subsections, after compositional studies are completed.

The described comprehensive analytical approach for the characterization of shale cores is systematic and, where possible, employs standardized analytical procedures and techniques, so that the data generated from different cores will be comparable. However, where different groups have developed expertise and analytical procedures not being used by others, comparison between their data and that obtained by standardized methods must be made.

All the information in physical, chemical and mineralogical properties of core samples generated by all the laboratories involved in shale characterization work will be computer-processed for rapid dissemination, accessibility, and correlative studies.

The suggested tasks for chemical, physical and mineralogical characterization studies are:

1. Determine the mode of occurrence and relative distribution of hydrocarbon phases in shale by instrumental or chemical extraction techniques.

2. Adsorption/desorption studies of gases through shale.

3. Determine hydrocarbon/matrix interface (bonding).

4. Develop microhydrocarbon assay for total hydrocarbon in place.

5. Determine quantitatively trace elements in shale cores.

6. Determine micromineralogy, pore size distribution and surface topography of shales.

7. Develop rapid assay method for the determination of outgassing.

8. Measure radioactivity and determine quantitatively the uranium and thorium concentrations.

9. Determine trace elemental distribution between the organic and inorganic phases.

10. Determine the modes of occurrence of uranium.

11. Determine shale mineralogy.

12. Correlate photography and gamma radiation core log.

13. Orient core and describe in detail the macro- and microfractures, including fracture density and orientation.

14. Describe in detail the lithology of the cores.

15. Determine porosity, permeability, specific gravity, bulk density, and fluid saturation.

16. Determine modulus of elasticity, Poisson's ratio, compressive strength, directional tensile strength and point load induced failure orientation.

17. Correlate physical properties with geophysical well logs.

18. Correlate chemical and physical properties with well logs.

19. Correlate well log data, chemical and physical properties with the occurrence of hydrocarbons.

CORE SAMPLE TERMINOLOGY

Horiz.	Cut 1:	"Interval":	material of a given rock-type and a broad classification, e.g., coal, shale, etc. (a stratigraphic interval or unit). Not a standard size -- naturally determined.
Horiz.	Cut 2:	"Segment":	random vertical lengths of the core taken at irregular vertical spacings as determined from well-log data or lithological descriptions.
Horiz.	Cut 3:	"Subsection":	full-diameter core samples; can be: (a) regularly spaced (b) continuous to include the total column of the core of a selected standard size.
Vert.	Cut 4:	"Halved Subsection":	(= "subsample"); vertical halves of "subsections"; also, "half-core samples" or "half-subsample" of a selected standard size.

Vert. Cut 5: "Quarter Subsection": (= "subsample"); vertical halves of "halved subsections"; also, "quarter-core samples" or "quarter-subsample" of a selected standard size.

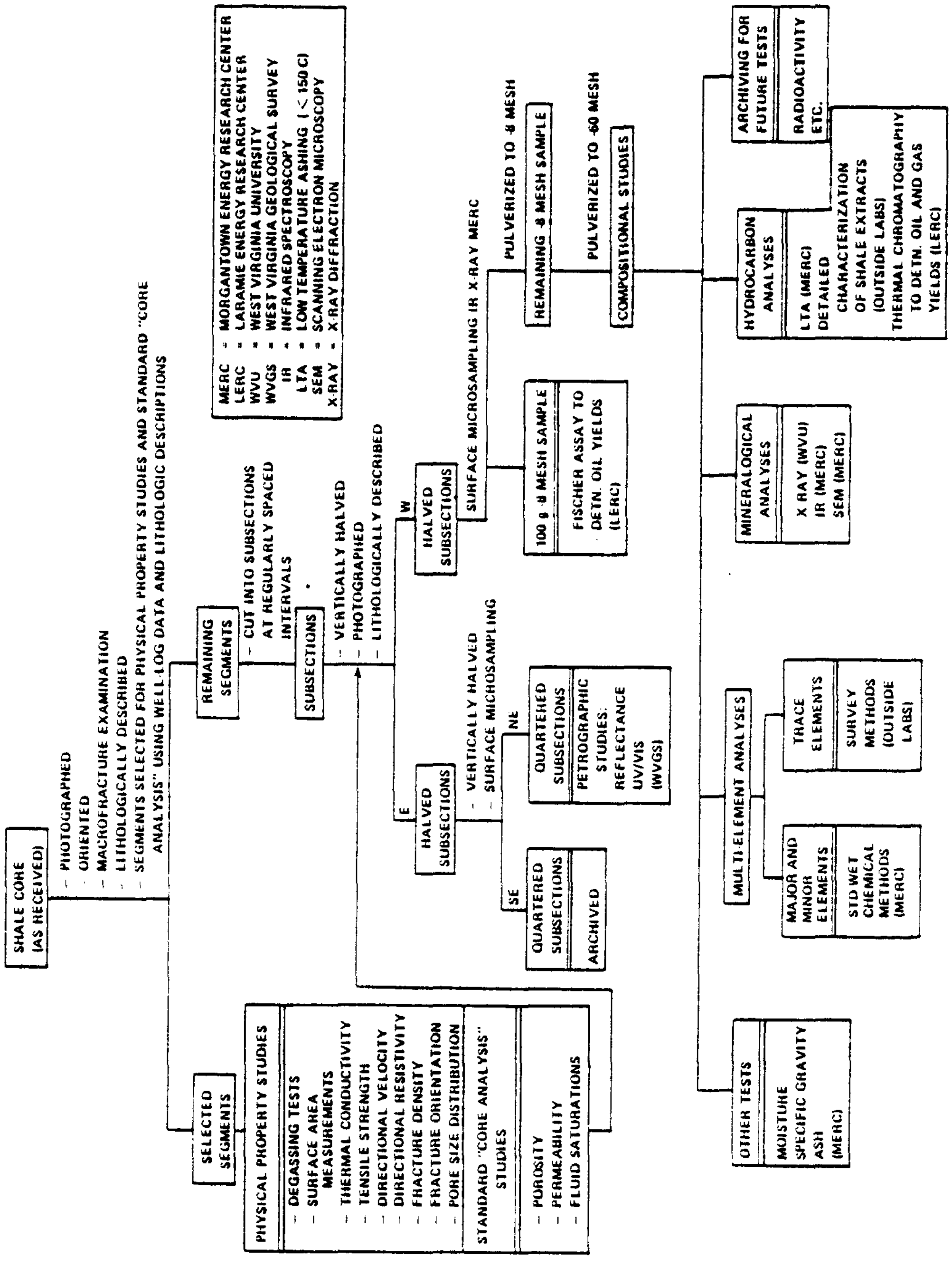

FIGURE 1. SEQUENCING OF ANALYSES FOR CHARACTERIZATION OF SHALE CORES